Alberta Government

Keynote

Day 1 - Keynote Speech

Anil Gupta – Central Modelling Office

ESRD - Central Modelling Office

Reaching Our **Full Potential**

Integrated Environmental Modelling

Anil Gupta, Ph.D., P.Eng.

Manager, Central Modeling Office
Policy Division
Environment and Sustainable Resource Development

Outline

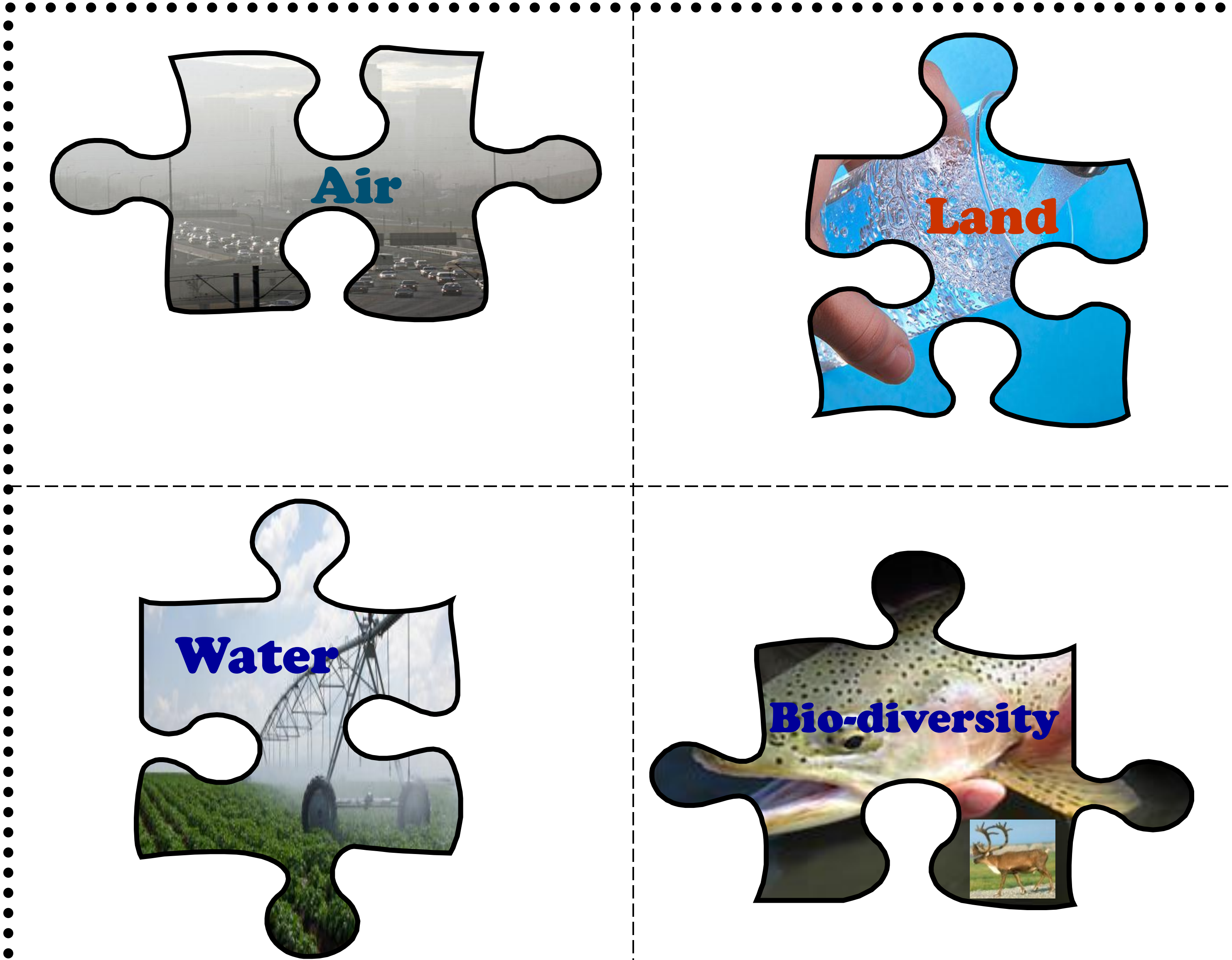
Integrated Modelling

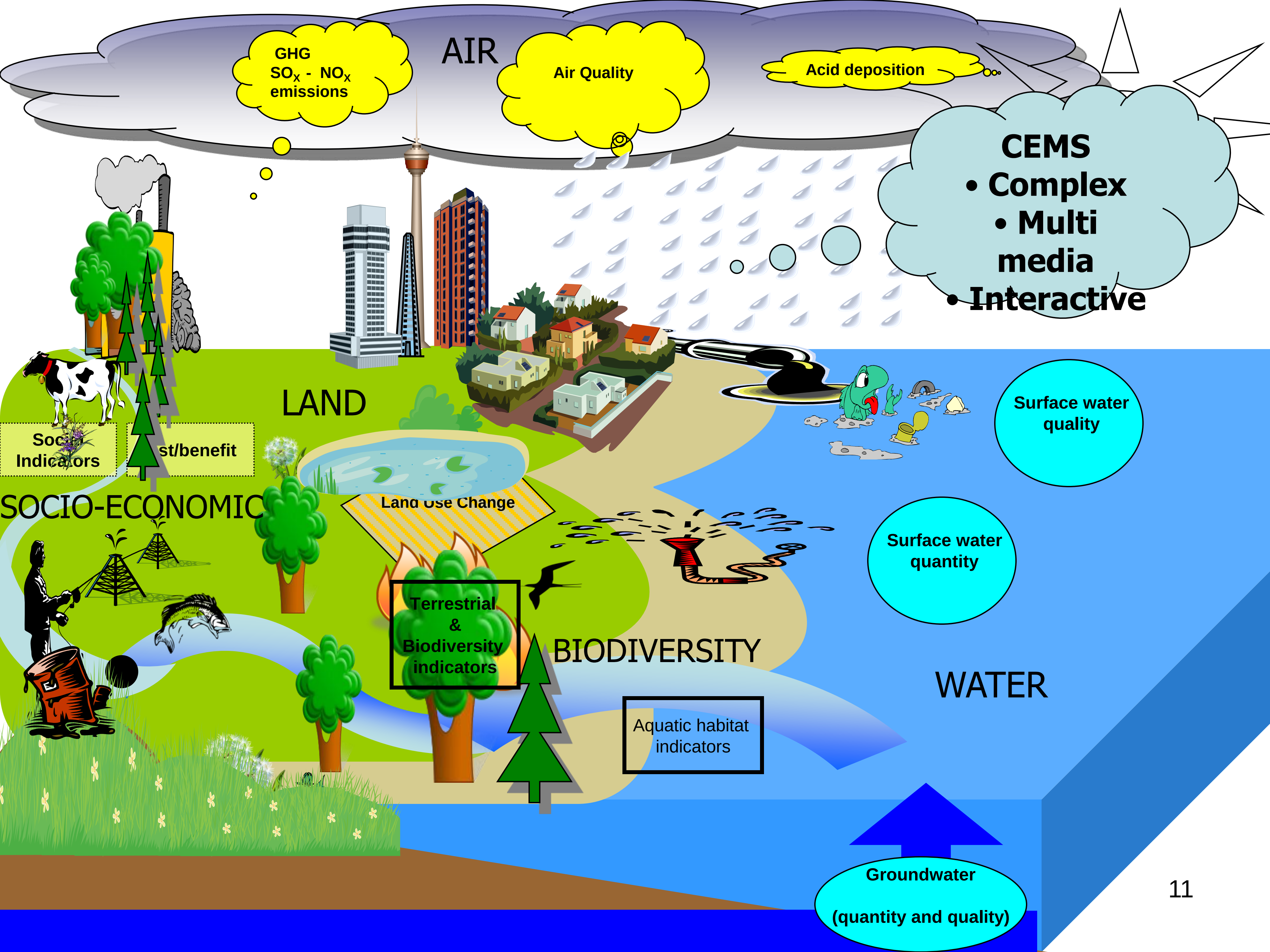
- Integrated modelling – what does it mean?
- Integration efforts – some examples
- What else is being done to address?

Central Modelling Office/ESRD/GOA

- ESRD Modelling Context
- Why do we model? – a regulatory perspective.
- Current modelling practices in ESRD
- Challenges and opportunities
- CMO structure and role in supporting/enhancing modelling in ESRD

Environment



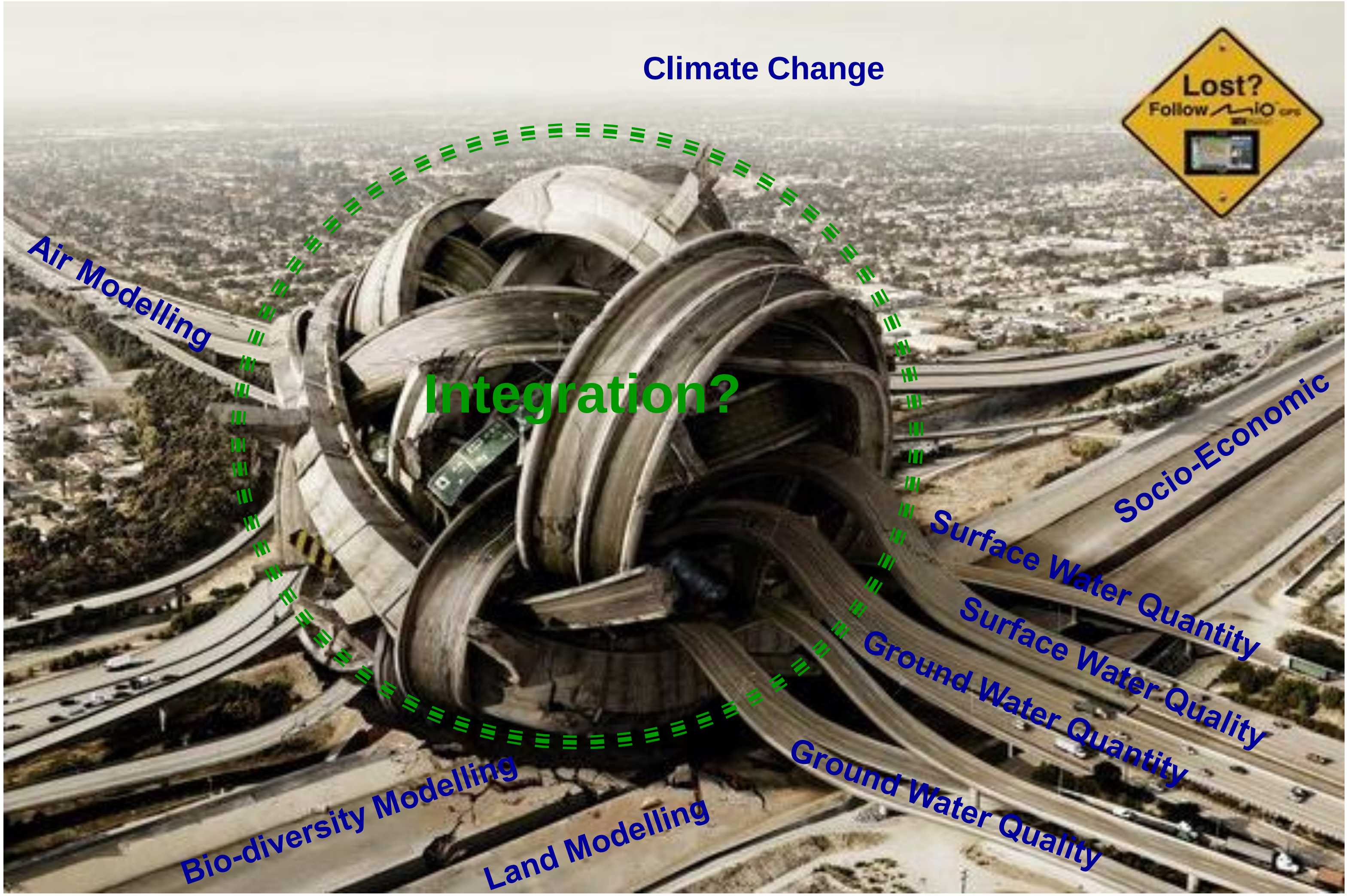

AIR
GHG
SO_X - NO_X
emissions
Air Quality
Acid deposition
CEMS
• Complex
• Multi
media
• Interactive
LAND
Socio
Indicators
st/benefit
SOCIO-ECONOMIC
Land Use Change
Terrestrial
&
Biodiversity
indicators
BIODIVERSITY
Aquatic habitat
indicators
Surface water
quality
Surface water
quantity
WATER
Groundwater
(quantity and quality)

Isolated (sector or media based) vs. Integrated

•In past - modelling efforts were either <u>sector based or media specific</u> (e.g., land, air, water and biodiversity).

They lacked the ability to consider how these landscape components interact with each other.

The Problem


Climate Change
Lost?
Follow
Air Modelling
Integration?
Socio-Economic
Surface Water Quantity
Surface Water Quality
Ground Water Quantity
Ground Water Quality
Bio-diversity Modelling
Land Modelling

Isolated (sector or media based) vs. Integrated

- CEMS Approach – ESRD/GOA is moving towards Cumulative Effect Management (CEM).

  One of the critical aspect to moving toward CEM is to create an **integrated, versatile multi-media environmental modelling system**, which can also encompass climate change adaptation to support policy and decision making. (plus linkages with, **socio-economics and energy** side of modelling).

The Solution

Integrated Modelling System

What does it mean by IEM?

Common understanding is important

Integrated environmental modeling, often requires to integrate (spatial) data and computational models from a variety of disciplines (e.g., related to physical, biotic, social, and economic environments) and at different scales, to understand and to solve complex societal problems that arise from the interaction of humans and environment, and to contribute in this way to establishing the foundation of sustainable development, to inform policy and to support decision-making.

(Rothman, 1997, Parker, 2002)

•Parker, P., et al., Progress in Integrated Assessment and Modelling. *Environmental Modelling & Software*, 3(17): 209–217, 2002.

•Rothman, Dale S., Robinson, John B., Growing Pains: A Conceptual Framework for Considering Integrated Assessments. *Environmental Monitoring and Assessment*, 46(1): 23–43, 1997.

•No single agency or model has the capability to address complex interdisciplinary environmental issues (e.g., cumulative effects management, climate change, etc.)

•Collaborative approaches are required to pool resources and provide consistent direction, while allowing flexibility to address different issues.

(Integrated) Environmental Modelling – Models & Modelers

A collaborative teamwork

- Integration efforts – some examples

ESRD/GOA Modelling Context

Increased reliance on models (modelling) to support CEMS, LUF-regional plans, evaluation & reporting, operations (approval & compliance), emergency management and other ESRD strategies including policy development and environmental monitoring.

•Why do we do modelling? (regulatory perspective)

- is a proven way of providing decision support to performance-driven, outcome based processes.
  - To diagnose and examine causes and precursor conditions of events that have taken place
  - To forecast outcomes and future events
- Modelling informs policy (MIP)
- Modelling compliments monitoring (MCM)
- Modelling ~ a proven tool for evaluation and reporting

Modelling use in ESRD

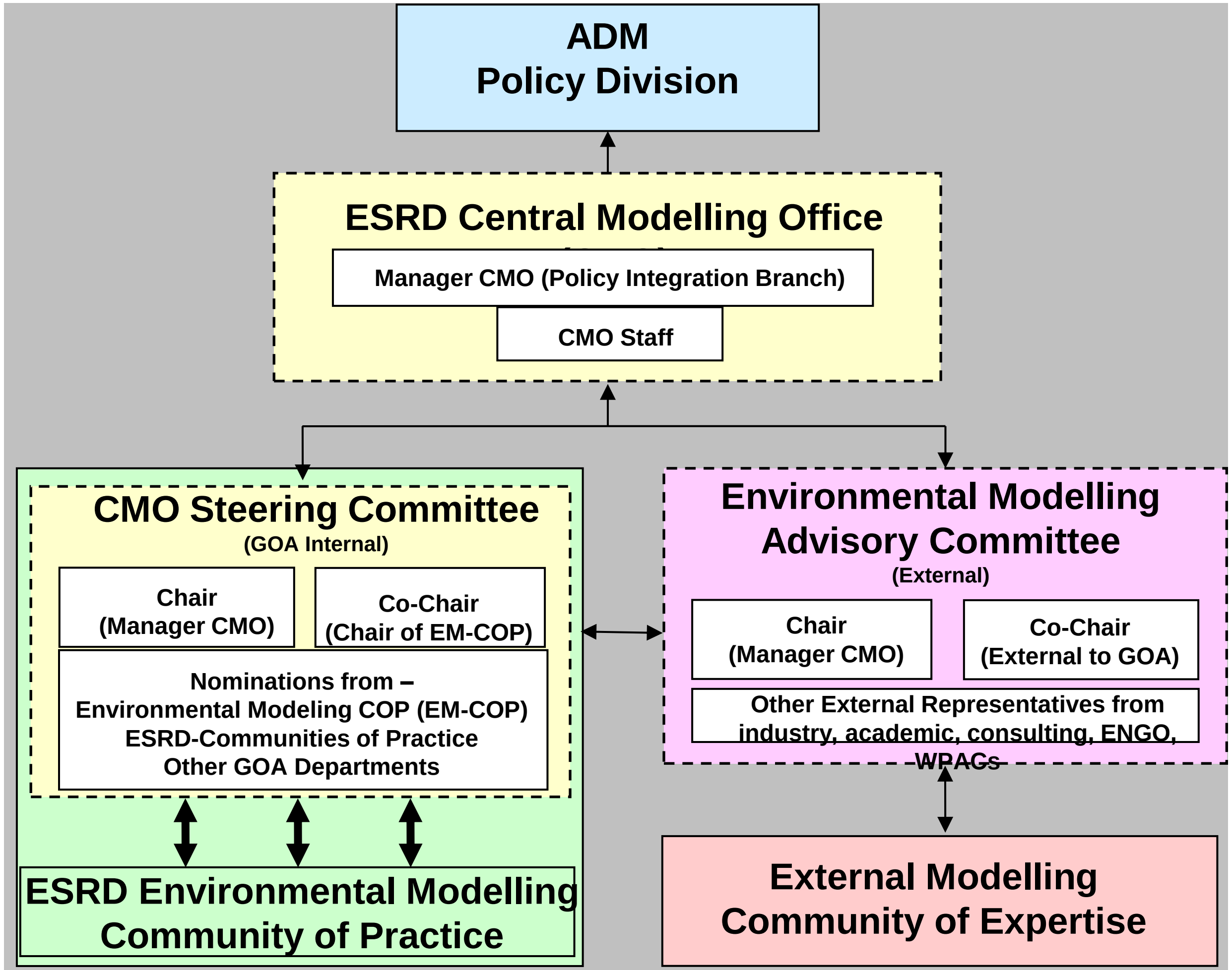
- Policy – development and analysis (what if)
- Regulatory decision making (approval, licensing etc.)
- Implementation applications (enforcement, compliance etc)
- Emergency management
- Routine operations – water supply, dam operations, effluent discharge, emissions,
- Planning
- Monitoring (compliments)
- Cumulative effects (of multiple projects/activities and/or across various media)
- Performance indicator – identify, triggers/limits
- E&R - Performance evaluation of management practices
- Predictions – short term and long term

ESRD Modelling Capacity

- Land Use Modeler
- Surface Water Modelers/Hydrologist
- Water Allocation Modelers
- Water Quality Modeler/Limnologists
- GW Modelers/Hydrogeologists – quantity & quality
- Air Quality Modelers
- Riparian Modelers
- Bio-diversity Modelers
- Forest Management
- Forest Fire
- Wildlife

Opportunities brings Challenges

CMO Structure



COP: Communities of Practice
ENGO: Environmental Non Government Organizations;
WPAC: Watershed Planning Advisory Committees

Role of CMO in Enhancing/supporting Modelling Work at ESRD

Pro-active Approach

- Coordination (oversight, guidance and support)
- Provide assurance to stakeholders (internal & external) that ESRD modelling adheres to standard guidelines and criteria and is done in a cumulative effects based manner with acceptable science rigour, credibility and transparency that is sustainable in the long term.
- Promote a cumulative effects based approach to modelling where strategic/regional and multi-media modelling efforts are integrated to best achieve environmental management objectives.
- Assess departmental modelling needs, funding priorities and resourcing needs and champion those needs on behalf of ESRD modelling community.
- Promote collaboration and information exchange between model developers and users.
- Promote Integration of socio-economic, energy and climate change modelling with environmental modelling.

What is being done by CMO?

- Alberta Modelling Guidelines – best modelling practices (BMP), standards, criteria, protocols...
- Evaluation of Modelling Tools
- Modelling Expert System
- Modeling Toolbox
- Centralized Modelling Repository
- Modelling Capacity - Computing Centre – high end hardware, software & version mgt
- Centralized Modeling Data Warehouse
- Annual/Bi-annual Environmental Modelling Workshops
- CMO - Steering Committee (GOA wide – internal): Charter
- CMO - Environmental Modelling Advisory Committee (External – include all sectors)
- Integrating socio-economic,energy and climate change modelling
- Modelling Center of Excellence

Alberta

Strategic / Spatial Integration

(Vertical Integration)

Enablers

-communication

-collaboration

Strategic Modelling (RSA)

- energy flow / development scenarios
- policy cost / benefit
- climate change / GHG emission scenarios
- human health risk
- others

Regional / Operational Modelling

Water

Surface Water

-quality / quantity
-Infrastructure/storage feasibility
-scenario / policy assessment
-Risk assessment (License approvals/transfers)
-EIA decision support
-others

Groundwater

-impact studies
-infrastructure / storage
-SW/GW interaction
-EOR support
-others

Air

- regional plan support (airsheds)
- NOx/Sox
- acid deposition
- PM & Ozone (target loads/ management framework/ emission caps)
- AAAQ
- evacuation zones
- others

Land & Biodiversity

-climate change / reclamation
-biodiversity risk
-Acid Deposition Management Framework support
-others

Multimedia Integration

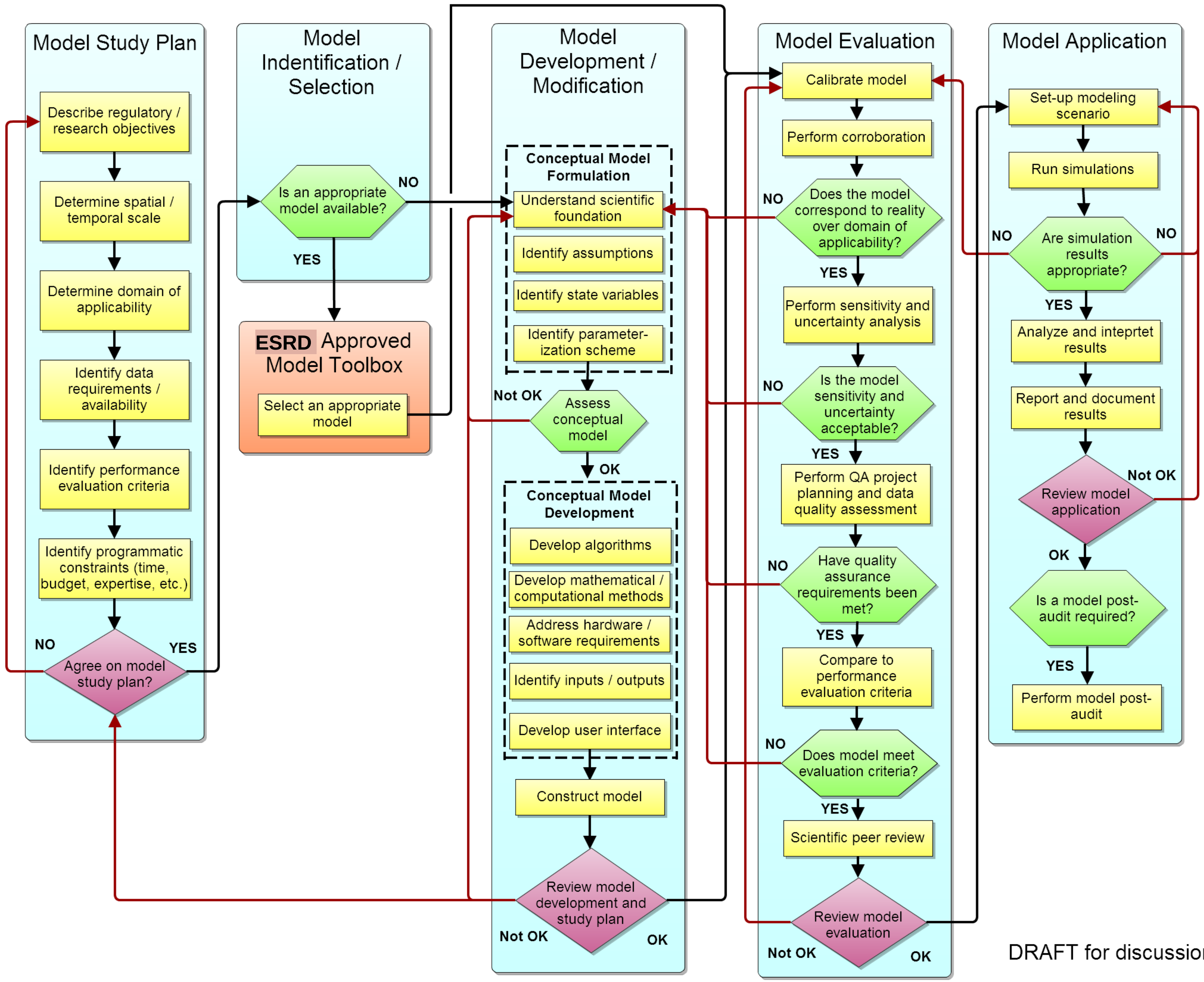
(Horizontal Integration)

Enablers

-research
-expert network
-collaboration
-common data

Model Integration

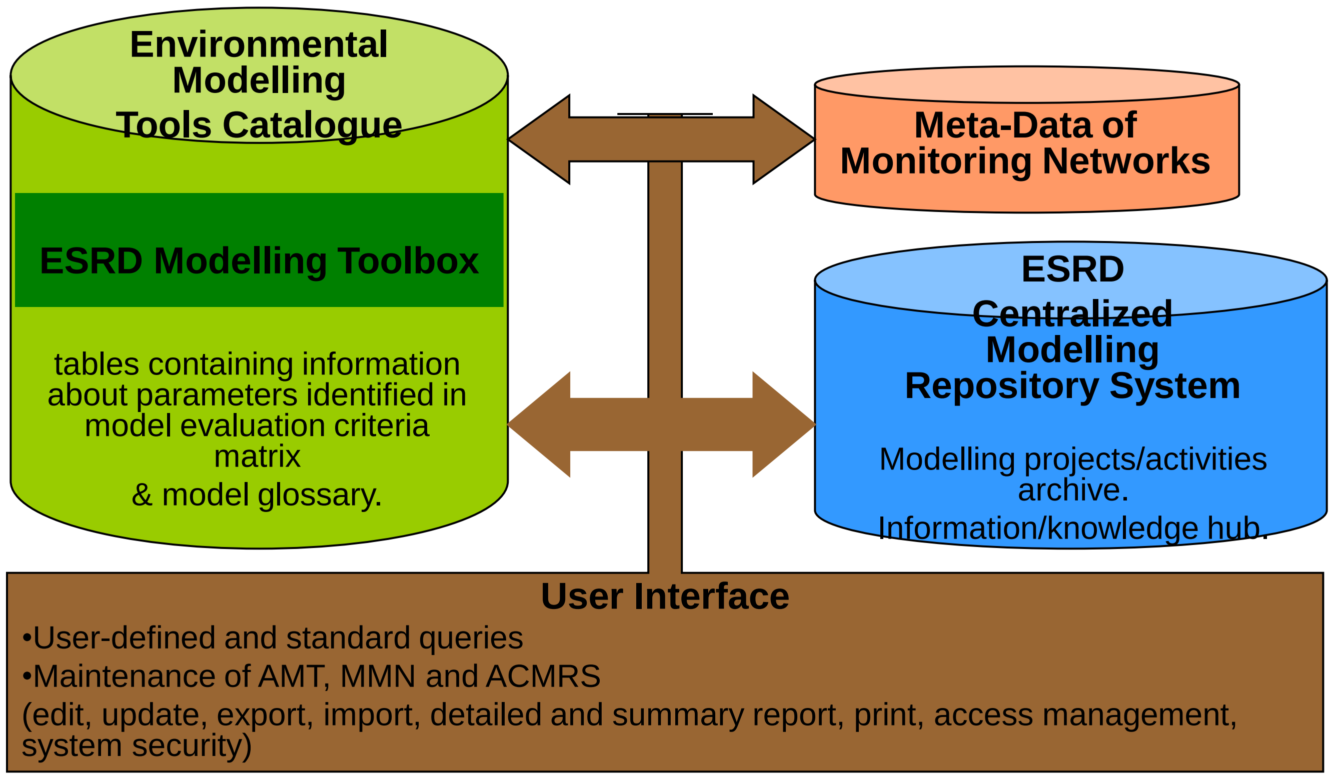
ESRD Modelling Process



DRAFT for discussion

•ESRD Modelling Expert System (EMES)

•Concept Diagram

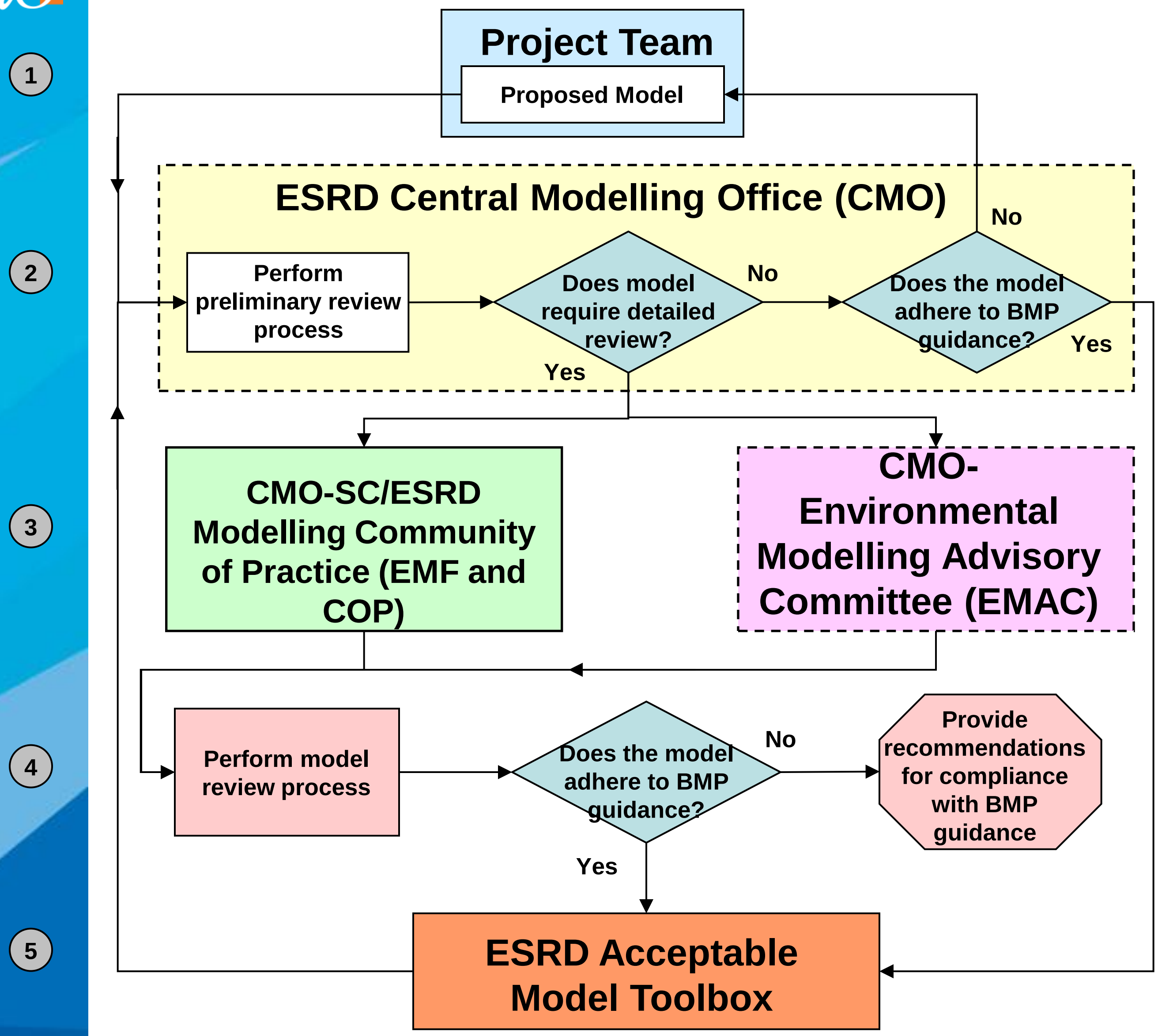


TETRA TECH

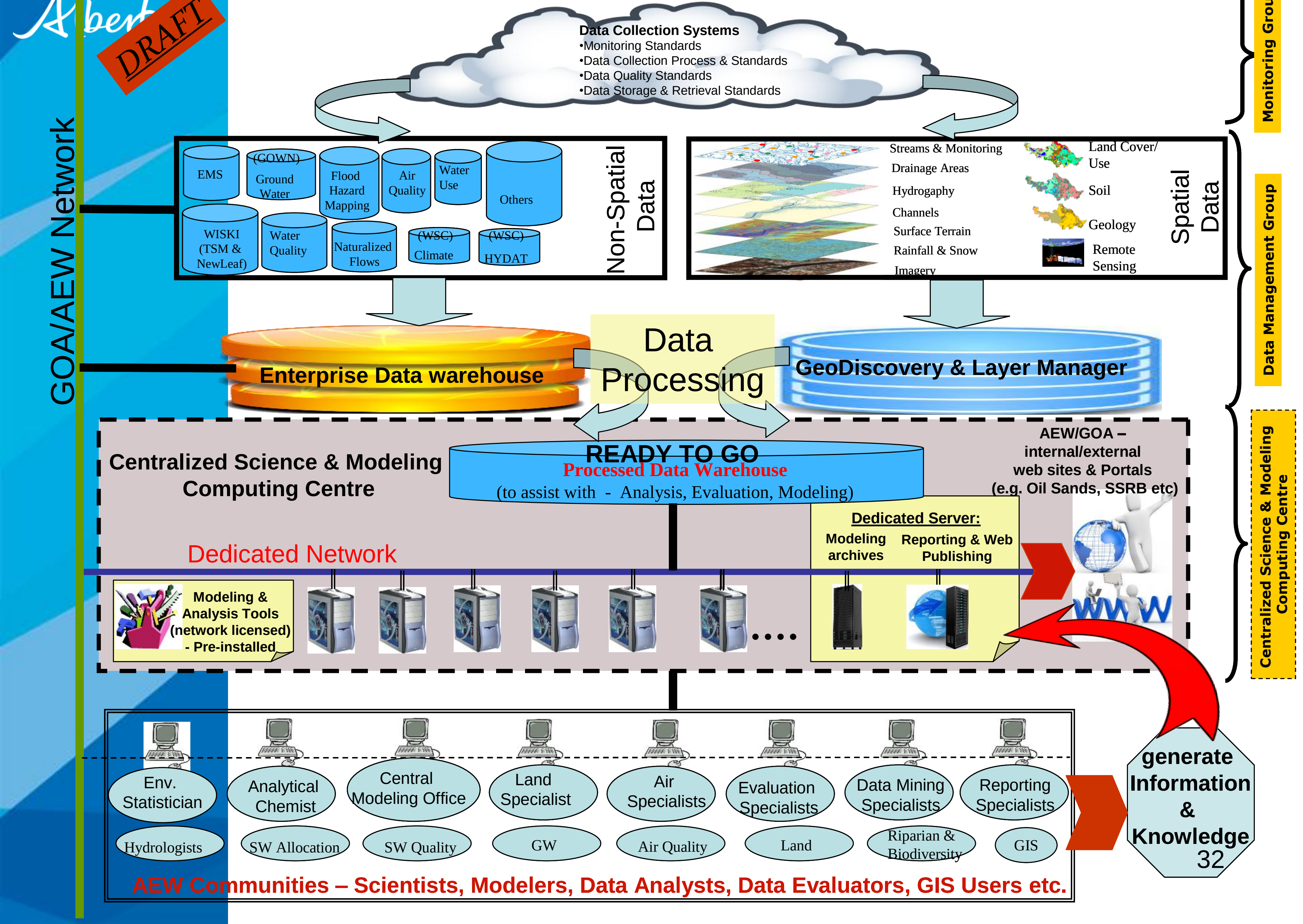
complex world | CLEAR SOLUTIONS™

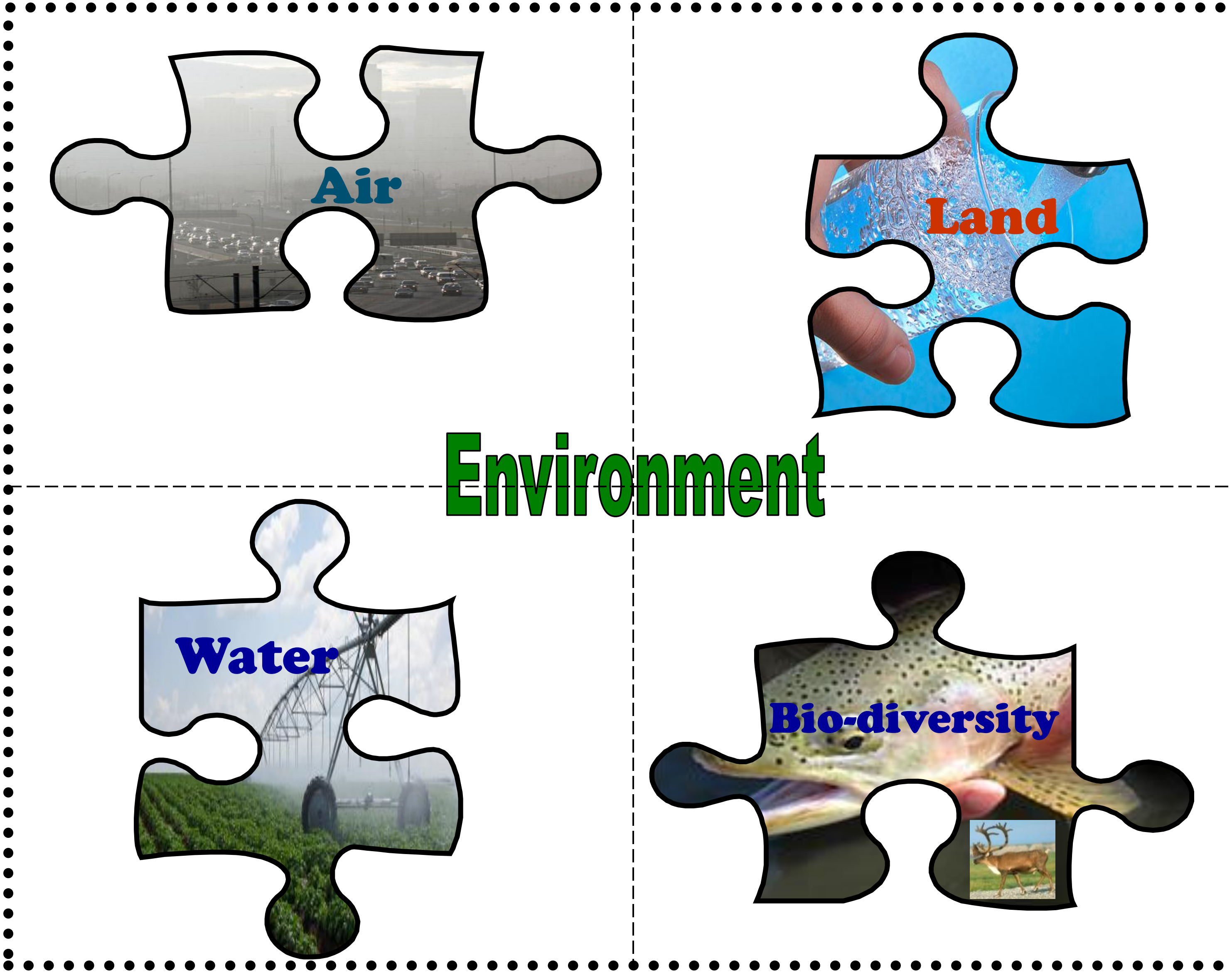
RWDI

ESRD Model Approval Process



Centralized Science and Modeling Computing Centre – Concept Diagram




Air
Land
Environment
Water
Bio-diversity


Land
Air
Integrated
Environment
Environmental
Water
Biodiversity
Modelling

Once upon a time, a student once went to his teacher.

He asked his teacher a question: "Sir, is there any good in talking a lot?"

The teacher replied: "Toads and frogs croak night and day,
but no one pays any attention to them.
But the cock crows at a certain time of night and wakes up everyone."

The teacher smiled at his student and said,
"This proves that no good is achieved by talking a lot.
What is important is to say the right thing at the right time.

Alberta

This is the right time. **Timing can not be better!**

The province is implementing CEMS to continue the economic development while safe guarding the environment.

Modelling, indeed pays a significant role:

- In policy development
- In implementation of CEMS through Regional Plans (LUF)

Modelling Integration:

- Horizontal (across media)
- Vertical (geospatial scale)
- Social dimension
- Economics
- Energy development
- Climate Change

What is the ultimate GOAL?
What is being done?
Why?
How is being done?
Are we on right track?

If we keep on doing what we are doing >> will this take us to where we want to be?

Do we need to change/adjust or align the things?

Enhanced Collaboration? What does it mean? How?

Develop a road map!

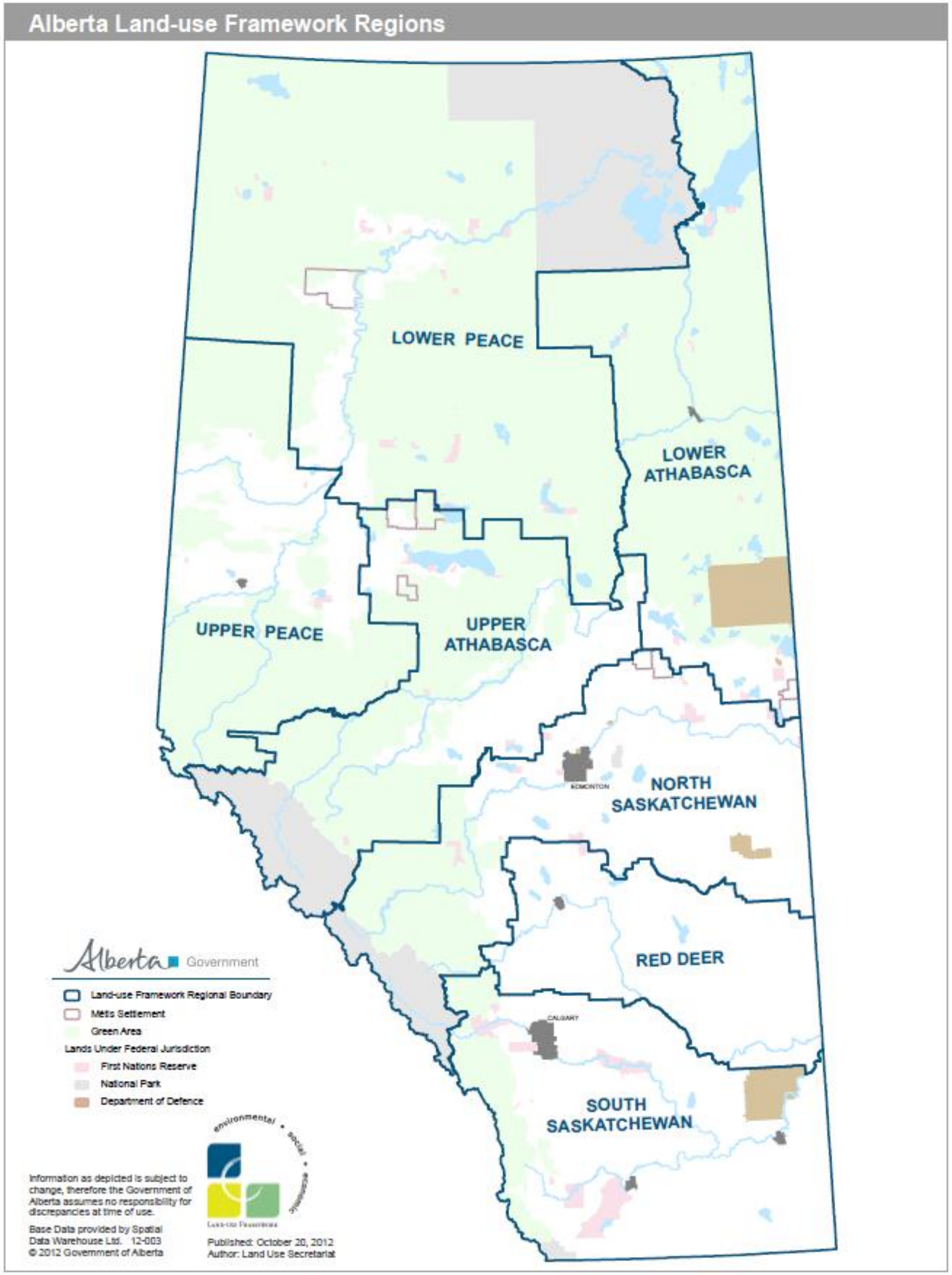
Workshop provides opportunity to showcase current practices and expand you understanding related to other media modelling.

I see this is the group that will **Walk the Talk**.

I have full confidence that together we can take the challenge!

Alberta

The End



Alberta Land-use Framework Regions
LOWER PEACE
LOWER ATHABASCA
UPPER PEACE
UPPER ATHABASCA
NORTH SASKATCHEWAN
RED DEER
SOUTH SASKATCHEWAN
Alberta Government
Land-use Framework Regional Boundary
Métis Settlement
Green Area
Lands Under Federal Jurisdiction
First Nations Reserve
National Park
Department of Defence
environmental • social • economic
Information as depicted is subject to change, therefore the Government of Alberta assumes no responsibility for discrepancies at time of use.
Base Data provided by Spatial Data Warehouse Ltd. 12-003
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Published: October 20, 2012
Author: Land Use Secretariat

Session 1

Day 1 – Session 1

Tim Wool – USEPA

BIOGRAPHY

Tim Wool is a National TMDL expert with the United States Environmental Protection Agency (USEPA), Region 4 office. Tim has over 25 years of experience in the development and application of water quality models. Tim has supported USEPA with the development of numeric nutrient criteria for the State of Florida. Tim has numerous experiences in developing and reviewing TMDLs for bacteria, nutrients, metals, dissolved oxygen, and mercury.

Day 1 – Session 1

Tim Wool – USEPA

ABSTRACT

This presentation will focus on the use and utility of using mechanistic models for making water quality management decisions. The strengths and weaknesses of using mechanistic models to make water quality management decisions will be presented. An overview of the Water Quality Analysis Simulation Program (WASP) will be given, high lighting the advantages of using a dynamic model. A modelling scenario will be given where a suite of mechanistic models were used to make a TMDL decision.

The Use of Mechanistic Models for Water Quality Management

Tim A. Wool
US EPA – Region 4
Atlanta, GA

Utility of Mechanistic Models

- Simplistic Representation of Reality
  - Cannot Simulate "Everything"
  - All Models are Wrong . . . .
- Interpolate
  - Known and Unknown
- Provides Linkage between
  - Loads and Response Variables
  - Can Determine Important Processes
    - Nutrients/DO/Algae/Light
- Management Strategies
  - Determine Load Reductions to meet WQS
    - Never to Exceed
    - X% Exceedence
    - Duration, Frequency and Magnitude
  - Evaluate Best Management Practices

Mechanistic Models

- Mathematical models based on fundamental equations that produce physical responses to temporal and spatial inputs
- Process-based, time-variable representation of processes
  - Watershed – rainfall/runoff, topography, land use, infiltration
  - Hydrodynamics - circulation, transport, deposition
  - Water Quality – algal growth/death, decay, nitrification, SOD
- Both graphical comparisons and statistical tests are required in model calibration and validation

Types of Mechanistic Models

- Landscape/Loading models
  - Runoff of water and dissolved materials on and through the land surface
  - Erosion of sediment and associated constituents from the land surface
- Receiving water models
  - Flow of water through streams and into lakes and estuaries
  - Transport, deposition, and transformation in receiving waters
- Linked models
  - Combination of landscape and receiving water models

Mechanistic Models -- Linked

Input — **Algorithms** — **Output**

Input

Time series
Meteorology
Streamflow
WQ sampling

Spatial/Landscape
Soils
Topography
Land cover
Pollutant characteristics

Receiving Waters
Physical data
Kinetics data
Fate & transport

Algorithms

Landscape/ Watershed Models
Hydrology
Buildup
Washoff
Erosion
Overland transport
Fate & transport

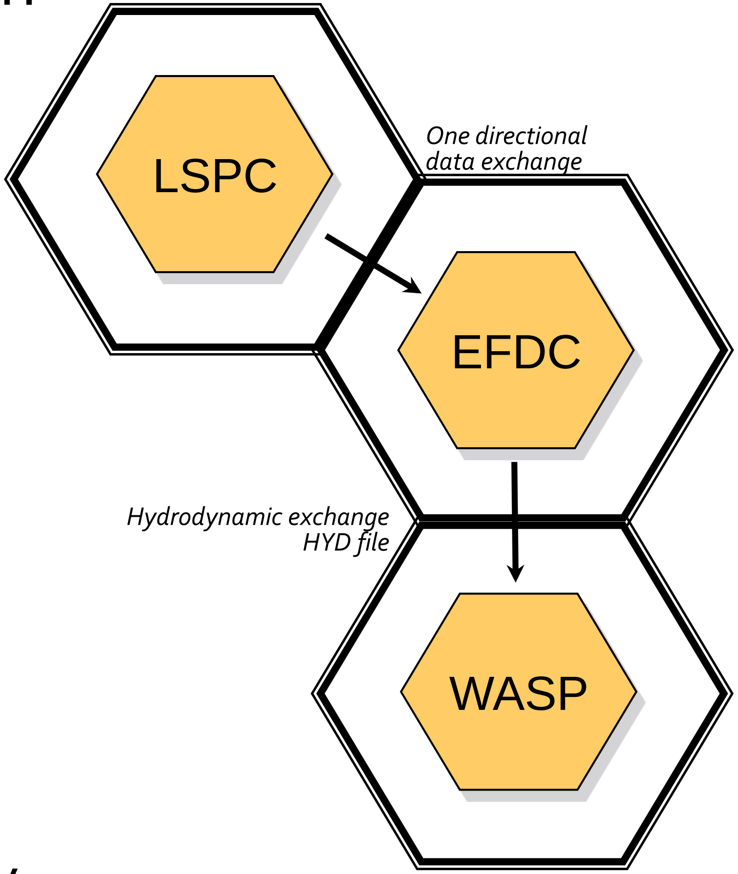
Receiving Water Models
Hydraulics
Hydrodynamics
Fate & transport
Scour & deposition
Chemical interactions

Output

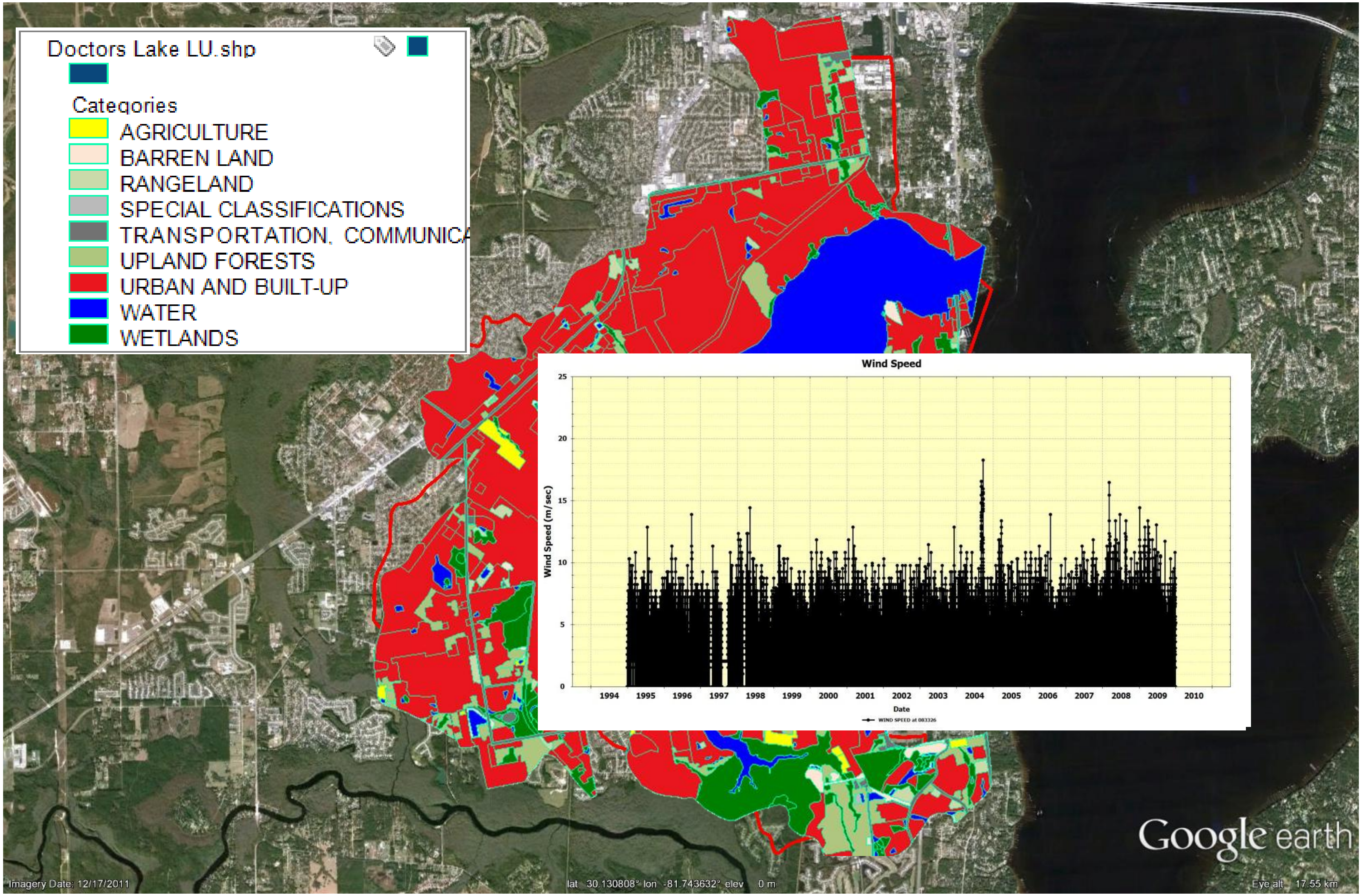
Time series
Summary statistics
% change/Improvement
Violations
Classification maps
Impact maps

Mechanistic Models -- Linked

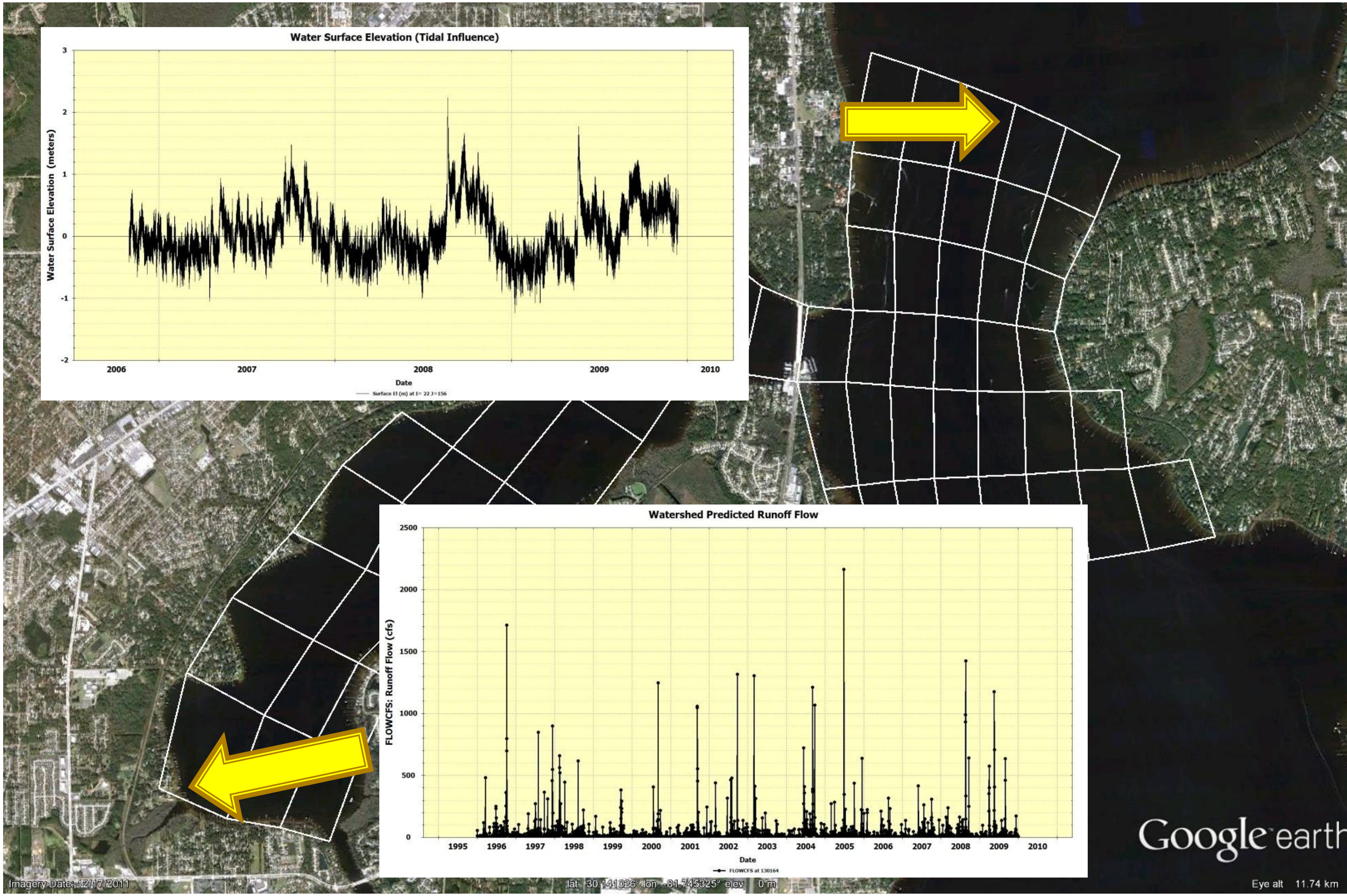
- LSPC – Loading Simulation Program C++
  - Simulates watershed loadings delivered to the estuary
- EFDC – Environmental Fluid Dynamics Code
  - Simulates the hydrodynamics within the estuary
- WASP – Water Quality Analysis Simulation Program
  - Simulates the water quality response within the estuary



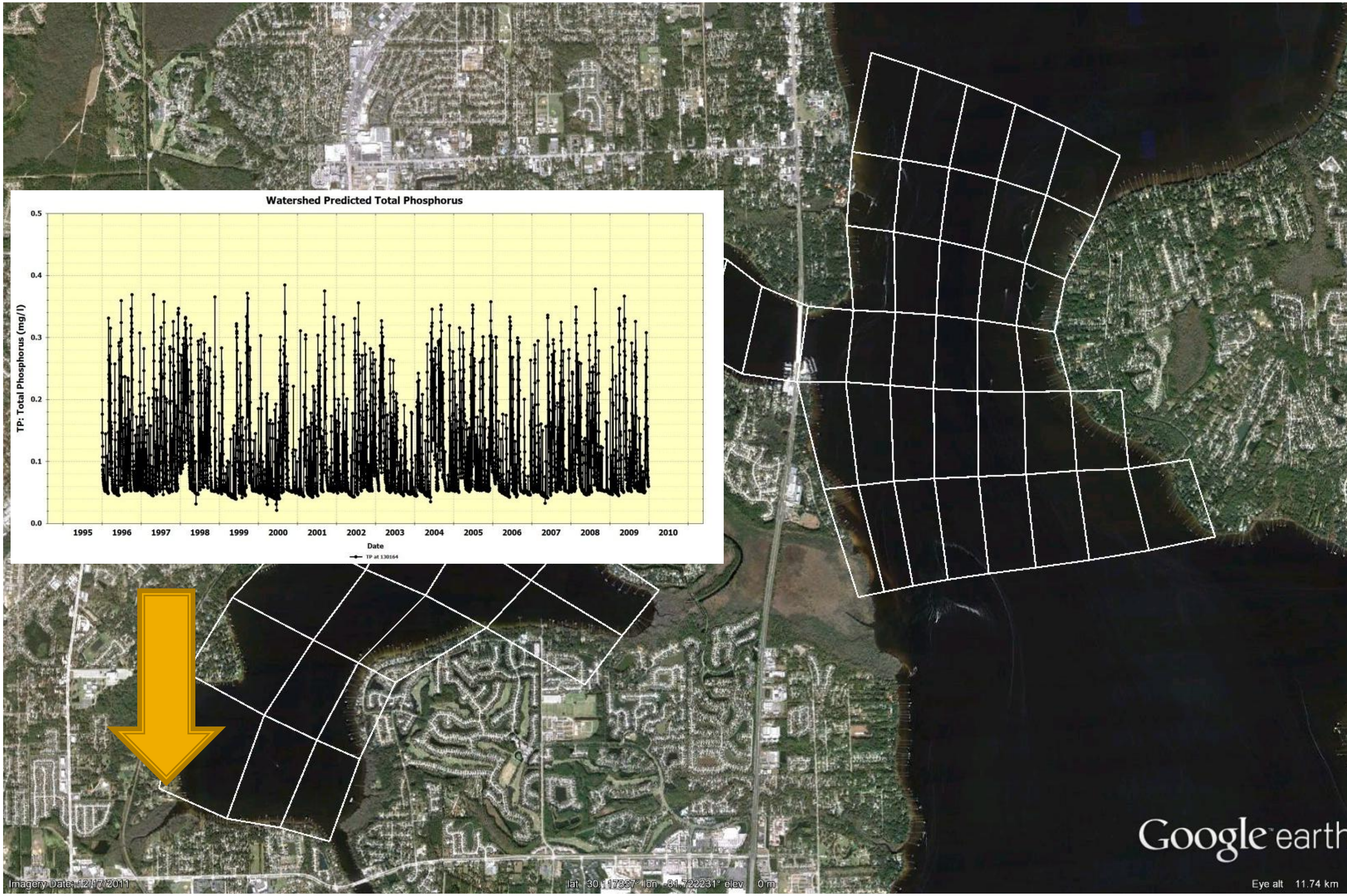
Example of Linked Models


Doctors Lake LU.shp
Categories
AGRICULTURE
BARREN LAND
RANGELAND
SPECIAL CLASSIFICATIONS
TRANSPORTATION, COMMUNICA
UPLAND FORESTS
URBAN AND BUILT-UP
WATER
WETLANDS
Wind Speed
Wind Speed (m/sec)
0
5
10
15
20
25
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Date
WIND SPEED at 083326
Imagery Date: 12/17/2011
lat 30.130808° lon -81.743632° elev 0 m
Google earth
Eye alt 17.55 km

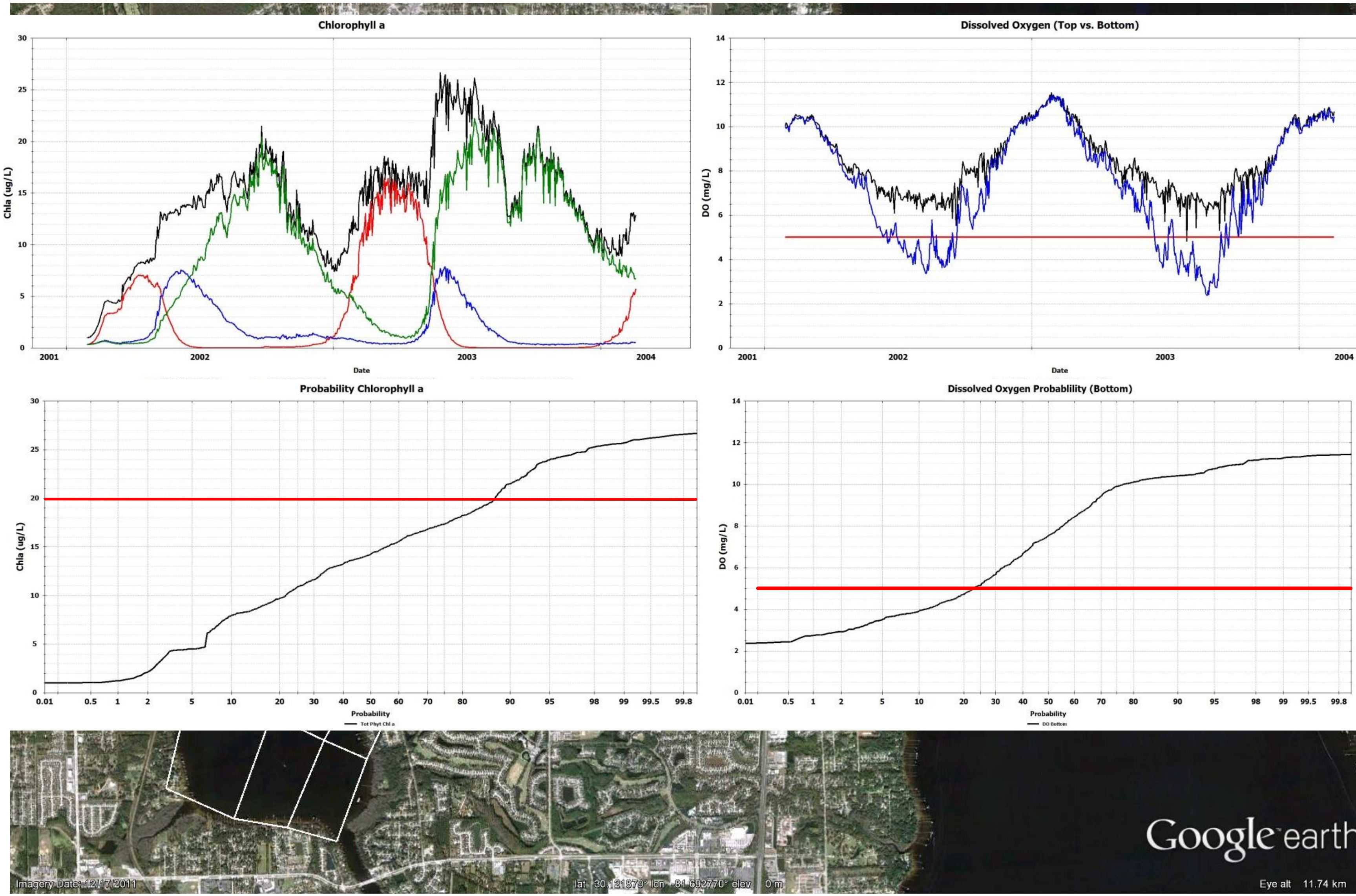
3 Dimensional Hydrodynamic Model



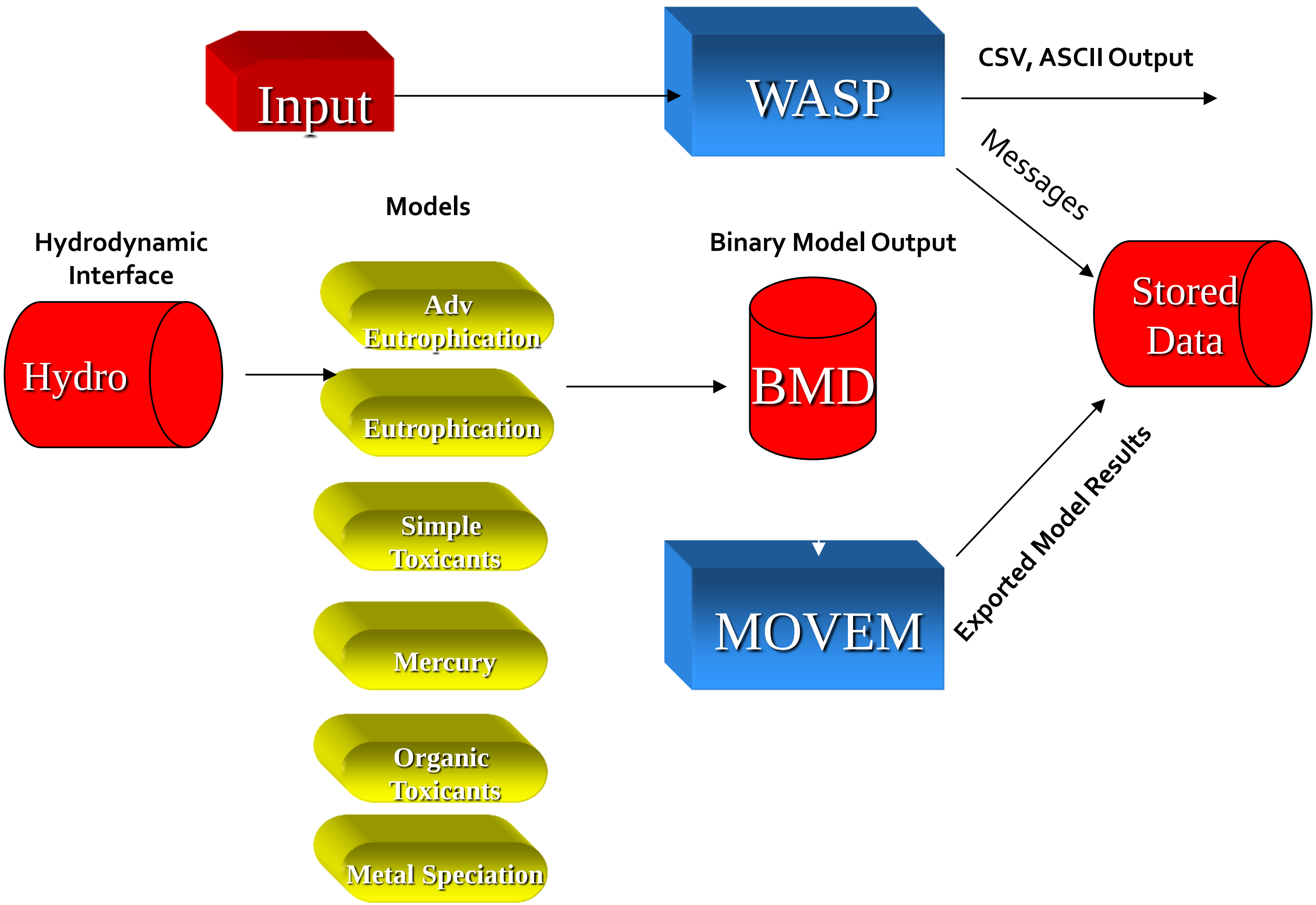
Water Quality Model



Water Quality Model

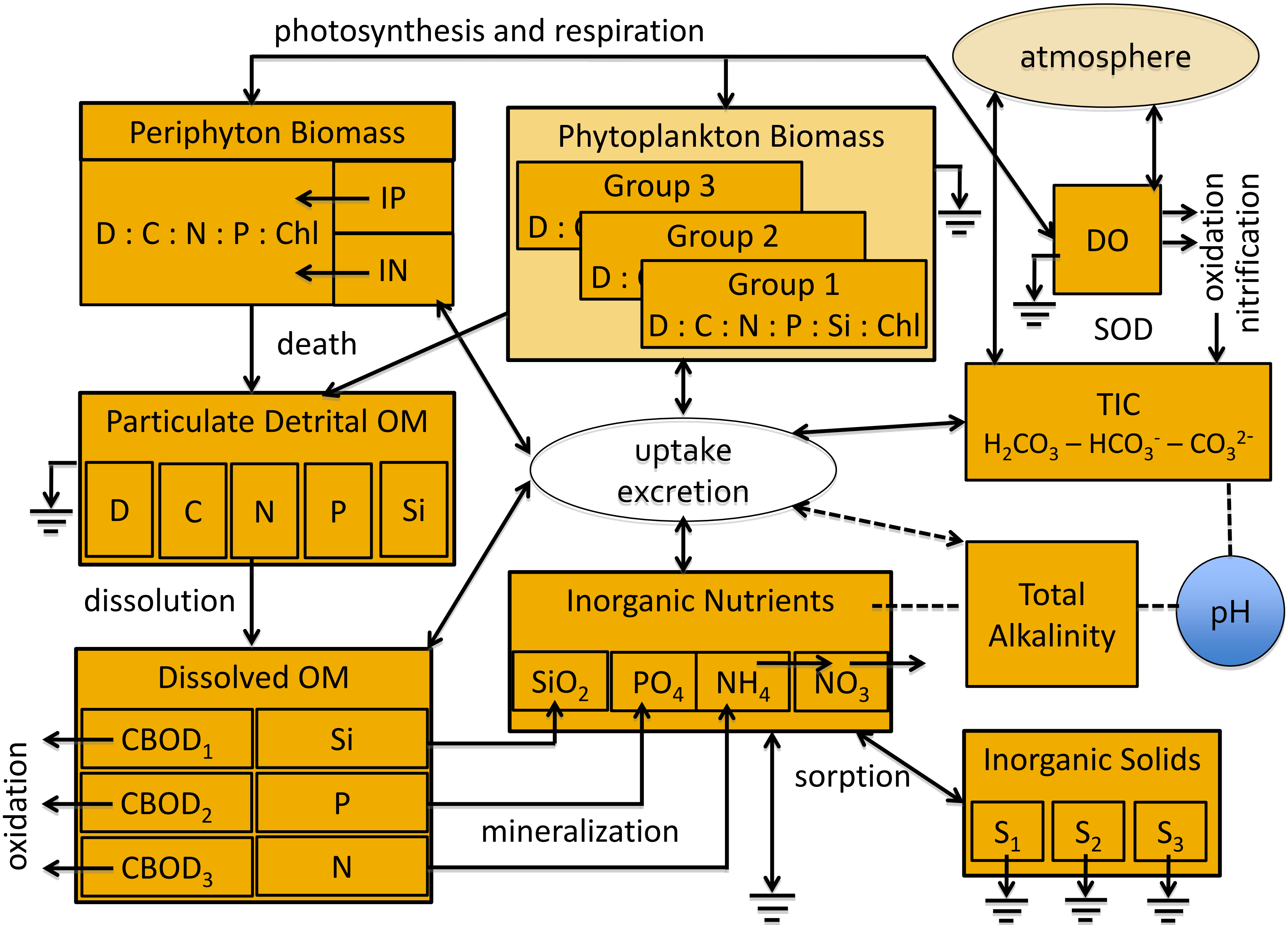


WASP Modeling Framework

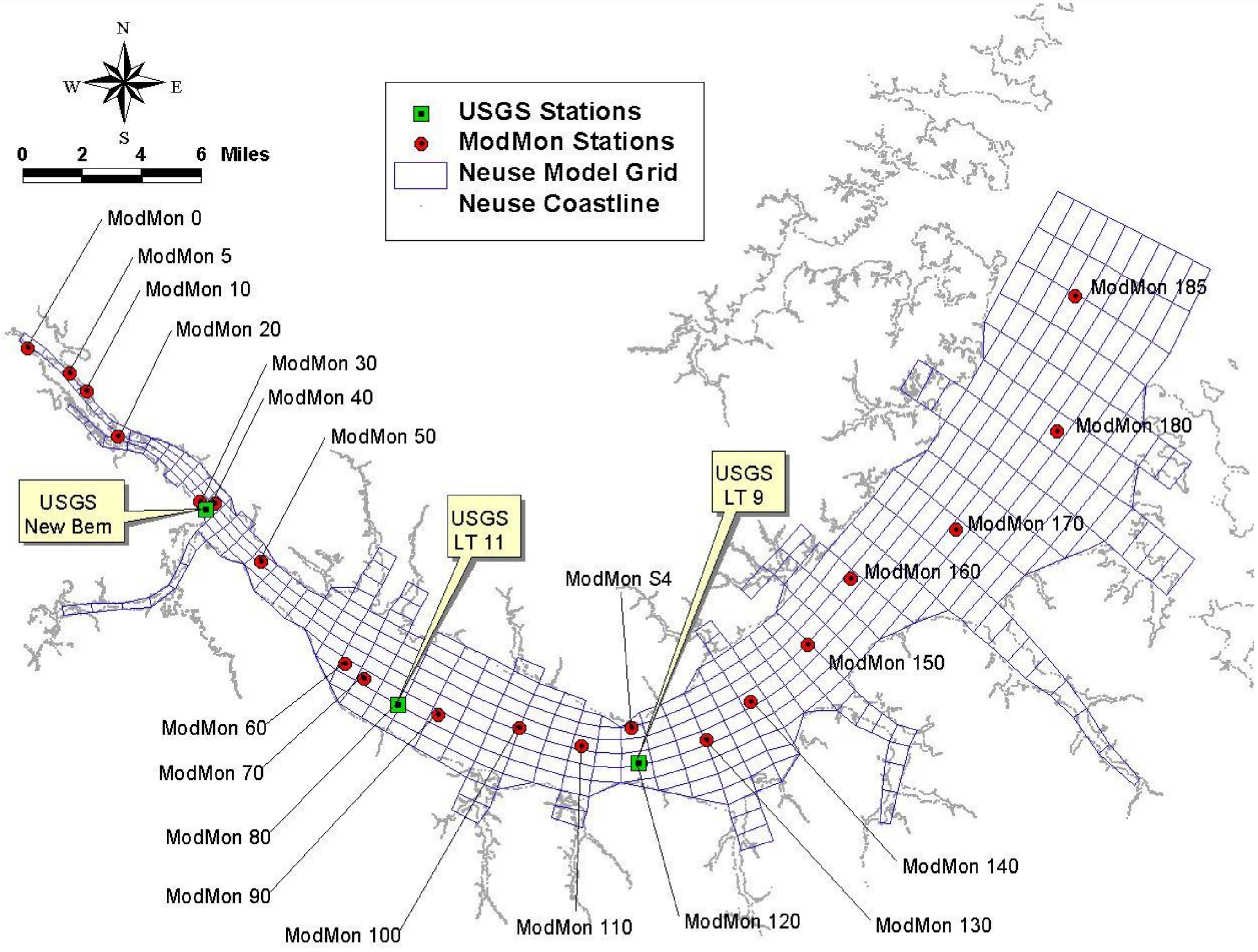


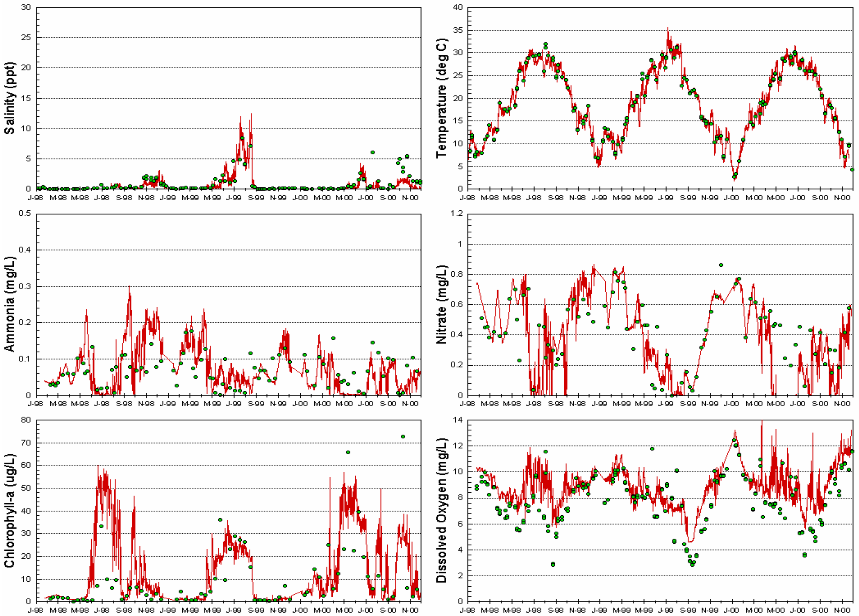
Conventional Water Quality

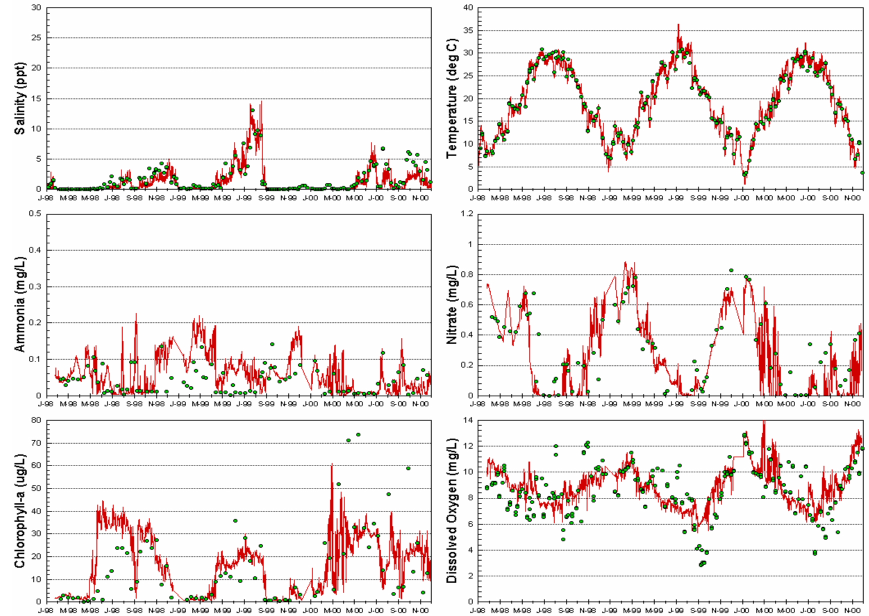
- Important Processes
  - Nutrient Dynamics
    - Nitrogen (Ammonia, Nitrate, DON, PON)
    - Phosphorus (Orthophosphate, DOP, POP)
    - Silica (Dissolved, Particulate)
  - Algal Dynamics
    - Multiple Algal Groups (Green, Blue Green, Diatoms)
    - Light (Algal Self Shading, DOC, TSS)
  - Dissolved Oxygen Dynamics
    - Multiple BOD (Slow, Med, Fast or Biotic, Watershed, WWTP)
    - Reaeration (Wind, Hydraulic)
    - Sediment Diagenesis (Oxygen Consumption, Nutrient Fluxes)

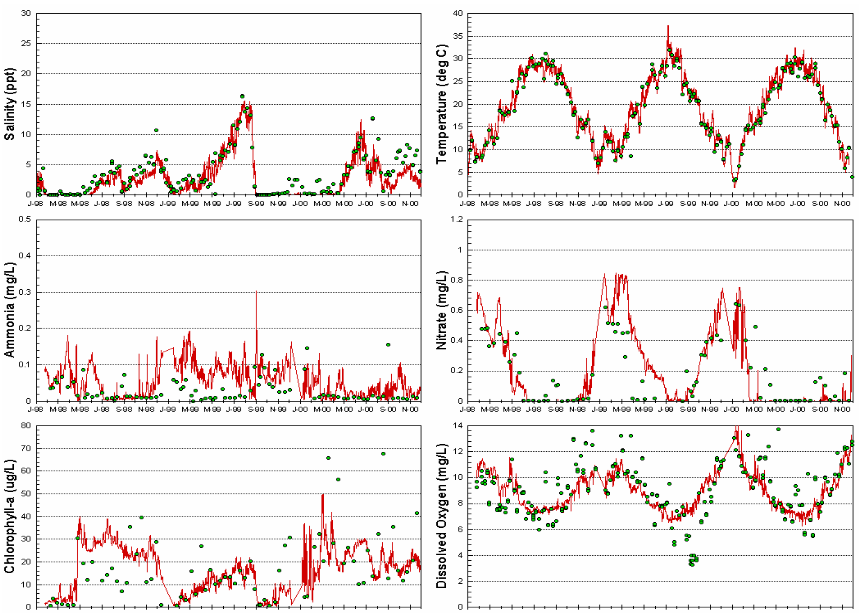

photosynthesis and respiration
atmosphere
Periphyton Biomass
D : C : N : P : Chl
IP
IN
Phytoplankton Biomass
Group 3
Group 2
Group 1
D : C : N : P : Si : Chl
DO
oxidation
nitrification
SOD
death
Particulate Detrital OM
D
C
N
P
Si
uptake
excretion
TIC
$H_2CO_3 – HCO_3^- – CO_3^{2-}$
dissolution
Total
Alkalinity
pH
Inorganic Nutrients
SiO_2
PO_4
NH_4
NO_3
Dissolved OM
$CBOD_1$
$CBOD_2$
$CBOD_3$
Si
P
N
oxidation
mineralization
sorption
Inorganic Solids
S_1
S_2
S_3

Nitrogen TMDL -- Neuse River/Estuary North Carolina




Salinity (ppt)
Temperature (deg C)
Ammonia (mg/L)
Nitrate (mg/L)
Chlorophyll-a (ug/L)
Dissolved Oxygen (mg/L)


Salinity (ppt)
Temperature (deg C)
Ammonia (mg/L)
Nitrate (mg/L)
Chlorophyll-a (ug/L)
Dissolved Oxygen (mg/L)


Salinity (ppt)
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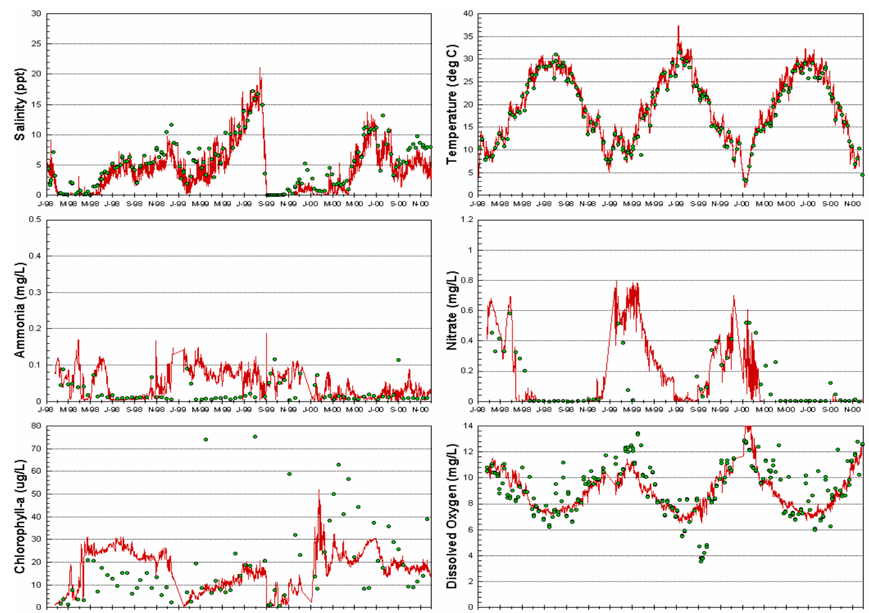
Nitrate (mg/L)
Chlorophyll-a (ug/L)
Dissolved Oxygen (mg/L)


Salinity (ppt)
Temperature (deg C)
Ammonia (mg/L)
Nitrate (mg/L)
Chlorophyll-a (ug/L)
Dissolved Oxygen (mg/L)

Questions ?

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404-562-9260

Day 1 – Session 1

Danielle Marceau – University of Calgary

BIOGRAPHY

Dr. Danielle Marceau is a professor in the Department of Geomatics Engineering at the University of Calgary and holds a Schulich Research Chair in GIS and Environmental Modelling. Her research program focuses on developing spatial simulation models, namely cellular automata (CA) and agent-based models (ABMs) to study the dynamics and interactions of natural and human systems. These models are integrated with Geomatics technologies to create intelligent computer-based information systems to guide decision making in environmental resource management. She applies her research in domains that are of particular relevance in Alberta and elsewhere in Canada: water and energy, land use and spatial planning, wildlife-human interactions, and disease propagation. Due to the interdisciplinary nature of her research, she works with scientists in different disciplines in collaboration with government agencies, industries, and non-for-profit organizations.

Day 1 – Session 1

Danielle Marceau – University of Calgary

ABSTRACT

Coupled natural/human systems are systems in which human activities interact with natural landscape components, raising complex issues of environmental resource management. To address this complexity, new modelling approaches are required to study the reciprocal interactions and feedback mechanisms that characterize these systems. Spatial simulation models such as cellular automata (CA) and agent-based models (ABMs) are increasingly used as laboratories to understand the rules that govern the interaction and evolution of these systems, and explore the future paths they can take through the testing of alternative scenarios. When combined to Geomatics technologies as components of spatial decision support systems, they become powerful tools to understand how human decisions are made, how these decisions affect the environment over which they are made, and which measures could be implemented to achieve a sustainable usage of environmental resources.

This presentation provides an overview of current research projects undertaken to address resource management issues in domains that are of high relevance in Alberta: land use and spatial planning, water and energy systems, and wildlife/human interactions including wildlife responses to human disturbances and disease propagation. Three common aspects to these projects will be highlighted: the necessity of an interdisciplinary approach, the benefits of spatial simulation models, and the importance of involving stakeholders in the modelling process.

Modeling coupled natural/human systems for environmental resource management

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Department of Geomatics Engineering
University of Calgary, Alberta, Canada
dmarceau@ucalgary.ca
Web site: www.ucalgary.ca/gcl

First Annual Environmental Modelling Workshop, CMO
University of Alberta, March 13-14, 2013

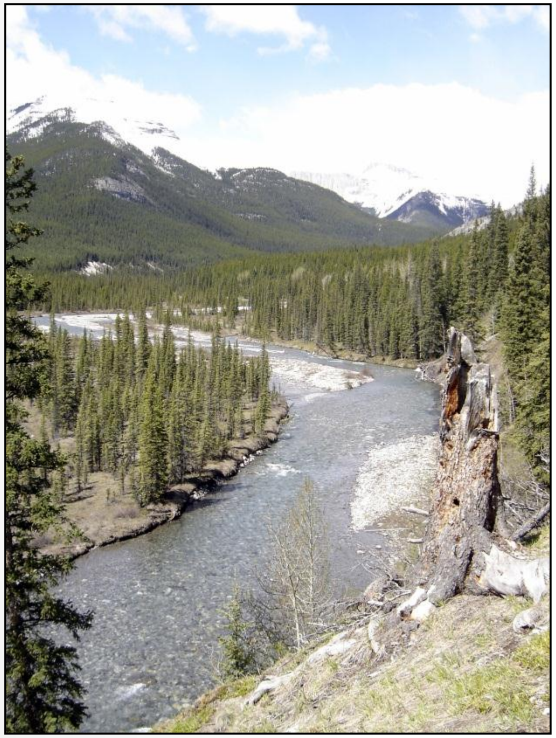
Research program objective

To develop spatial decision support systems using Geomatics technologies and simulation models to study complex coupled natural/human systems

- Coupled natural/human systems:
  - Systems in which human activities interact with natural landscape components, raising complex issues of environmental resource management

- Focus on (current projects):
  - Land-use change
  - Water resources
  - Spatial planning
  - Wildlife response to human disturbances
  - Disease propagation

The Elbow River watershed project



Dr. Danielle Marceau, Geomatics Eng., UofC

Nishad Wijesekara, Majeed Pooyandeh, Babak Farjad, Ph.D. students

Dr. Shawn Marshall, Geography, UofC

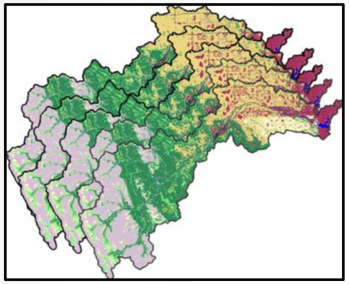
Dr. Anil Gupta, AESRD

Patrick Delaney, DHI Water and Environment, Canada

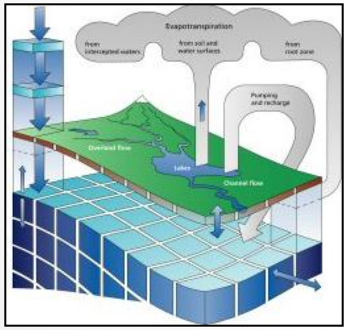
Several stakeholders

Objective

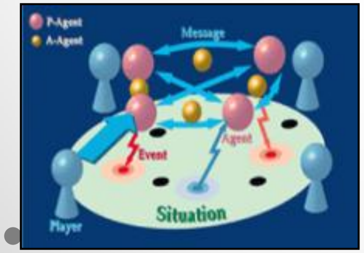
To study the impact of land-use and climate change on the hydrology of the watershed while considering the perspective of stakeholders



- This is achieved through the development of an integrated modeling system that includes:
  - A cellular automata (CA) to simulate scenarios of land-use change

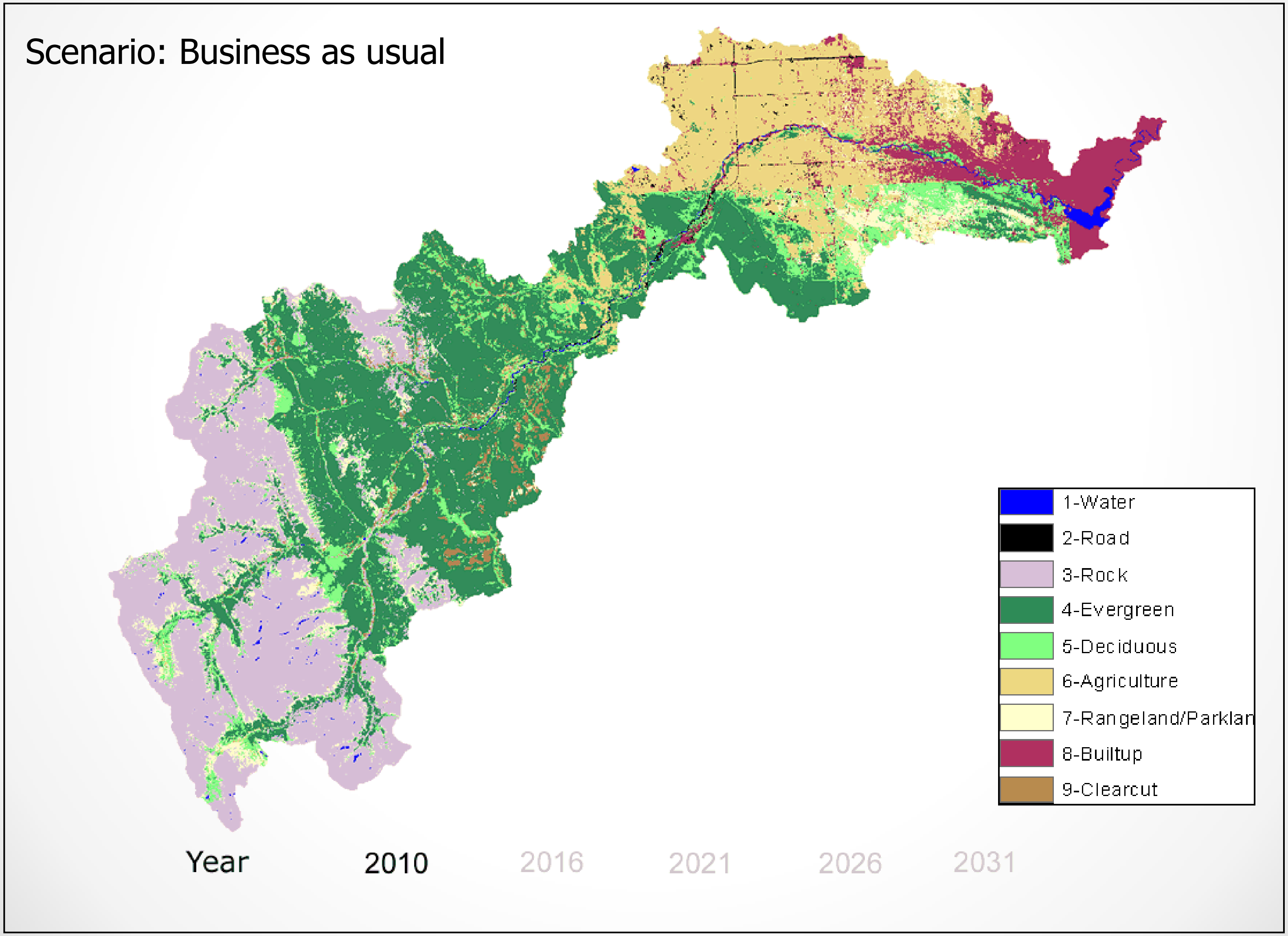


  - A spatially-distributed hydrological/climate model (MIKE SHE)

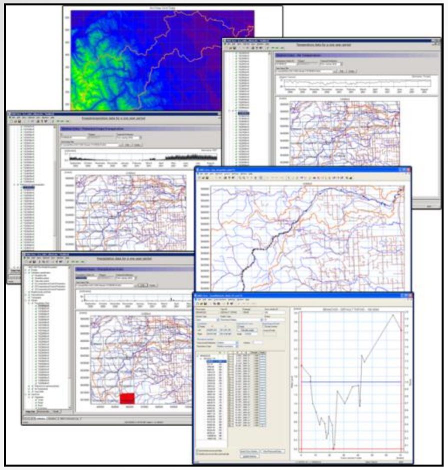


  - A web-based agent-based model (ABM) to support the negotiation of stakeholders concerned by land development and water resources

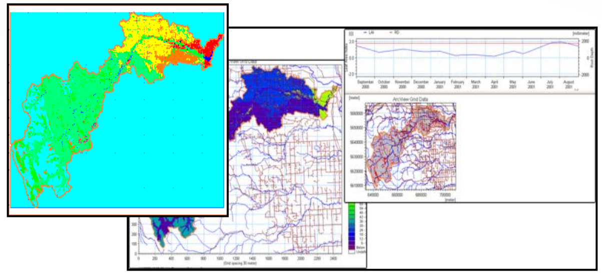
Land-use change CA modeling



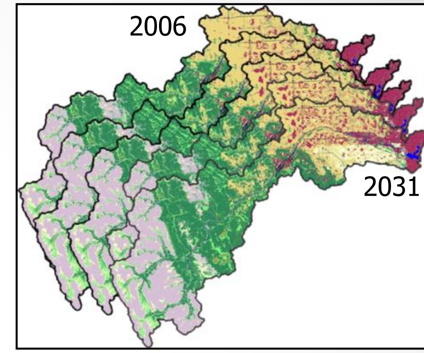
MIKE SHE simulations

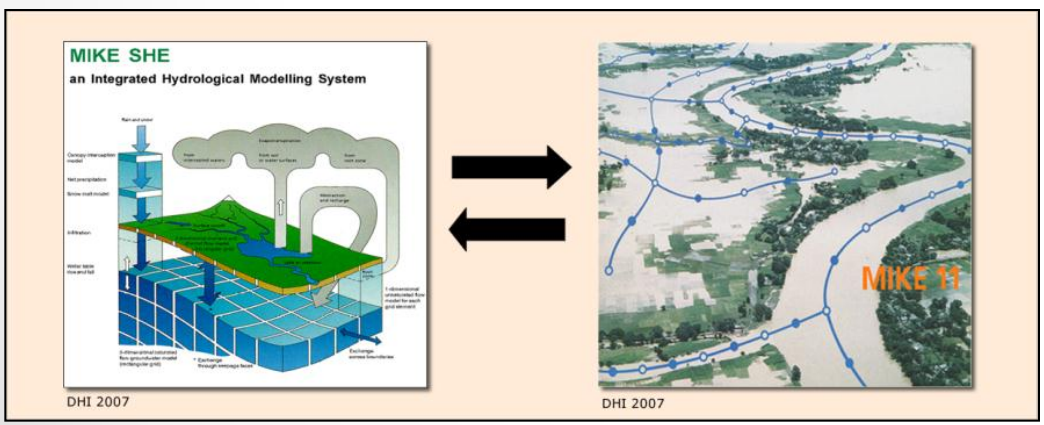


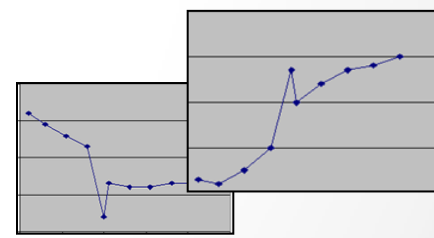
- Topography
- Climate data
- River channel data
- Ground water table



- Surface roughness
- Leaf area index
- Root depth







- Total water balance
- Total overland flow
- Evapotranspiration

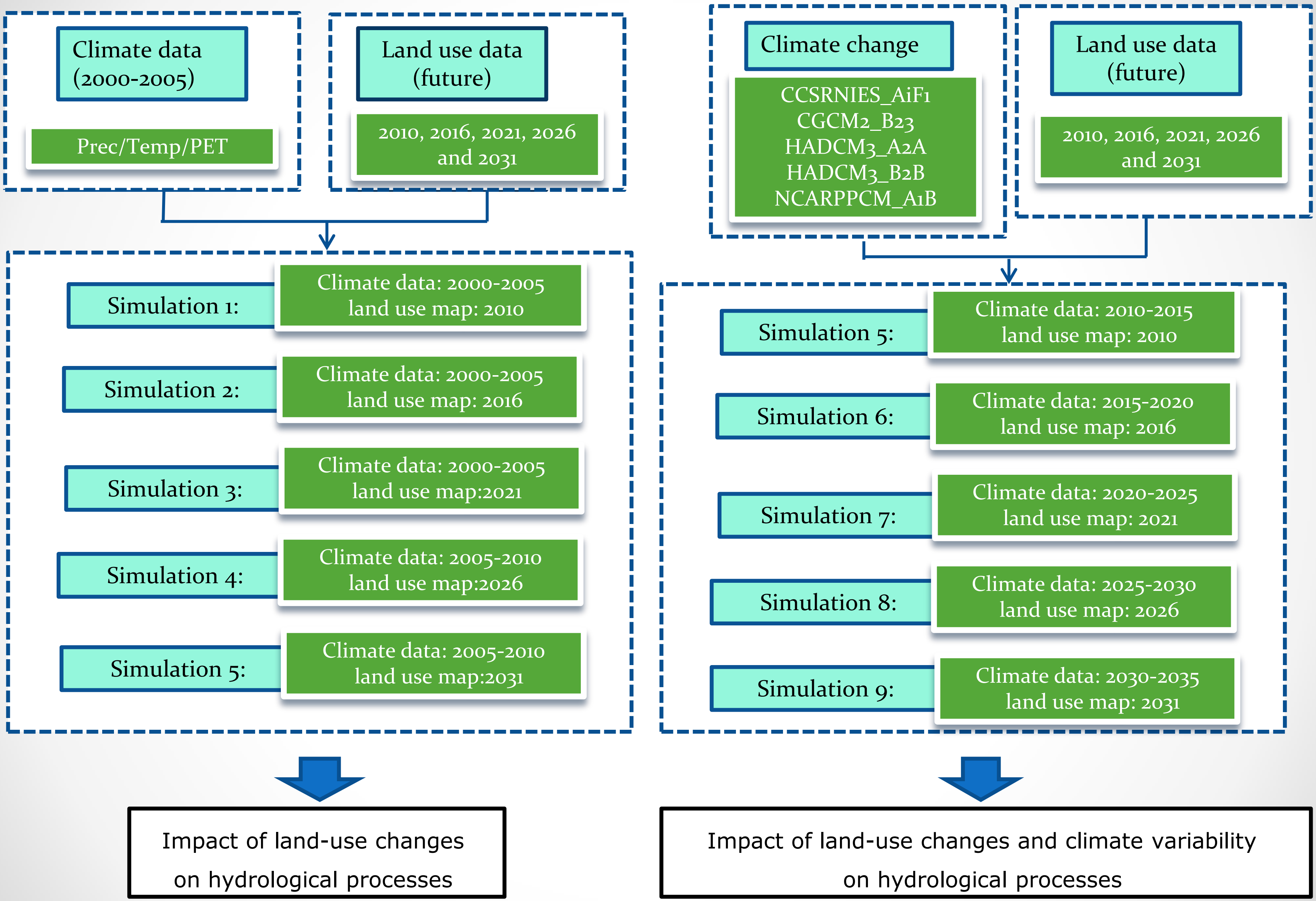
(Wijesekara and Marceau, 2012)

Impact of land-use scenarios on hydrology

Scenario	OL (mm)	BF (mm)	ET (mm)	Inf (mm)
BAU	454.0	110.0	1809.3	276.1
RV-LUC	445.4	109.9	1779.6	318.0
BC-LUC	440.3	115.7	1795.9	306.6
P-LUC	584.1	110.0	1669.4	243.3

(Wijesekara et al., 2013)

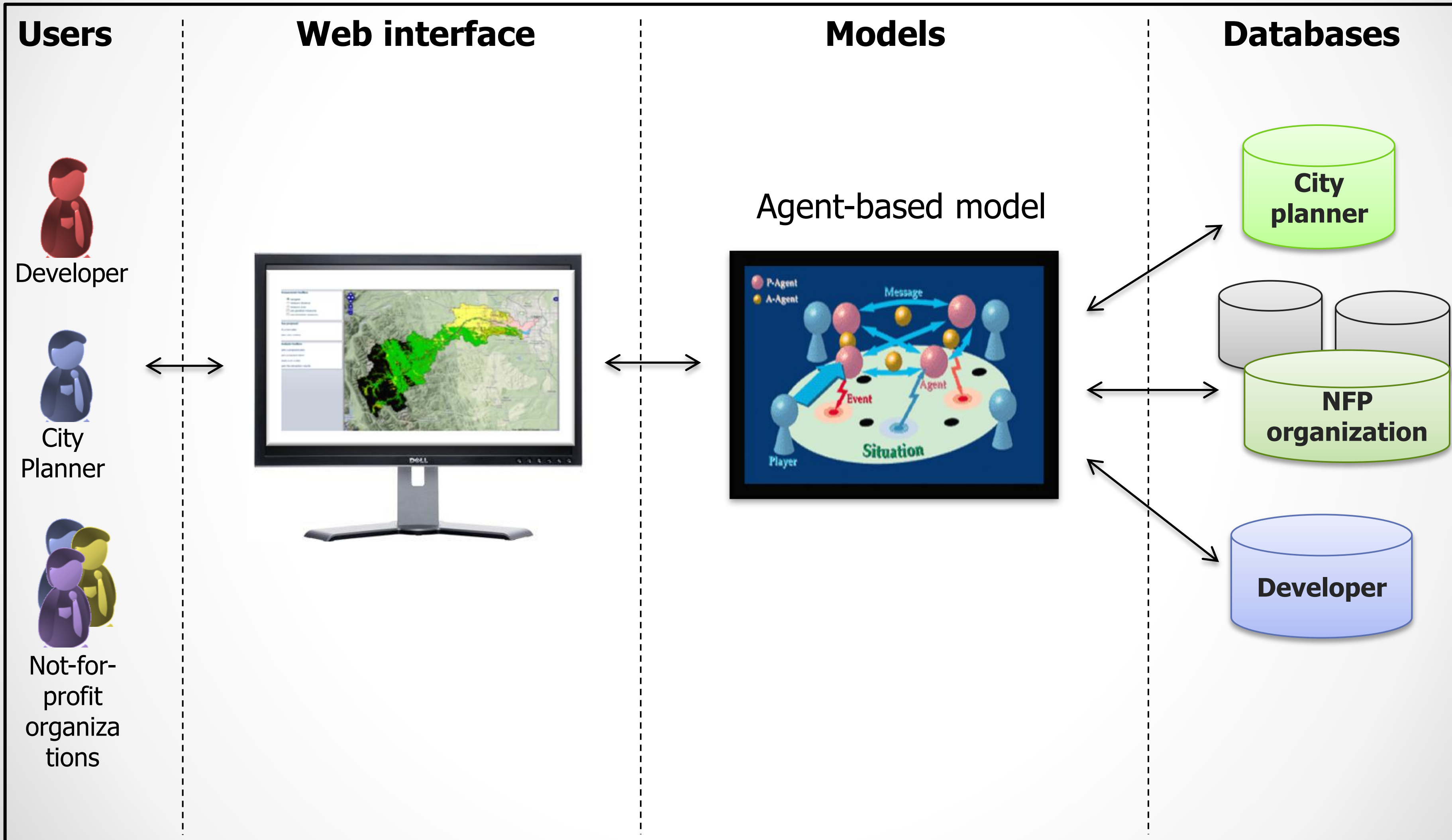
- BAU: business as usual
- RV-LUC: new development concentrated in the Rocky View County
- BC-LUC: new development concentrated in Bragg Creek
- P-LUC: development based on projected population growth



Climate data (2000-2005)
Prec/Temp/PET
Land use data (future)
2010, 2016, 2021, 2026 and 2031
Simulation 1:
Climate data: 2000-2005 land use map: 2010
Simulation 2:
Climate data: 2000-2005 land use map: 2016
Simulation 3:
Climate data: 2000-2005 land use map:2021
Simulation 4:
Climate data: 2005-2010 land use map:2026
Simulation 5:
Climate data: 2005-2010 land use map:2031
Impact of land-use changes on hydrological processes
Climate change
CCSRNIES_A1F1
CGCM2_B23
HADCM3_A2A
HADCM3_B2B
NCARPPCM_A1B
Land use data (future)
2010, 2016, 2021, 2026 and 2031
Simulation 5:
Climate data: 2010-2015 land use map: 2010
Simulation 6:
Climate data: 2015-2020 land use map: 2016
Simulation 7:
Climate data: 2020-2025 land use map: 2021
Simulation 8:
Climate data: 2025-2030 land use map: 2026
Simulation 9:
Climate data: 2030-2035 land use map: 2031
Impact of land-use changes and climate variability on hydrological processes

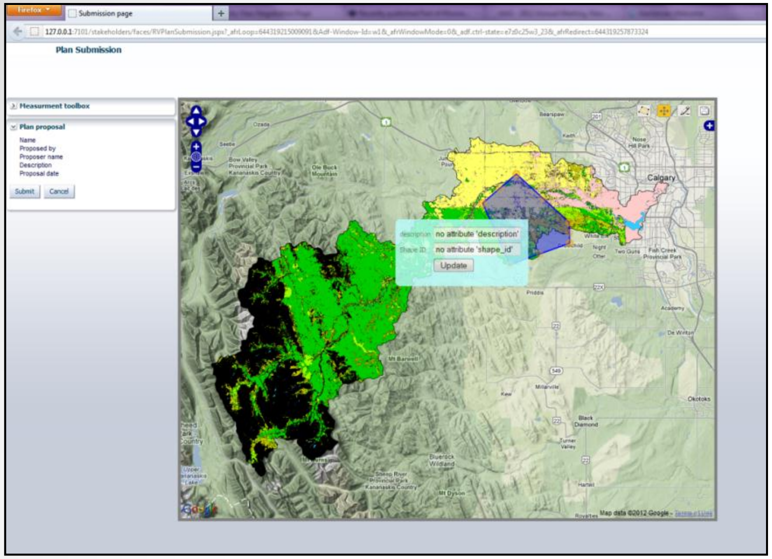
(Farjad, 2012)

Representing stakeholder' perspectives

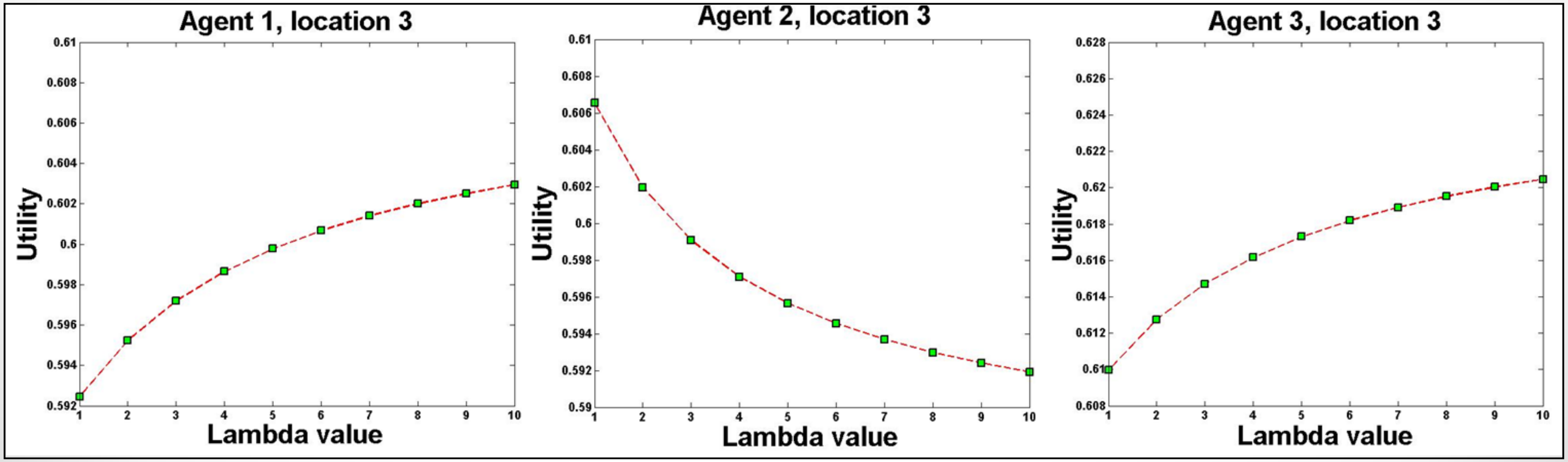


(Pooyandeh and Marceau, 2012)

Agents' negotiation

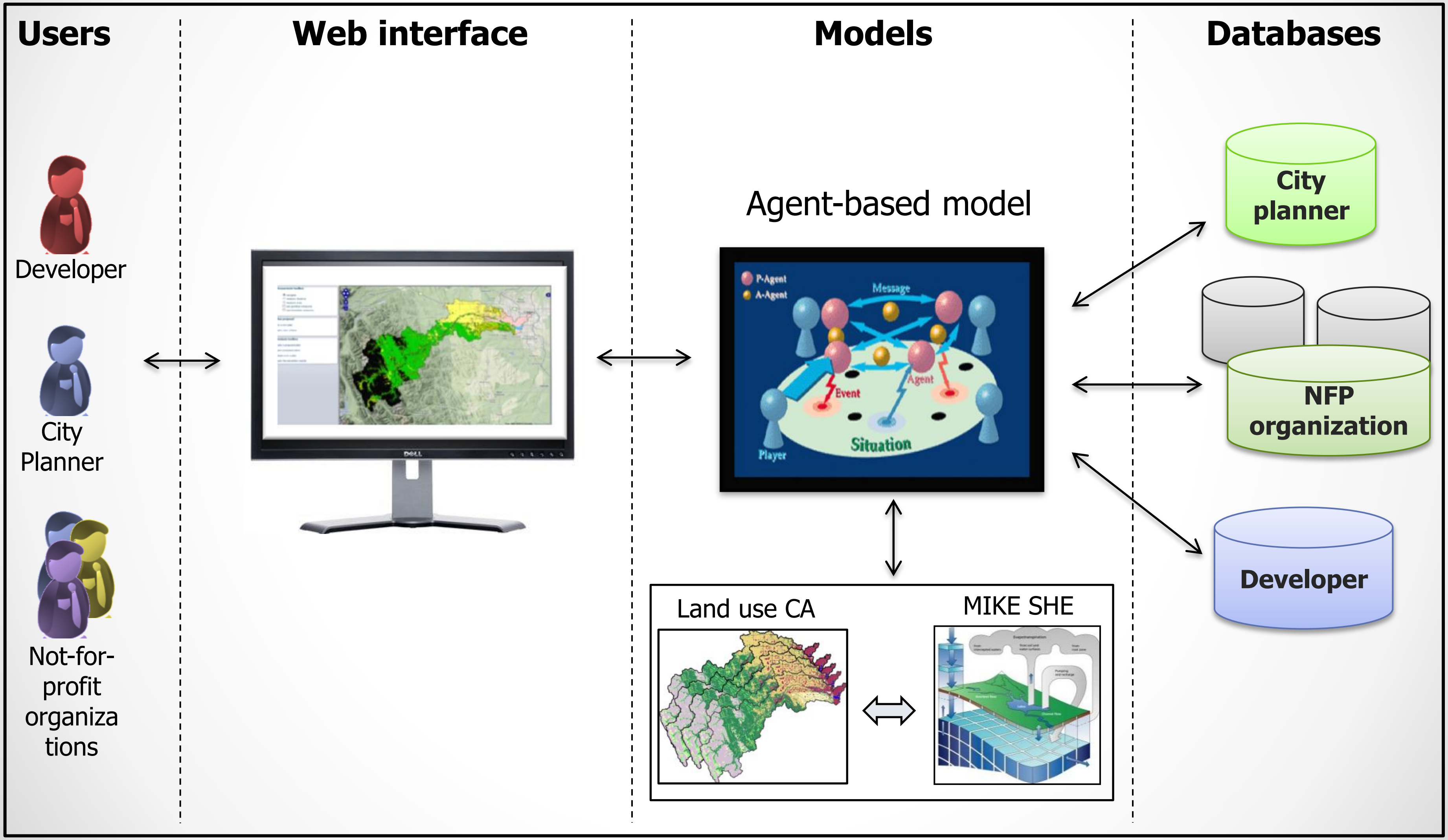


- Utility: objective (satisfaction) of the agent
- Lamba value: weights adjusted by each agent during the negotiation
- An agreement is reached when each agent is satisfied at a minimum level of 0.6



(Pooyandeh and Marceau, 2013)

Representing stakeholder' perspectives

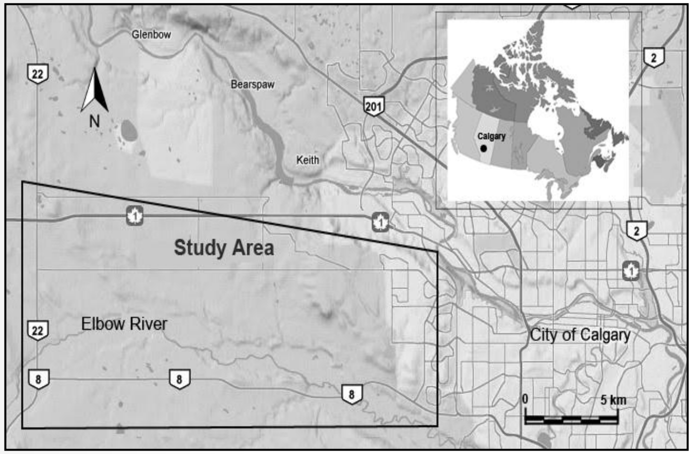


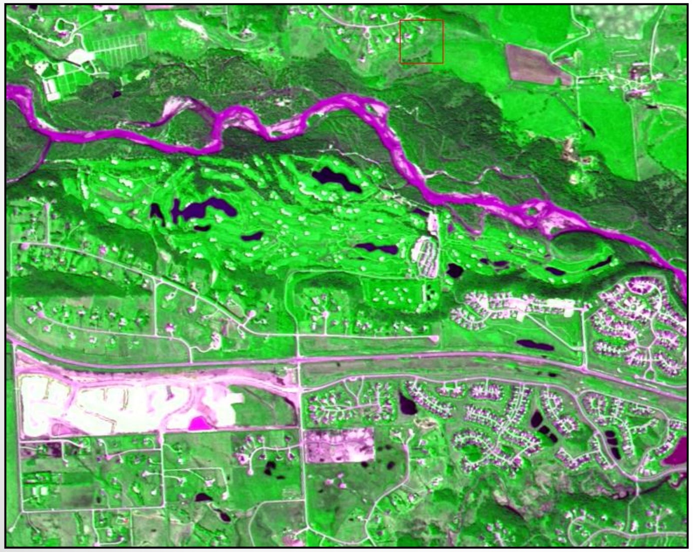
(Pooyandeh and Marceau, 2012)

Calgary/Rocky View land-use dynamics

Dr. Danielle Marceau, Geomatics Eng., UofC
Fang Wang, Ph.D. student
Colleen Sheppard, Calgary Regional Partnership
Rocky View County

Objective and Method

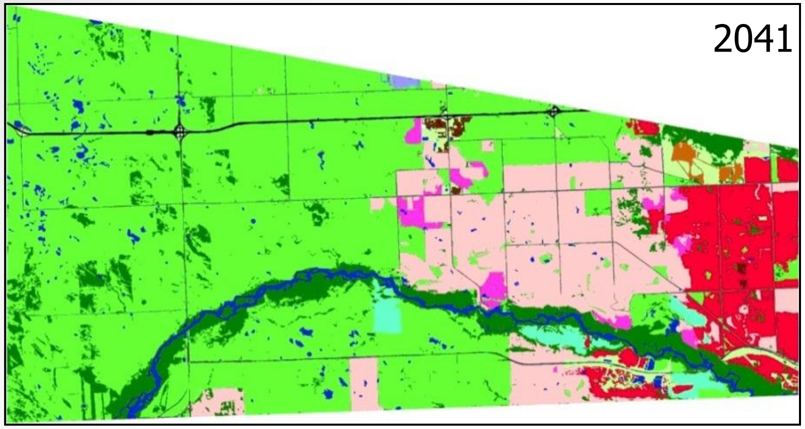


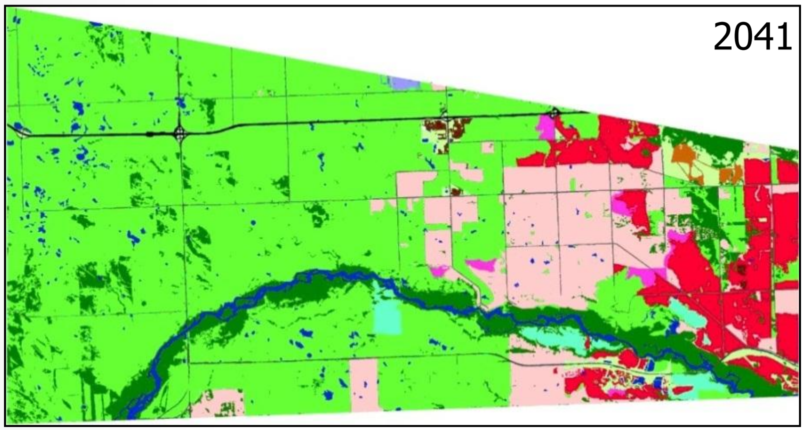


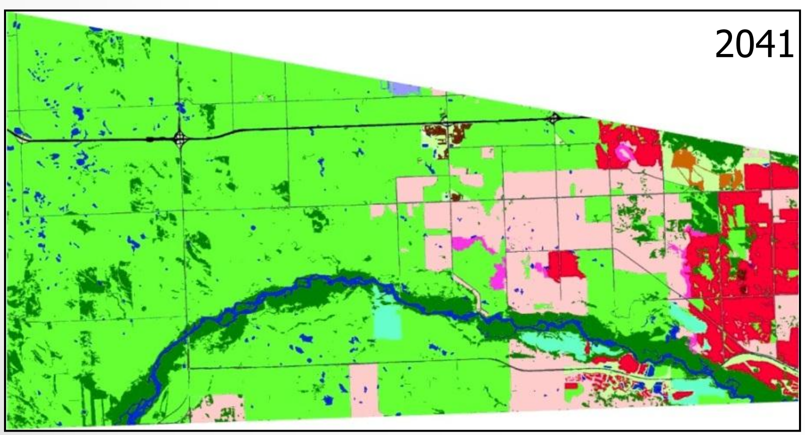
- Objective:
  - To explore scenarios of land-use change in a dynamic area of Calgary/Rocky View at very fine spatial scale (5 m)
- Method:
  - A patch-based CA model was developed to take into account the internal spatial heterogeneity of the land-use classes
  - e.g.: a residential area composed of houses, streets, and green spaces

(Wang and Marceau, 2012)

Simulated scenarios

1.


2.


3.


1. Business-as-usual Scenario

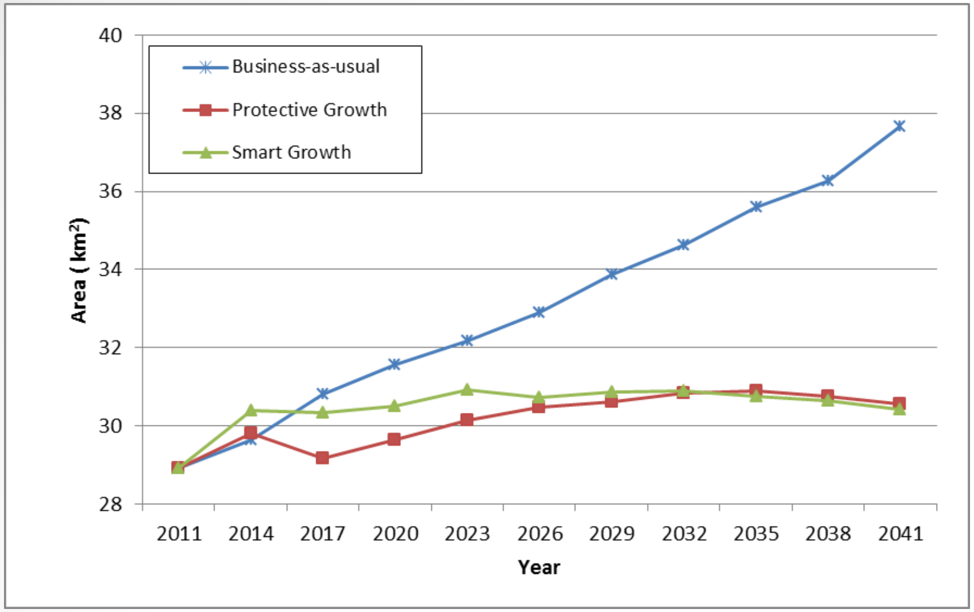
2. Protective Growth Scenario

3. Smart Growth Scenario

- 0:No Data
- 1:Commercial/Institutional
- 2:Industrial
- 3:Airport
- 4:Urban Residential
- 5:Country Residential
- 6:Road Level 1
- 7:Road Level 2
- 8:Road Level 3
- 9:Golf Course
- 10:Agriculture
- 11:Water
- 12:Forest
- 13:Green Area
- 14:Under Development

Result: Sustainability

1.



1. Projected area for country residential
2. Land consumption in 2041

2.

Class	Business-as-usual Scenario (km^2)	Protective Growth Scenario (km^2)	Smart Growth Scenario (km^2)
Country Residential	37.67	30.56	30.43
Urban Residential	18.69	19.83	16.55
Agriculture	139.13	144.42	148.13
Forest	25.05	27.13	27.16

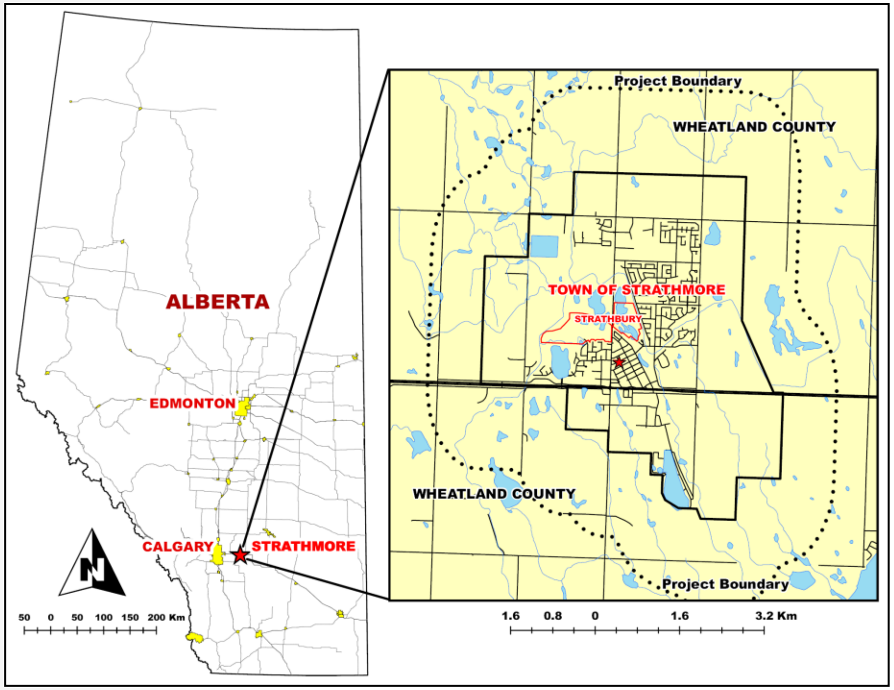
(Wang and Marceau, 2012)

Spatial planning in Strathmore

(Town of Strathmore web site)

Dr. Danielle Marceau, Geomatics Engineering, UofC
Michael Kieser, M.Sc. student
Stakeholders in Strathmore

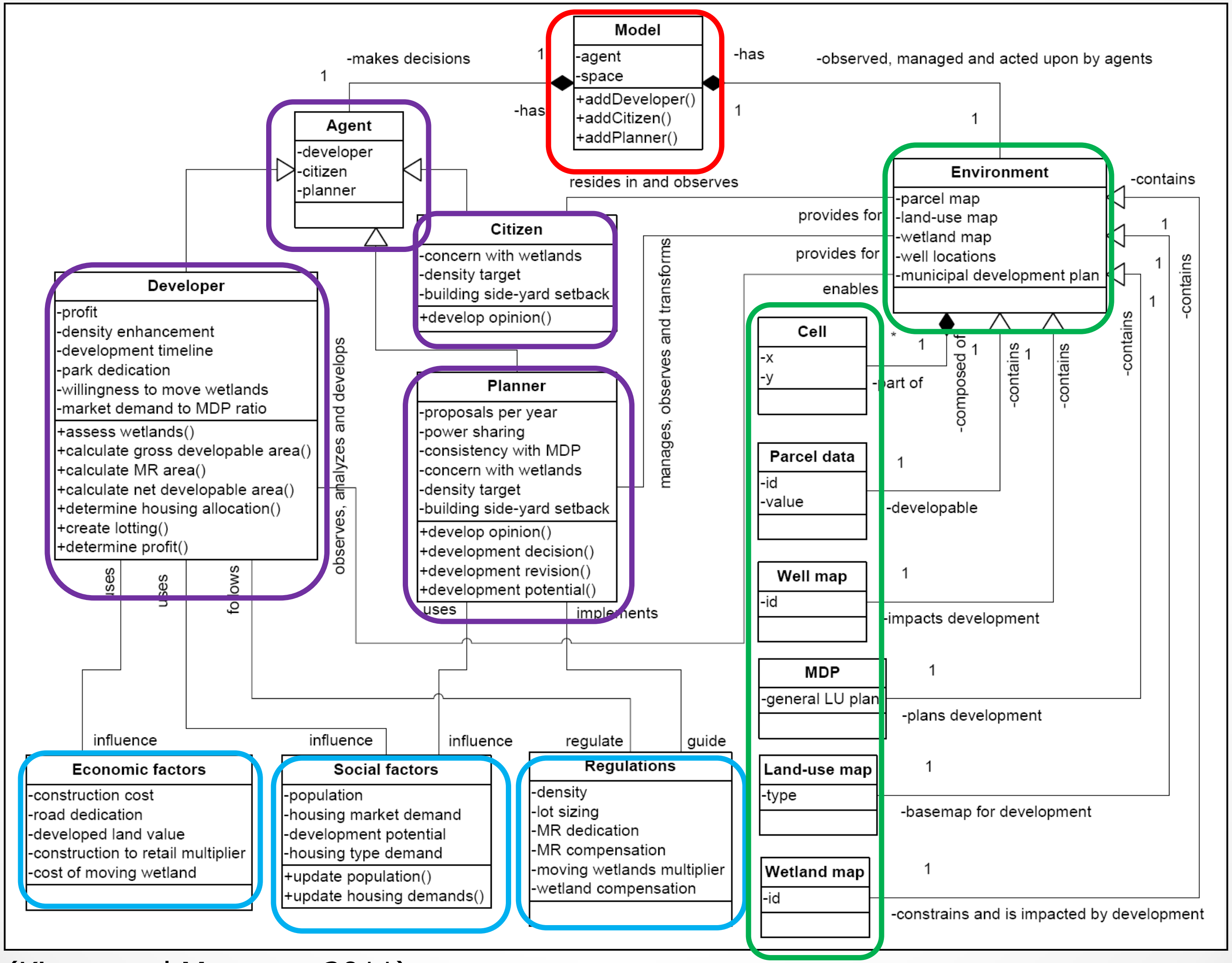
Objective and Method



(Kieser and Marceau, 2011)

- Objective:
  - To simulate the land development process in a proposed residential subdivision in Strathmore
  - To evaluate the impact of five scenarios over 10 years
- Method:
  - An agent-based model was developed to take into account the stakeholders' perspectives along with government regulations, planning policies and design standards

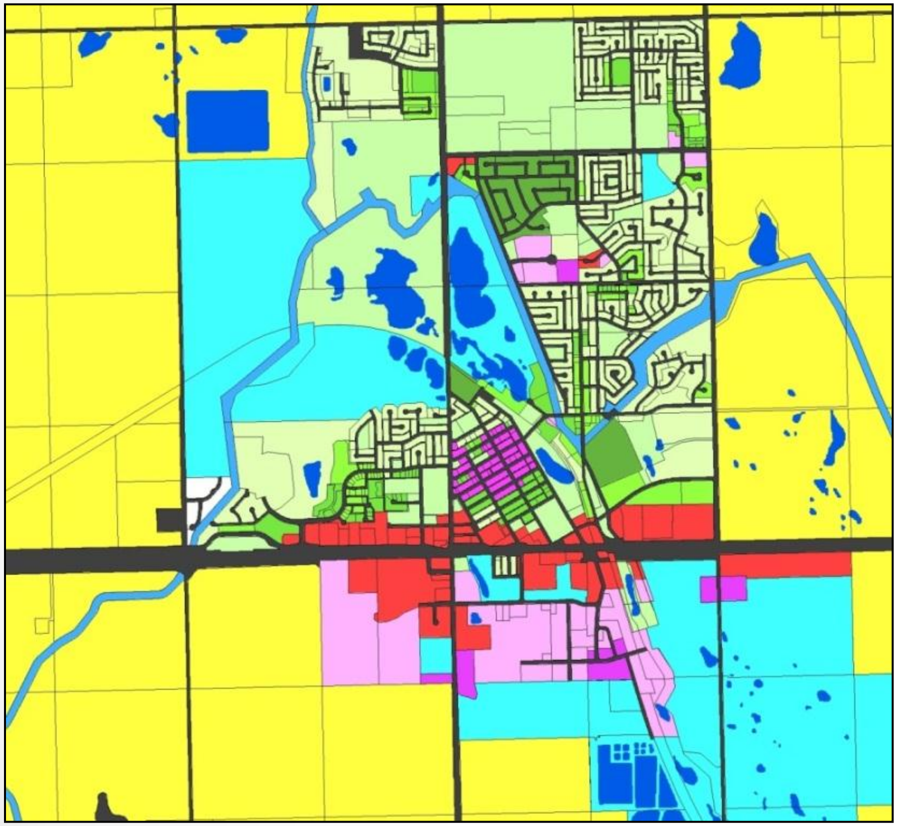
Conceptual model



(Kieser and Marceau, 2011)

Land use in 2007

Spatial resolution: 4 m



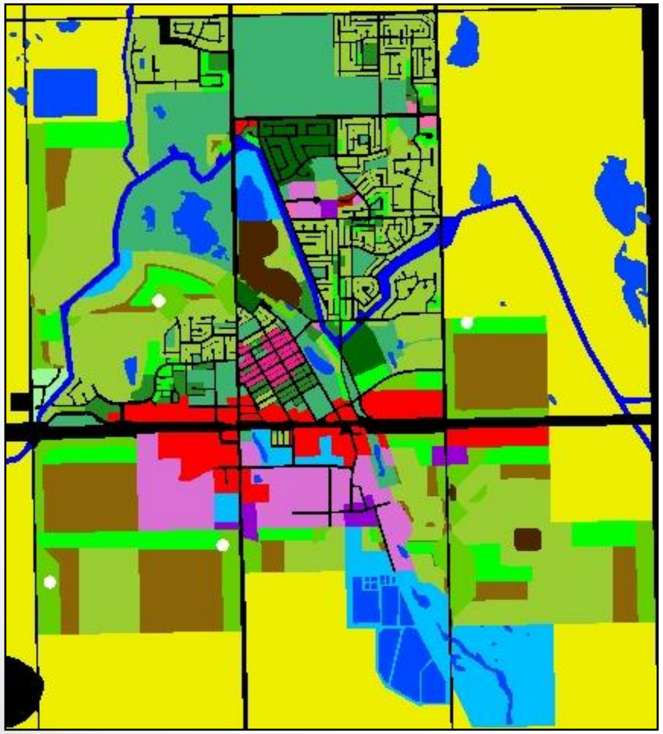
(Kieser and Marceau, 2011)

Legend

- Wetlands
- C1 - Commercial
- CB - Central Business
- CHWY - Highway Commercial
- DC3 - Direct Control
- P1 - Public Service
- M1 - Restricted Light Industrial
- M2 - Light Industrial
- CR1 - Country Residential
- R1 - Single Detached Residential
- R2 - Mixed Housing
- R2X - Medium Density Attached
- R3 - Apartment District
- MHP - Mobile Home Park
- MR - Municipal Reserve
- ER - Environmental Reserve
- OS - Open Space
- AG - Agriculture
- UR - Urban Reserve
- WID Canal
- Roads

Scenario 1: Business as usual

This scenario projects current development goals into the future

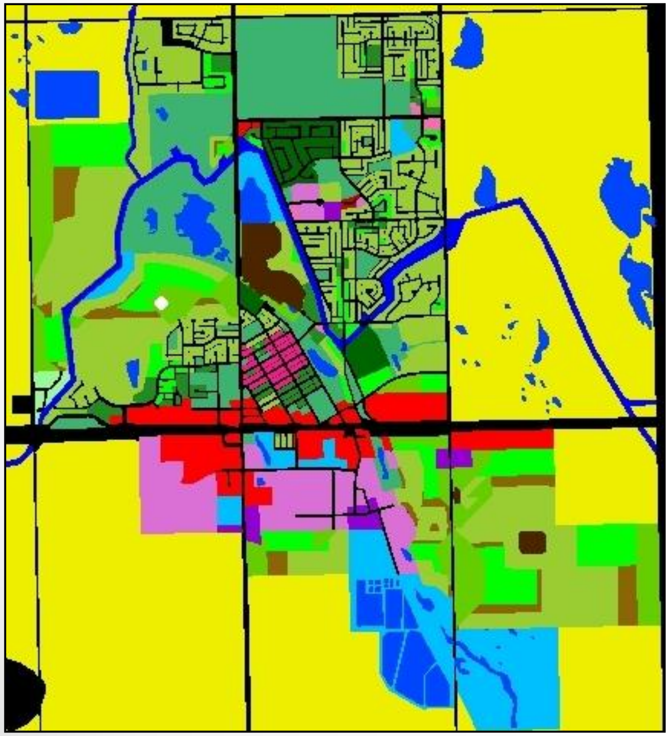


(Kieser and Marceau, 2011)

- By year 9, the development potential has surpassed the housing demand (170%)
- After 10 years, land-use change has occurred over 280 ha contained within 17 land parcels

Scenario 2: Change in the market

This scenario simulates an adaptation to the market demand for smaller housing types

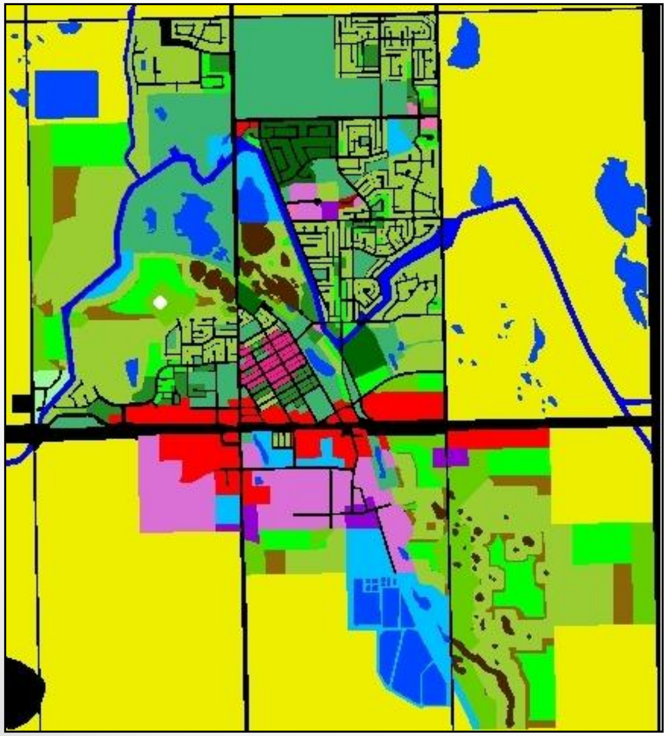


(Kieser and Marceau, 2011)

- This scenario results in the development potential being 30% greater than the housing demand
- After 10 years, land-use change occurs on 176 ha contained within 11 land parcels

Scenario 3: Sustainable development

This scenario controls development rate, gives preference to smaller housing types, decreases the road infrastructure, does not disturb wetlands



(Kieser and Marceau, 2011)

- Land-use change occurs on 198 ha contained within 11 land parcels
- This scenario creates more intricate patterns and presumably a more interesting community

The woodland caribou project
(*Rangifer tarandus caribou*)

Dr. Danielle Marceau, Geomatics Eng., UofC
Dr. Christina Semeniuk, PDF
David Birkigt, Researchc Associate
Dr. Marco Musiani, EVDS and Veterinary Medecine, UofC
Dr. Greg McDermid, Geography, UofC
Dr. Mark Hebblewhite, University of Montana
Scott Grindal, ConocoPhillips Canada

Objective

To determine how the industrial activities influence woodland caribou habitat selection and use in the study area

- An ABM/CA model was developed to:
    - Simulate and recreate the movement behaviors of caribou to explore how they select and use their winter habitat
    - Determine the relative impact of different industrial features on caribou habitat selection strategies in winter
    - Assess how caribou adapt to their changing environment

Modeling approach

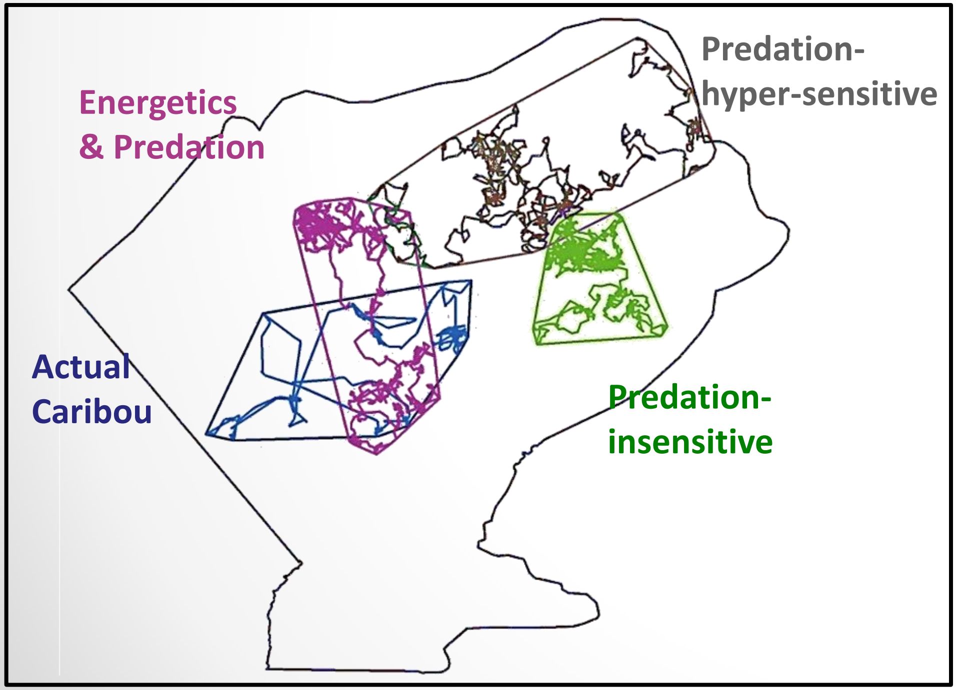
Our modeling approach combines movement ecology with behavioural ecology within an ABM/CA framework

- The ABM simulates caribou as individual agents that:
  - Are capable of making trade-off decisions to maximize their survival and reproductive success
  - Are spatially aware of their surrounding environment
  - Have a memory
  - Can learn where to forage, while concurrently avoiding predators and habitat disturbance

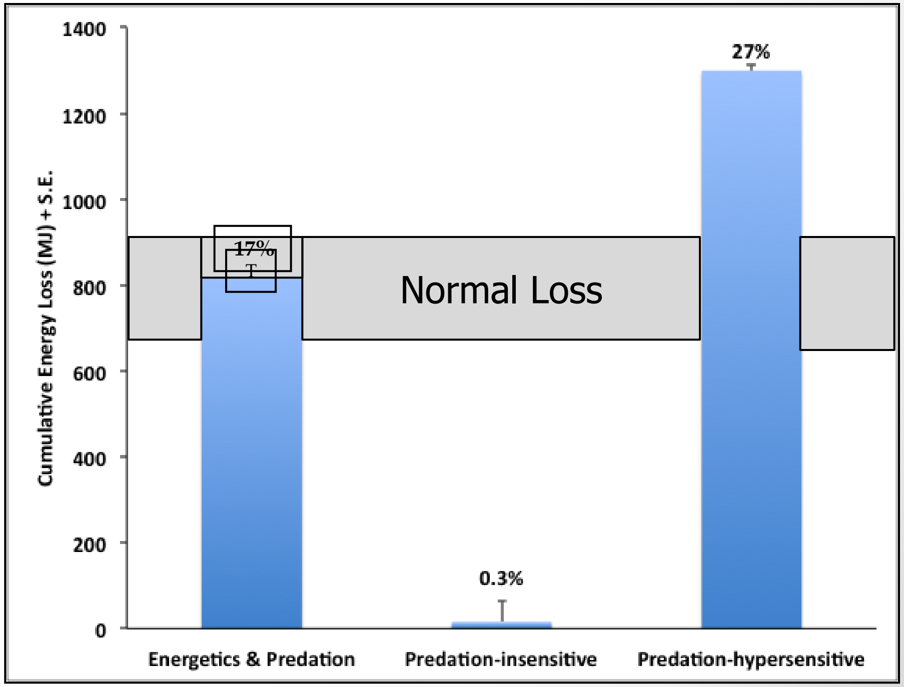
Result: Strategy for habitat use

The Energetics and Predation scenario in which the caribou agent must trade-off its daily energy requirement, minimize its reproductive energy loss, and minimize the predation risk is the best-fit scenario

Representative paths and home ranges



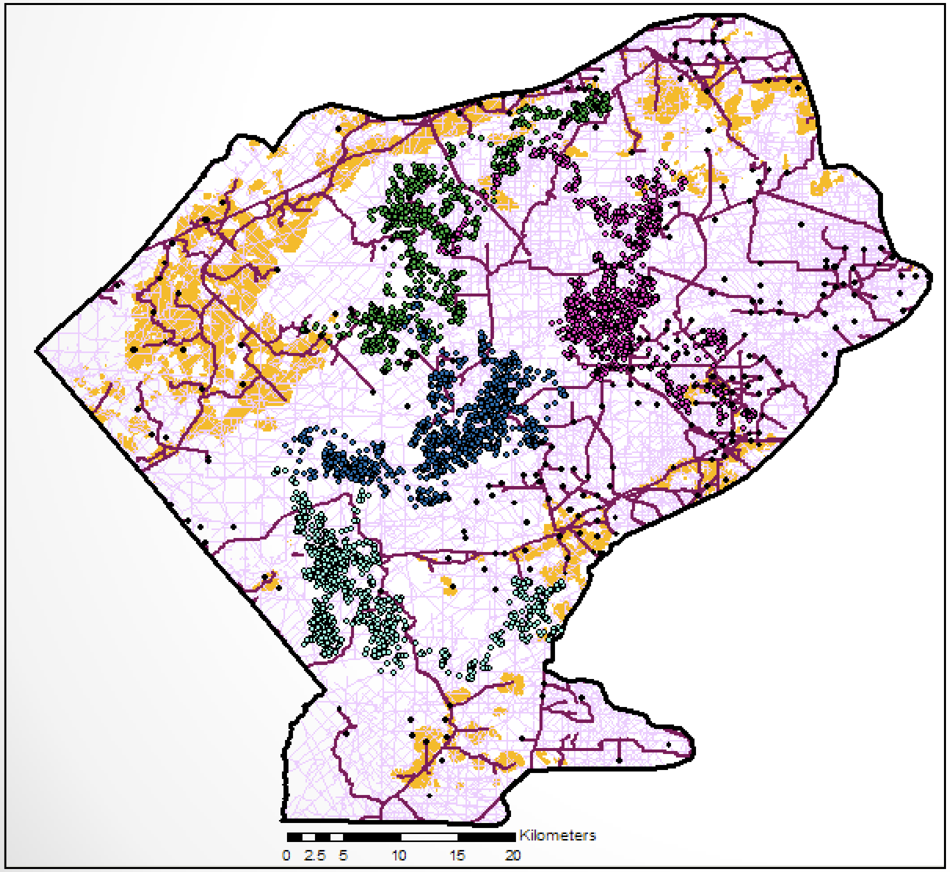
Cumulative energy loss



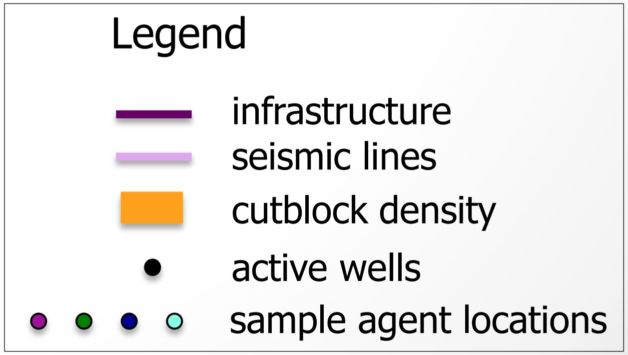
(Semeniuk et al., 2012)

Result: Sensitivity to industrial activities

Forestry and oil and gas features distinctly affect the spatial and energetic responses of caribou



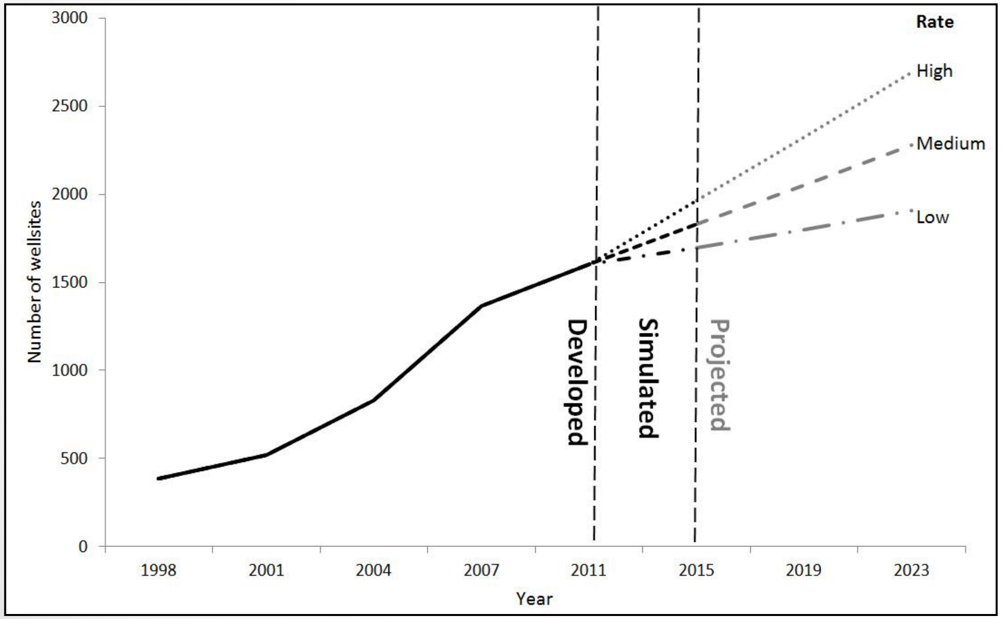
- Caribou are most sensitive to the presence of linear features
- They are sensitive to a minor extent to cutbloc density and active wellsites



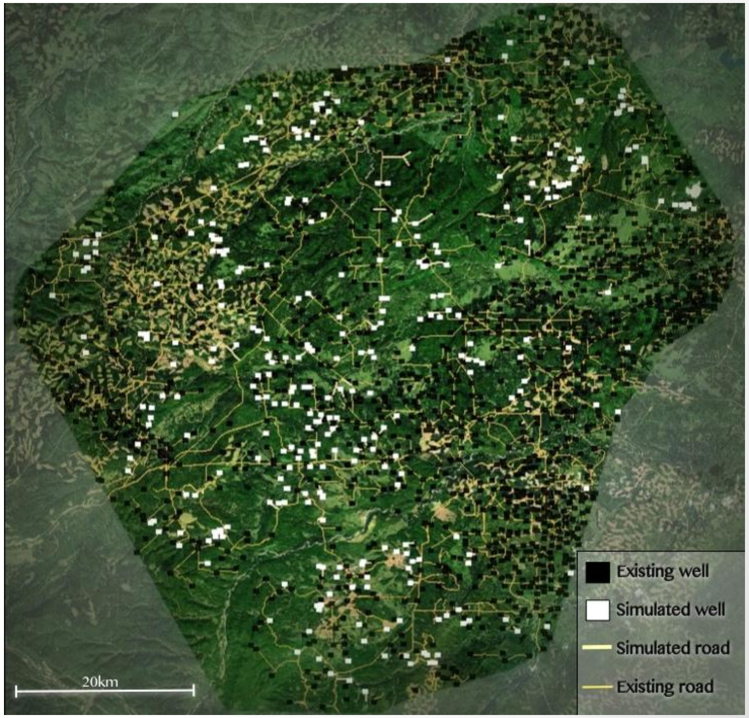
(Semeniuk et al., 2013)

Projecting in the future

A cellular automata was developed to simulate three scenarios of upstream development over the next 10 years



2015: medium development rate



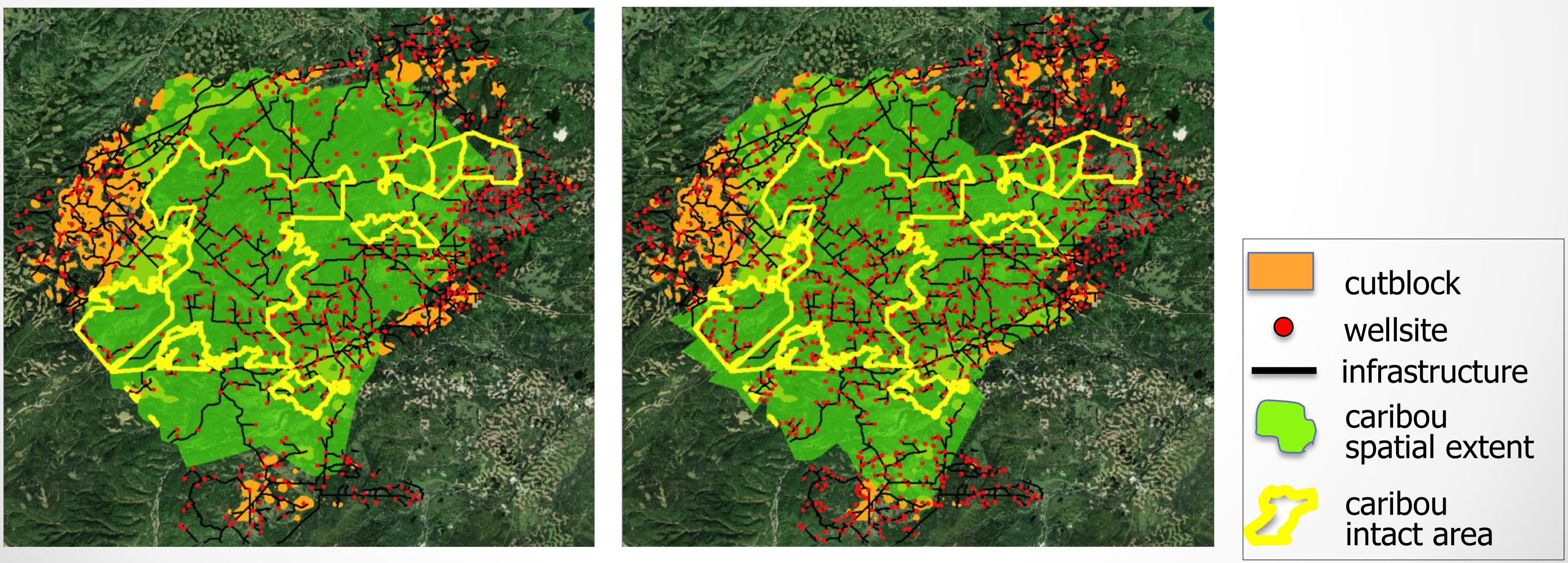
(Birkigt et al., 2013)

Result: Adaptation to projected conditions

Projected environmental conditions up to 2023 using a cellular automata reveal how caribou adapt to the changes in their habitat

2011: Intact area: 63%

2023: Intact area: 53%



(Semeniuk et al., 2013)

Modeling disease propagation with ABMs

Wildlife - Cattle

Dr. Karen Orsel, Veterinary Medicine, UofC
Dr. Ale Massolo, Veterinary Medicine, UofC
Dr. Danielle Marceau, Geomatics Eng., UofC
Dr. Aaron Reeves, PDF
Mathieu Provost, Ph.D. Student
Ranchers

Coyote – Dog - Human

Dr. Ale Massolo, Veterinary Medicine, UofC
Dr. Danielle Marceau, Geomatics Eng., UofC
Ken Mori, M.Sc. Student, Geomatics Eng.
City of Calgary

Conclusion

Understanding the complex interactions between human and natural systems is essential for environmental resource management

- It requires an interdisciplinary scientific approach
- It requires a flexible and comprehensive modeling approach to investigate multiple scenarios
- It requires the involvement of stakeholders as they are key actors in the process of identifying and implementing sustainable management measures

Acknowledgements

- Funding for these projects is provided by:
  - GEOIDE
  - MITACS
  - NSERC
  - ConocoPhillips Canada
  - Tecterra
  - Alberta Environment Sustainable Resource Development (AESRD)
  - DHI (in-kind)
  - Calgary Regional Partnership
  - Alberta Innovates (scholarship)
  - University of Calgary (Internal awards)

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Day 1 – Session 1

Richard Leduc – AirMet Science Inc.

BIOGRAPHY

Richard Leduc's, Ph.D., work is related to meteorology and air quality. He actively works (private sector) in modelling, network development and data analysis. He published the Québec Guidelines on dispersion modelling and authored sections of Québec Air quality regulation. He also works as an Associate Professor (volunteer) at Laval University with graduate students.

Day 1 – Session 1

Richard Leduc – AirMet Science Inc.

ABSTRACT

A simple technique to obtain wind field in urban areas was implemented and coupled to a stochastic lagrangian particle model. The main features of these approaches will be outlined along with some practical problems. Examples of applications in urban areas will be presented. Some ongoing and future work will conclude the presentation.

APPLICATION OF LAGRANGIAN MODELLING IN URBAN AREAS

Richard Leduc, Ph.D.

Environmental Modelling Workshop

Edmonton, March 13 2013

SPECIAL THANKS

- Thanks to Jesse Thé, Lakes Environmental, and Yann Contratto, Olfactoexpert for their continual support

PLAN

- Introduction
- Wind field
- Particle model
- Examples

BASE REFERENCE

- H.C. RODEAN, 1996
- ***STOCHASTIC LAGANGIAN MODELS OF TURBULENT DIFFUSION***
- American Meteorological Society, Meteorological Monograph , Volume 26
- JD Wilson Alberta University works are significative

Introduction

- Basic motivation:
  - how to calculate and illustrate in a simple way the wind field around an industrial complex to help in some occasions to refine results of AERMOD
  - and show how a plume could behave
- Everything done here is based on published litterature

Introduction

- 2 blocs are necessary:
  - obtain wind field solution in built areas – industrial complex or urban center
  - resolve the equations for lagrangian transport of parcels

WIND FIELD

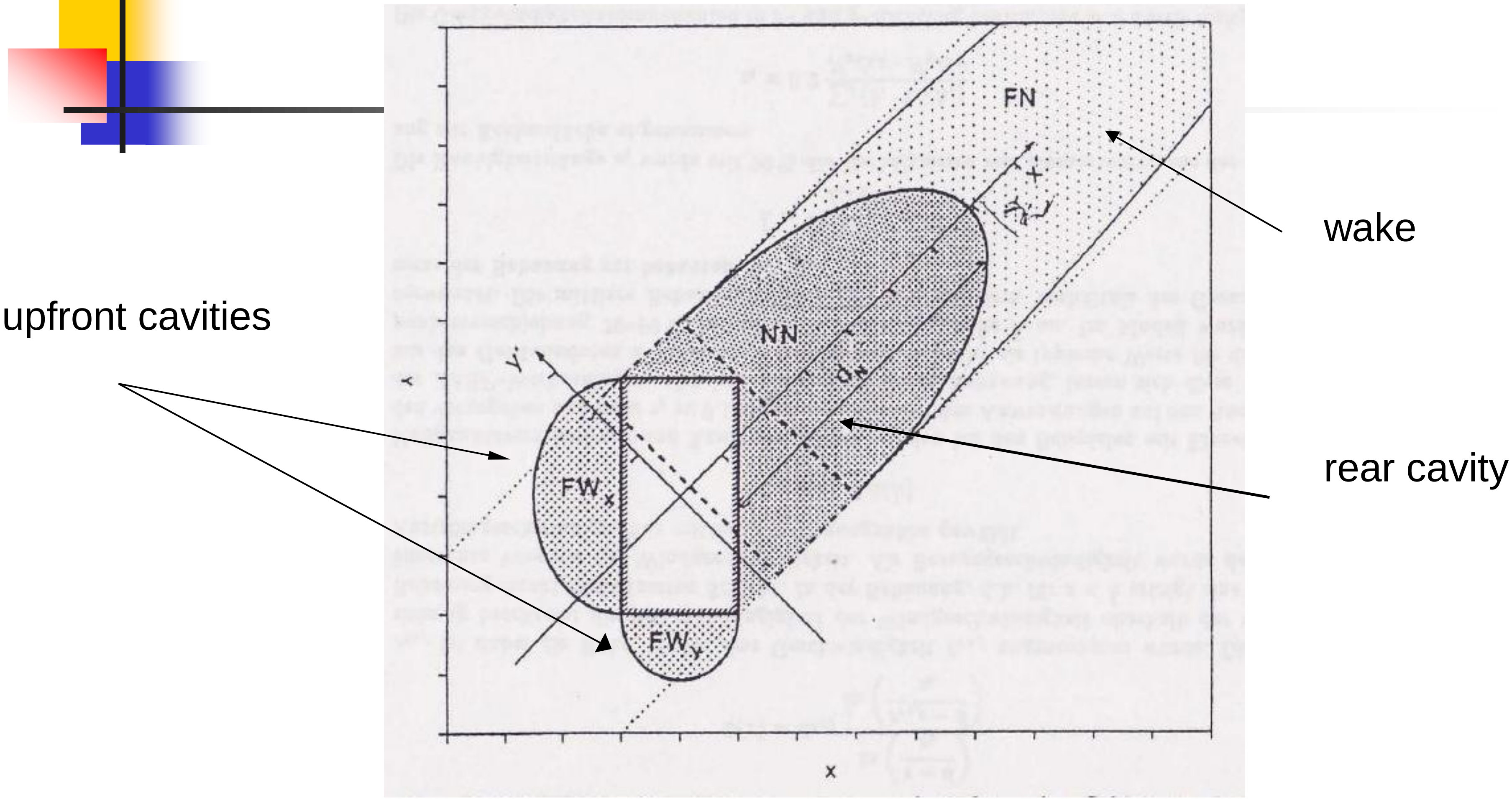
- Options
  - CFD model: solve basic movement equations
    - interesting, precise
    - longer execution time
  - parameter model
    - simplified building effects
    - quite fast

AIRFLO MODEL

- Based on Rockle (1990), Kaplan et Dinar (1996), Los Alamos (2003 and others) following Hosker (1984)

- Wind field parametrized according to influence zone around a building
  - base on one building not too excentric form (cubic or rectangle)

parametrized zones



upfront cavities

	FX	FY
a_x	$L_f \sin^2\theta \sqrt{1-\left(\frac{z}{0.6H}\right)^2}$	$\frac{L}{2}$
a_y	$\frac{W}{2}$	$L_f \cos^2\theta \sqrt{1-\left(\frac{z}{0.6H}\right)^2}$
vent initial	$u_0=0$	$v_0=0$

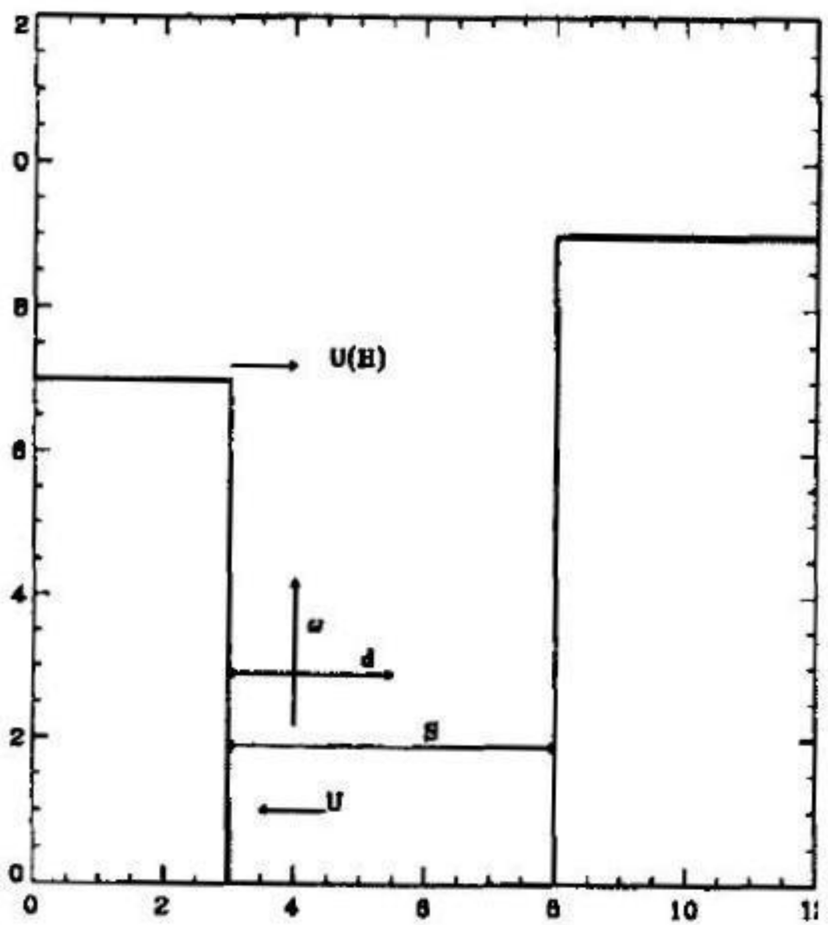
$$\frac{L_f}{H} = \frac{2(W/H)}{1+0.8W/H}$$

rear cavity and wake

¤	N¤	F¤
a_x ¤	$L_r\sqrt{1-\left(\frac{z}{H}\right)^2}$ ¶ ¤	$3L_r\sqrt{1-\left(\frac{z}{H}\right)^2}$ ¤
a_y ¤	$\frac{b_e}{2}$ ¶ ¤	$\frac{b_e}{2}$ ¤
composante x¤	$u_0 = -u(H)\left(1-\frac{d_l}{d_N}\right)^2$ ¶ ¤	$u_0 = u(z)\left(1-\frac{d_N}{d_l}\right)^{1.5}$ ¤
composante y¤	$v_0 = -v(H)\left(1-\frac{d_l}{d_N}\right)^2$ ¶ ¤	$v_0 = v(z)\left(1-\frac{d_N}{d_l}\right)^{1.5}$ ¤

$$\frac{L_r}{H} = \frac{1.8W/H}{(L/H)^{0.3}(1+0.24W/H)}$$

street canyon



si S < S**

$$\frac{S^{**}}{H} = \begin{cases} 1.25 + 0.15\,W/H & W/H < 2, \\ 1.55 & W/H \geqslant 2. \end{cases}$$

¶

$$U = -U(H)\frac{d}{0.5S}\left(\frac{S-d}{0.5S}\right) \cdot\cdot\cdot\cdot\; W = -\left|\frac{U(H)}{2}\left(1-\frac{d}{0.5S}\right)\right|\left(1-\frac{S-d}{0.5S}\right)$$ ¶

¶

S: street width

d: distance from grid point to upwind building

U(H) wind on roof of upwind building

for non perpendicular wind to canyon axis wind is decomposed in parallel and perpendicular components

- Buildings are defined
  - 4 corners, height
  - for industrial complex, take BPIP
- Each grid point is determined
  - free
  - inside a building
  - in zone: upfront, cavity, wake, canyon
  - search for street canyons is tedious
    - grid points in street canyons are saved in a file for further applications

Initial wind field

- MOST profile according to the weather conditions (wind, temperature, cloud ect) and local variables (roughness, albedo ect)
- Each grid point is attributed an initial wind field depending on its position with respect to building zones

Wind field solution

- Initial wind field is the start up wind for the application of a mass conservation model on the modelling domain (divergence minimization)

- the function E is minimize over the whole domain
- (u_0,v_0,w_0): initial wind field: wind attributed in various zones
- (u,v,w): final wind field

$$E(u,v.w)=\int_V\left[\alpha_1^2\left(u-u_0\right)^2+\alpha_2^2\left(v-v_0\right)^2+\alpha_3^2\left(w-w_0\right)^2\right]dV$$

- with a zero divergence constraint on the final wind field

$$\nabla \bullet V = 0$$

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$

- is the same as to minimize J

$$J(u,v,w;\lambda)=\int_V \begin{bmatrix} \alpha_1^2\left(u-u_0\right)^2+\alpha_2^2\left(v-v_0\right)^2+\alpha_3^2\left(w-w_0\right)^2+ \\ \lambda\left(\dfrac{\partial u}{\partial x}+\dfrac{\partial v}{\partial y}+\dfrac{\partial w}{\partial z}\right) \end{bmatrix} dV$$

- and λ(x,y,z) is subjected to the following identity and is solved numerically; R is called the source term (divergence)

$$\frac{\partial^2\lambda}{\partial x^2}+\frac{\partial^2\lambda}{\partial y^2}+\left(\frac{\alpha_1}{\alpha_2}\right)^2\frac{\partial^2\lambda}{\partial z^2}=R$$

then the final wind field (u,v,w) is obtained as a function of (x,y,z) with λ(x,y,z)

$$u = u_0 + \frac{1}{2\alpha_1^2}\frac{\partial\lambda}{\partial x}$$

$$v = v_0 + \frac{1}{2\alpha_1^2}\frac{\partial\lambda}{\partial y}$$

$$w = w_0 + \frac{1}{2\alpha_2^2}\frac{\partial\lambda}{\partial z}$$

- The λ equation is discretized as

$$R_{i,j,k} = \frac{\lambda_{i+1,j,k} - 2\lambda_{i,j,k} + \lambda_{i-1,j,k}}{\Delta x^2} + \frac{\lambda_{i,j+1,k} - 2\lambda_{i,j,k} + \lambda_{i,j-1,k}}{\Delta y^2} +$$

$$\left(\frac{\alpha_1}{\alpha_2}\right)^2 \frac{\lambda_{i,j,k+1} - 2\lambda_{i,j,k} + \lambda_{i,j,k-1}}{\Delta z^2}$$

$$R(I,J,K) = -2\alpha_1^2\, DIV(I,J,K)$$

- At solid surfaces such as wall and roofs the wind and the derivatives are null

$$\frac{\partial \lambda}{\partial x} = 0 \ ou \ \frac{\partial \lambda}{\partial y} = 0 \ ou \ \frac{\partial \lambda}{\partial z} = 0$$

- At points where there are solid surfaces discretized λ equation is adjusted to have zero derivatives. For example for a solid surface to EAST and one SOUTH

$$\frac{\partial^2 \lambda}{\partial x^2} = \frac{\partial}{\partial x}\left(\frac{\partial}{\partial x}\right) = \frac{1}{\Delta x}\left(\left.\frac{\partial \lambda}{\partial x}\right|_{i+1/2} - \left.\frac{\partial \lambda}{\partial x}\right|_{i-1/2}\right)$$

$$= \frac{1}{\Delta x}\left(0 - \left.\frac{\partial \lambda}{\partial x}\right|_{i-1/2}\right) = \frac{1}{\Delta x}\left(-\left.\frac{\partial \lambda}{\partial x}\right|_{i-1/2}\right)$$

$$= \frac{\lambda_{i-1} - \lambda_i}{\Delta x^2}$$

$$\frac{\partial^2 \lambda}{\partial y^2} = \frac{\lambda_{j+1} - \lambda_j}{\Delta y^2}$$

- which is put back in the discretized equation

$$R_{i,j,k} = \frac{\lambda_{i-1,j,k} - \lambda_{i,j,k}}{\Delta x^2} + \frac{\lambda_{i,j+1,k} - \lambda_{i,j,k}}{\Delta y^2} + \left(\frac{\alpha_1}{\alpha_2}\right)^2 \frac{\lambda_{i,j,k+1} - 2\lambda_{i,j,k} + \lambda_{i,j,k-1}}{\Delta z^2}$$

- to obtain a value for $\lambda_{i,j,k}$

$$\lambda_{i-1,j,k} - \lambda_{i,j,k} + A\left(\lambda_{i,j+1,k} - \lambda_{i,j,k}\right) + B\left(\lambda_{i,j,k+1} - 2\lambda_{i,j,k} + \lambda_{i,j,k-1}\right) = \Delta x^2 R_{i,j,k}$$

$$\lambda_{i,j,k} = \frac{-\Delta x^2 R_{i,j,k} + \lambda_{i-1,j,k} + A\lambda_{i,j+1,k} + B\left(\lambda_{i,j,k+1} + \lambda_{i,j,k-1}\right)}{2\left(0.5 + 0.5A + B\right)}$$

$$A = \Delta x^2 / \Delta y^2 \quad B = \Delta x^2 \left(\alpha_1 / \alpha_2\right)^2$$

- Every point has its own equation depending on where is the solid surface (example wall to the NORTH, wall to WEST, roof UNDER)
- $\lambda_{i,j,k}$ field is then obtained iteratively according to the procedure given by Press (Numerical Recipes in FORTRAN)
- Final wind (u,v,w) is then obtained for all grid points
- Wind field for downtown Montréal (170 structures) calculated in 2 minutes: 1 min for initial search of canyon, 1 min for wind calculation, 4 millions grid points

AIRLAG MODEL

- Moves particules in the wind field (U,V,W) from AIRFLO
- Same spatial discretization
- Wind, buildings and other infos imported from AIRFLO output

Few equations

- Speed increments of a parcel moving in a wind field (U_1,U_2, U_3) are shown in Rodean, based on Thomson; these have a tensor form. The terms contain a deterministic part and a stochastic part to mimic turbulence

$$du_i = a_i(\vec{x},\vec{u},t)dt + b_{ij}(\vec{x},\vec{u},t)dW_j(t)$$

$$a_i = -\left(\frac{C_0\varepsilon}{2}\right)\lambda_{ik}(u_k - U_k) + U_j\frac{\partial U_i}{\partial x_j} + \frac{1}{2}\frac{\partial \tau_{ij}}{\partial x_j}$$

$$+\left[\frac{\partial U_i}{\partial x_j} + \frac{\lambda_{lj}}{2}\left(U_m\frac{\partial \tau_{il}}{\partial x_m}\right)\right]\left(u_j - U_j\right)$$

$$+\left[\frac{\lambda_{lj}}{2}\frac{\partial \tau_{il}}{\partial x_k}\right]\left(u_j - U_j\right)\left(u_k - U_k\right)$$

- expressing the tensors as summations

$$a_i = \sum_{k=1}^{3}\left(-\left(\frac{C_0\varepsilon}{2}\right)\lambda_{ik}(u_k - U_k)\right) \qquad T1$$

$$+\sum_{j=1}^{3} U_j \frac{\partial U_i}{\partial x_j} \qquad T2$$

$$+\sum_{j=1}^{3} \frac{1}{2}\frac{\partial \tau_{ij}}{\partial x_j} \qquad T3$$

$$+\sum_{j=1}^{3}\left[\frac{\partial U_i}{\partial x_j}\right](u_j - U_j) \qquad T4a$$

$$+\sum_{l=1}^{3}\sum_{j=1}^{3}\sum_{m=1}^{3}\frac{\lambda_{lj}}{2} U_m \left(\frac{\partial \tau_{il}}{\partial x_m}\right)(u_j - U_j) \qquad T4b$$

$$+\sum_{l=1}^{3}\left(\frac{\lambda_{lj}}{2}\right)\sum_{j=1}^{3}\sum_{k=1}^{3}\left(\frac{\partial \tau_{il}}{\partial x_k}\right)(u_j - U_j)(u_k - U_k) \qquad T5$$

τ is the shear stress matrix

λ is inverse of τ

- and for a_1 !!!!

$$a_1 = -\frac{C_0\varepsilon}{2}\left(\lambda_{11}(u_1-U_1)+\lambda_{12}(u_2-U_2)+\lambda_{13}(u_3-U_3)\right)$$

$$+U_1\frac{\partial U_1}{\partial x_1}+U_2\frac{\partial U_1}{\partial x_2}+U_3\frac{\partial U_1}{\partial x_3}+\frac{1}{2}\left(\frac{\partial\tau_{11}}{\partial x_1}+\frac{\partial\tau_{12}}{\partial x_2}+\frac{\partial\tau_{13}}{\partial x_3}\right)$$

$$+\frac{\partial U_1}{\partial x_1}(u_1-U_1)+\frac{\partial U_1}{\partial x_2}(u_2-U_2)+\frac{\partial U_1}{\partial x_3}(u_3-U_3)$$

$$+\frac{1}{2}\left(U_1\frac{\partial\tau_{11}}{\partial x_1}+U_2\frac{\partial\tau_{11}}{\partial x_2}+U_3\frac{\partial\tau_{11}}{\partial x_3}\right)\left(\lambda_{11}(u_1-U_1)+\lambda_{12}(u_2-U_2)+\lambda_{13}(u_3-U_3)\right)$$

$$+\frac{1}{2}\left(U_1\frac{\partial\tau_{12}}{\partial x_1}+U_2\frac{\partial\tau_{12}}{\partial x_2}+U_3\frac{\partial\tau_{12}}{\partial x_3}\right)\left(\lambda_{21}(u_1-U_1)+\lambda_{22}(u_2-U_2)+\lambda_{23}(u_3-U_3)\right)$$

$$+\frac{1}{2}\left(U_1\frac{\partial\tau_{13}}{\partial x_1}+U_2\frac{\partial\tau_{13}}{\partial x_2}+U_3\frac{\partial\tau_{13}}{\partial x_3}\right)\left(\lambda_{31}(u_1-U_1)+\lambda_{32}(u_2-U_2)+\lambda_{33}(u_3-U_3)\right)$$

$$+\frac{1}{2}\Bigg(\left(\lambda_{11}(u_1-U_1)+\lambda_{12}(u_2-U_2)+\lambda_{13}(u_3-U_3)\right)\left(\frac{\partial\tau_{11}}{\partial x_1}(u_1-U_1)+\frac{\partial\tau_{11}}{\partial x_2}(u_2-U_2)+\frac{\partial\tau_{11}}{\partial x_3}(u_3-U_3)\right)$$

$$+\left(\lambda_{21}(u_1-U_1)+\lambda_{22}(u_2-U_2)+\lambda_{23}(u_3-U_3)\right)\left(\frac{\partial\tau_{12}}{\partial x_1}(u_1-U_1)+\frac{\partial\tau_{12}}{\partial x_2}(u_2-U_2)+\frac{\partial\tau_{12}}{\partial x_3}(u_3-U_3)\right)$$

$$+\left(\lambda_{31}(u_1-U_1)+\lambda_{32}(u_2-U_2)+\lambda_{33}(u_3-U_3)\right)\left(\frac{\partial\tau_{13}}{\partial x_1}(u_1-U_1)+\frac{\partial\tau_{13}}{\partial x_2}(u_2-U_2)+\frac{\partial\tau_{13}}{\partial x_3}(u_3-U_3)\right)\Bigg)$$

- Expressions are complex
- In a simple case without buildings one can use a reference system aligned with the mean wind i.e. with $U_2=0$, $U_3=0$ also (no vertical movement in the mean flow) and so many terms go to 0

- With buildings U_3 (vertical wind) may be non zero; but a moving doubly rotated system can have $U_2=0$ and $U_3=0$
- This was developped; but this requires continual change in reference frame following the particle and complex calculations (much time consuming) and interaction with buildings is difficult to follow
- Ordinary reference frame (x,y,z) is used

- To improve calculation speed all variables that could be computed before start are done (position dependent values are attributed to matrices)

Solid surfaces

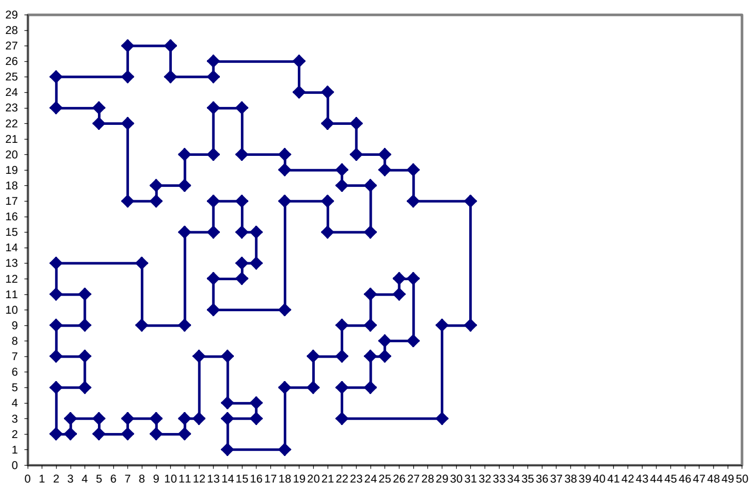
- Parcels are reflected on solid surface and on ground
- Tennis ball refection in 3d
- Special cases as ground to building, building corners, roof to wall ect are considered

Examples

- Only qualitative results examples are shown here
- Model validation will be undertaken

- A short anecdote....☺!
  - Rockle parametrization is based on rectangular forms
  - non-rectangular buildings are thus approximated as superposition of rectangles
  - one would like to have some procedure to get rectangles from polygonal buildings; defined for example as in AERMOD VIEW with BPIP file

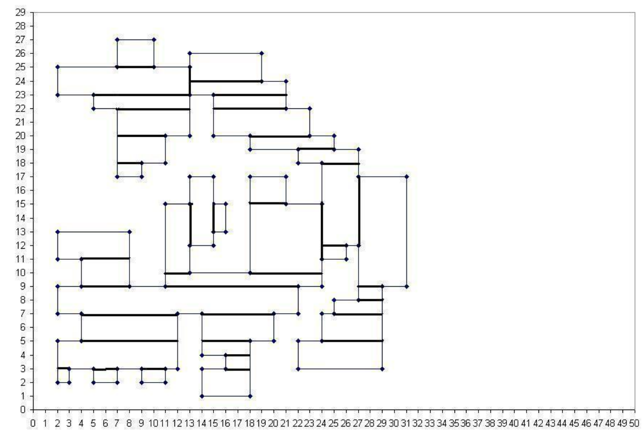
- efforts were devoted to program an algorithm to decompose concave rectilinear polygons in a minimum number of rectangles that superpose or do not superpose
  - what a job ☹☹.....
  - program will be made available on internet

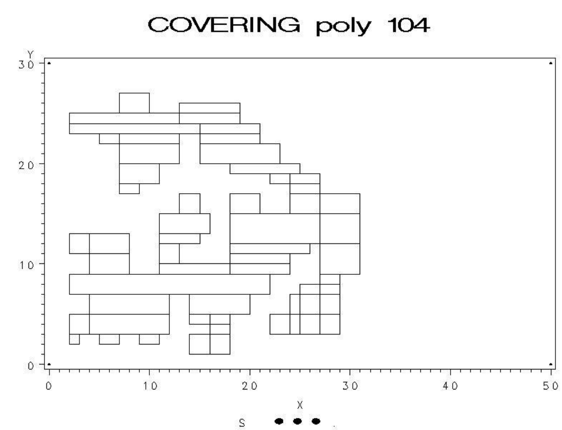


original 104 vertex

juxtaposition

superposition





Québec, summer 2012: legionela episod
13 deads
origin: one cooling tower ; identified 20 september

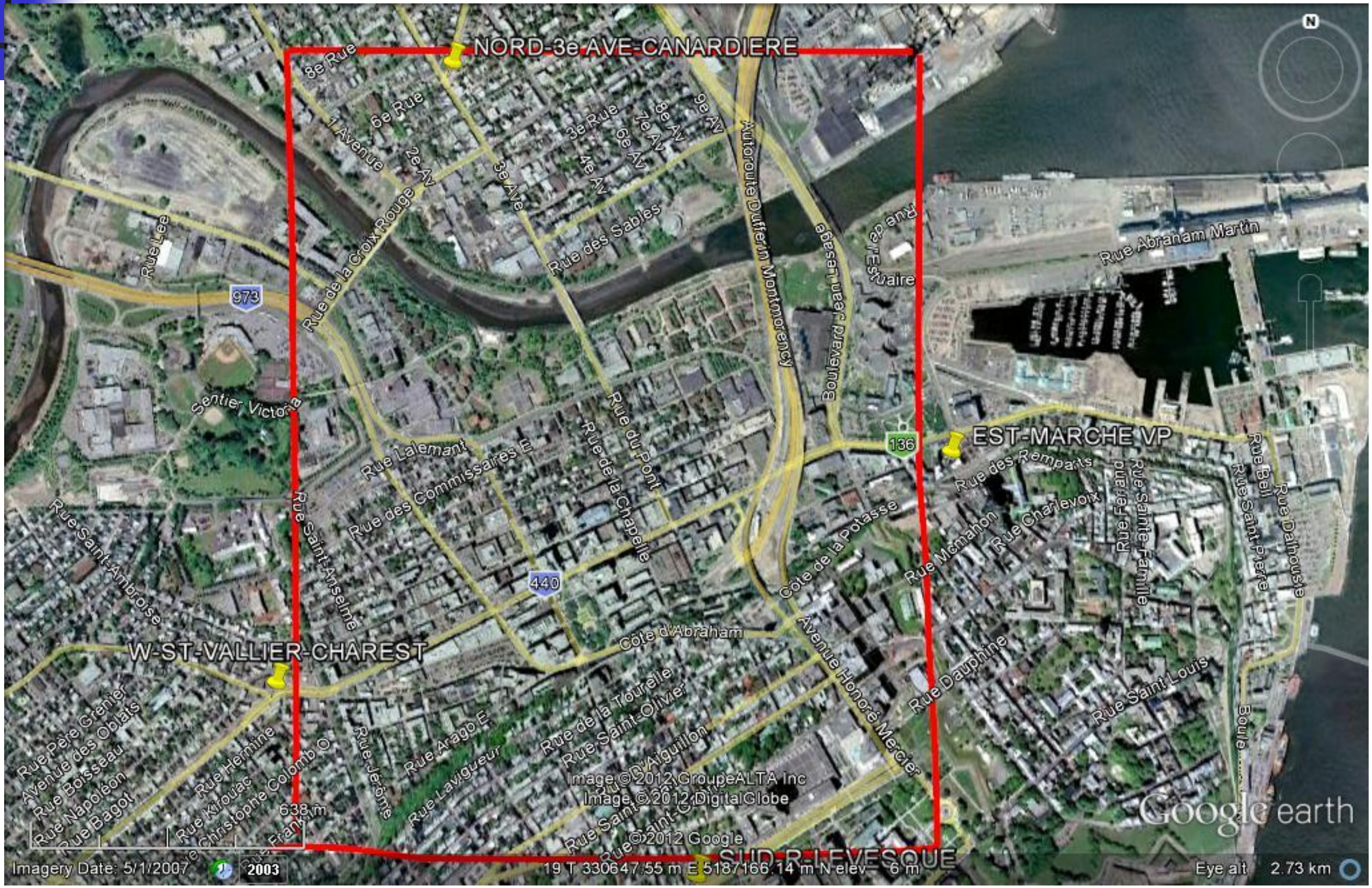
27/08/2012 news

a try for AIRLAG

as a volounteer test

the problem region were search was made

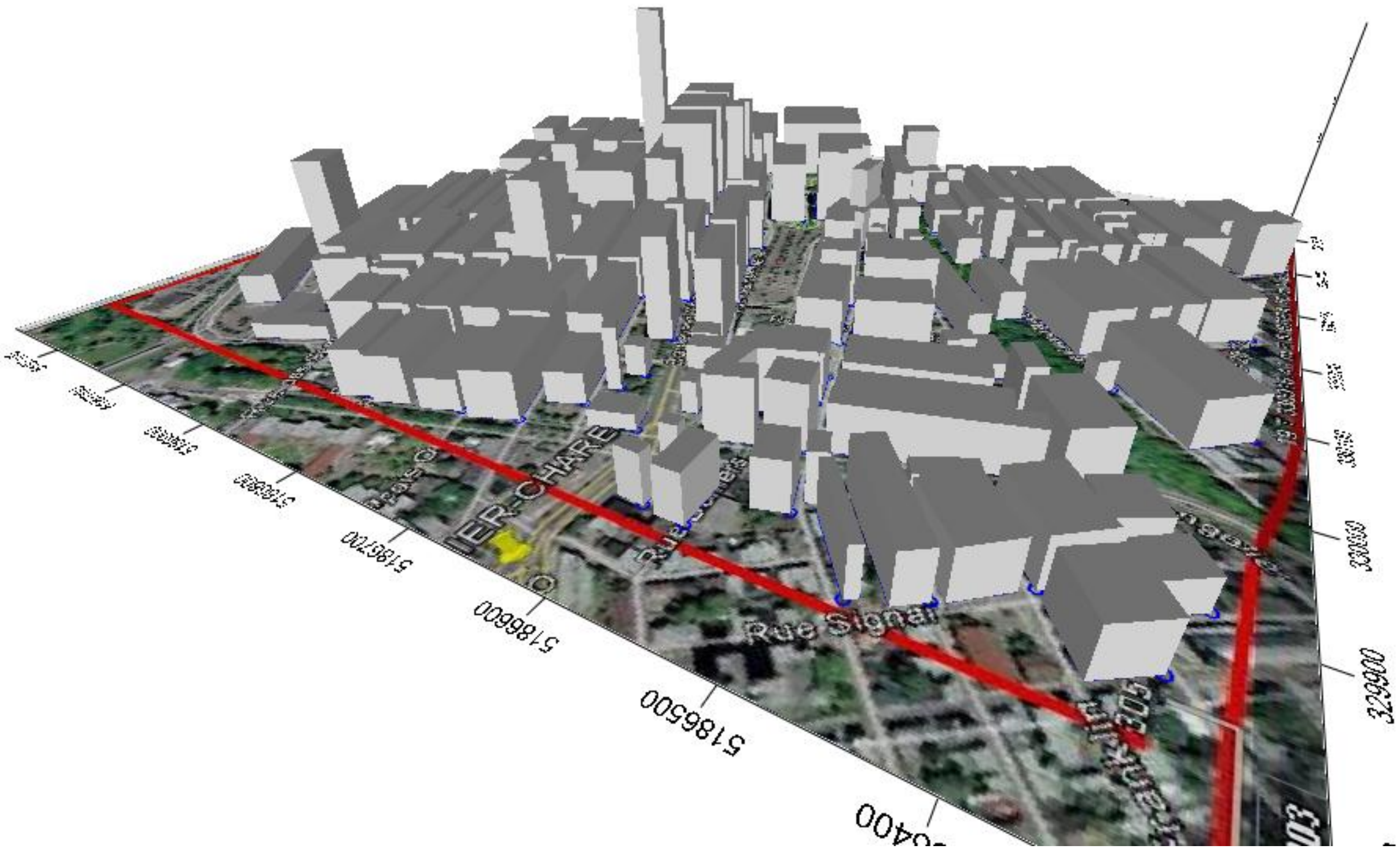
470 structures individual or joined (hand worked-no interface to municipal building data base yet) were input to AIRFLO/AIRLAG



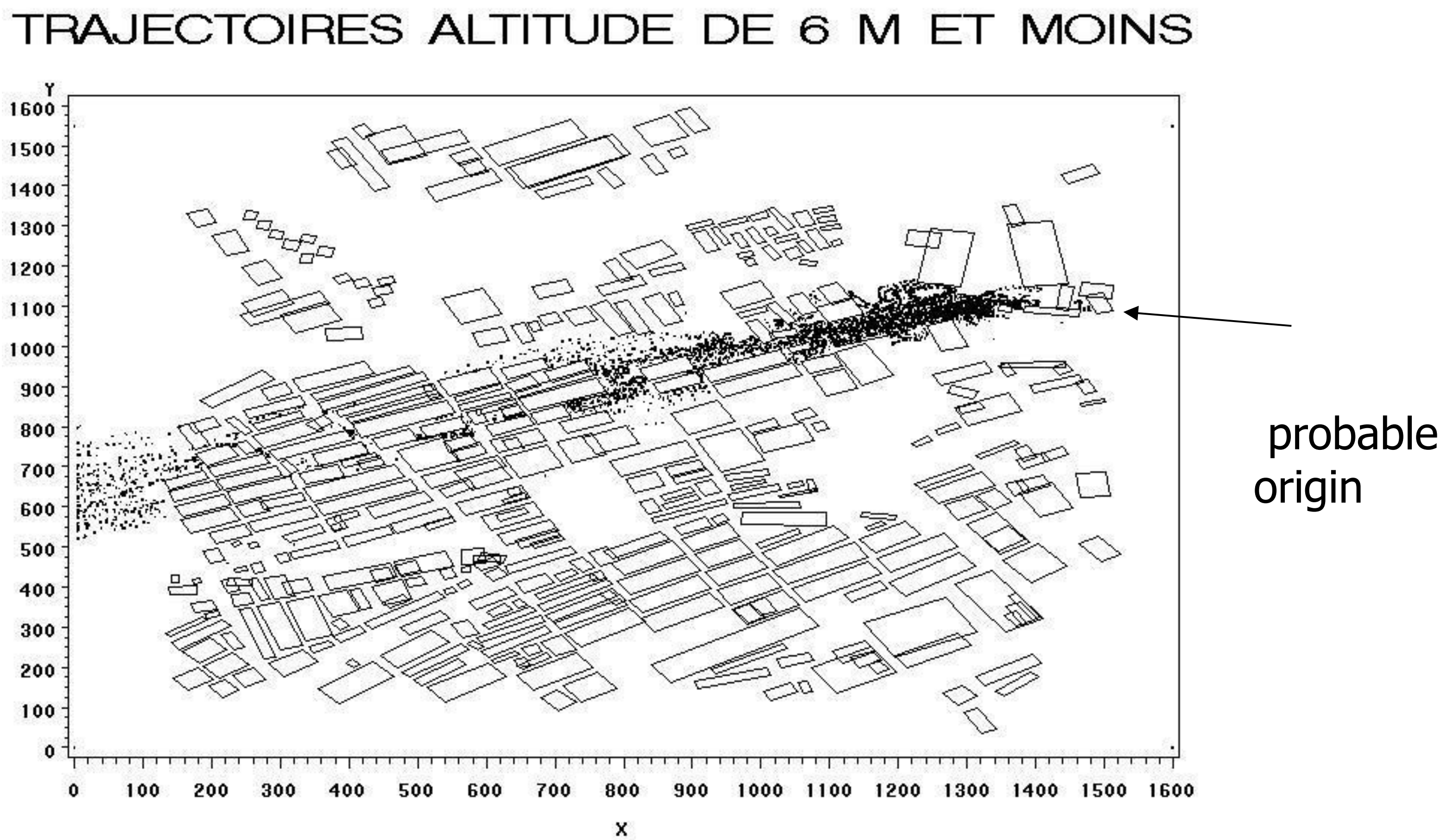
one part of the region, view towards NE

domain 1.5 km x 1.5 km

3D buildings view from AERMOD View



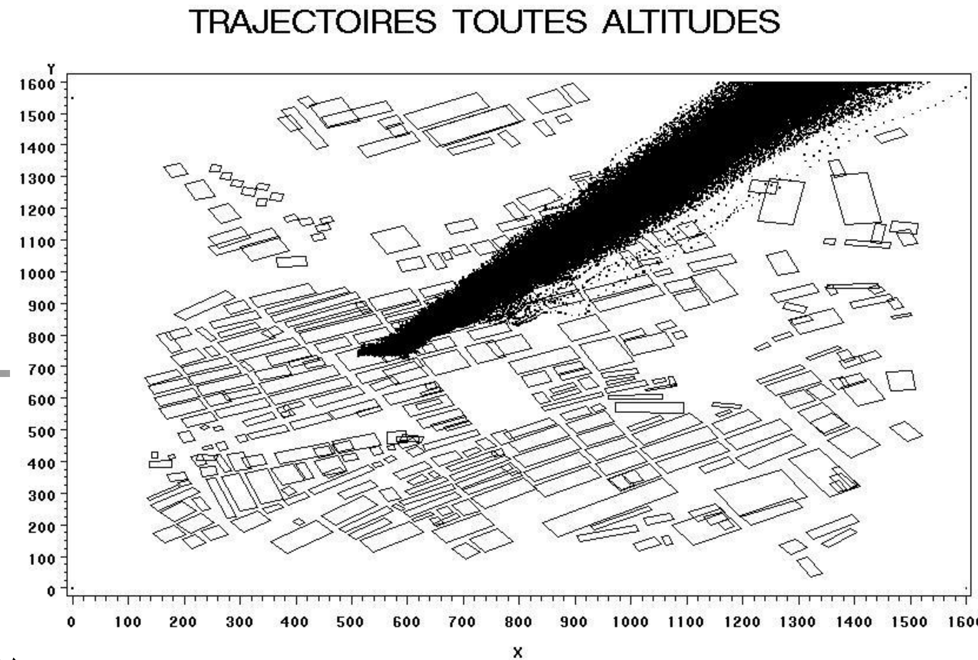
one place was suspected
trial: EAST wind, summer daytime

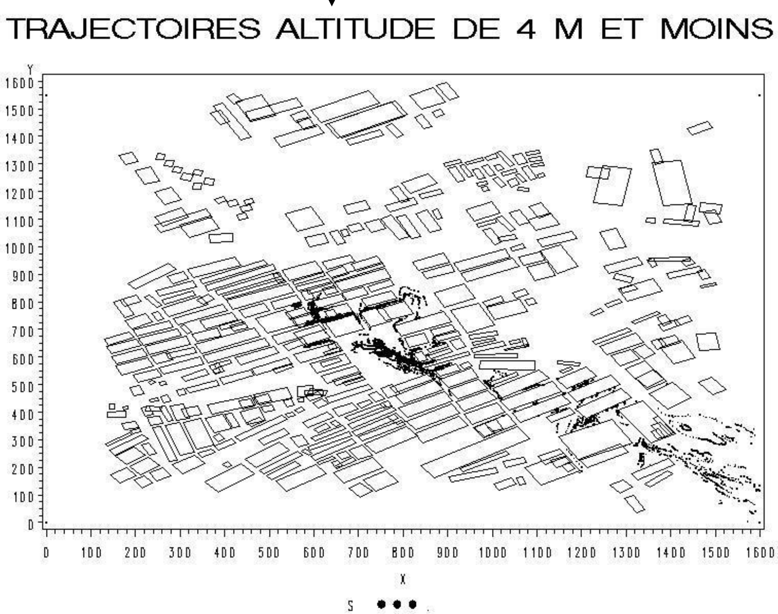


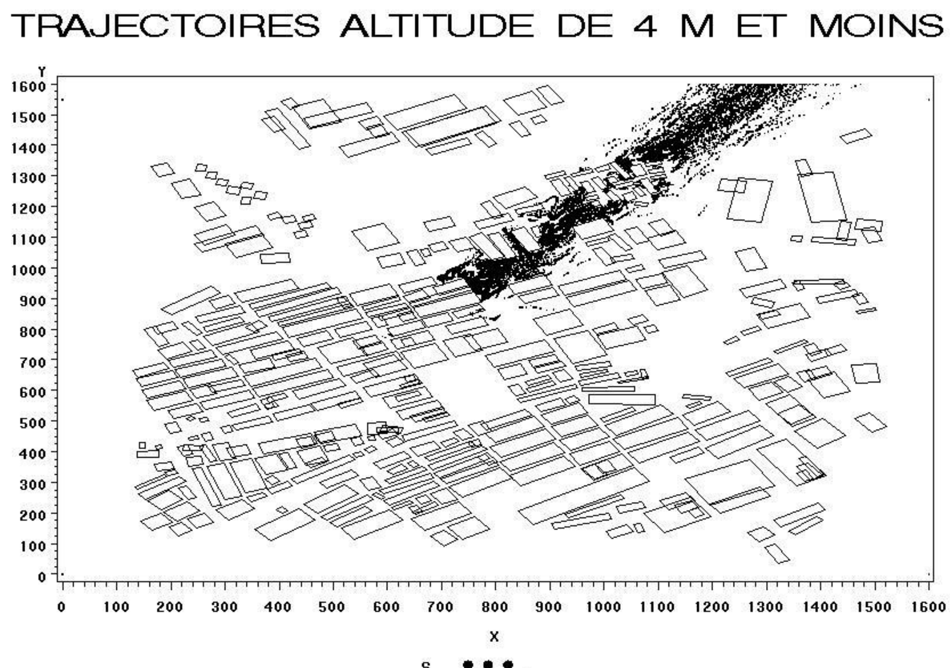
identified source roof

wind SW

wind NW

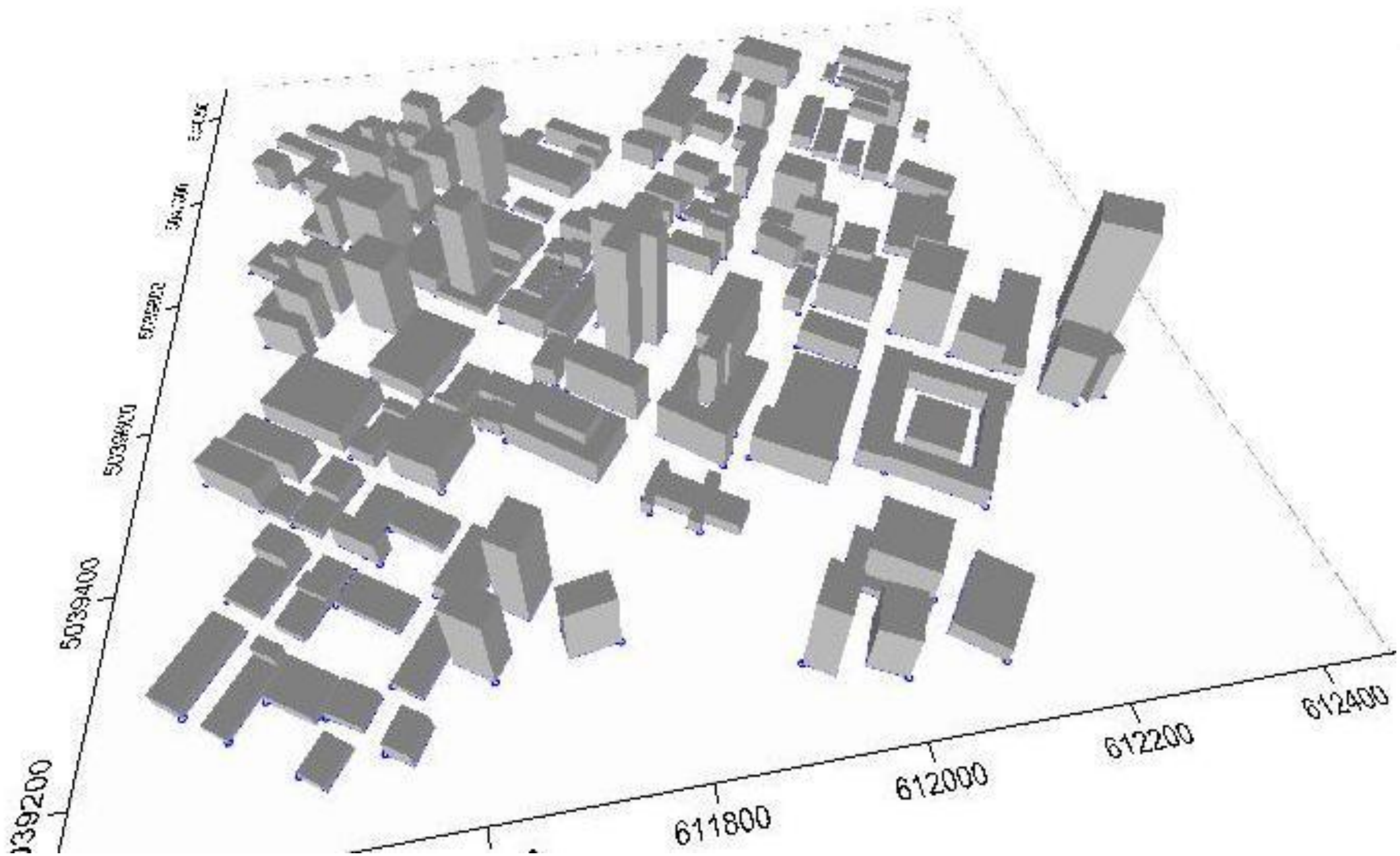


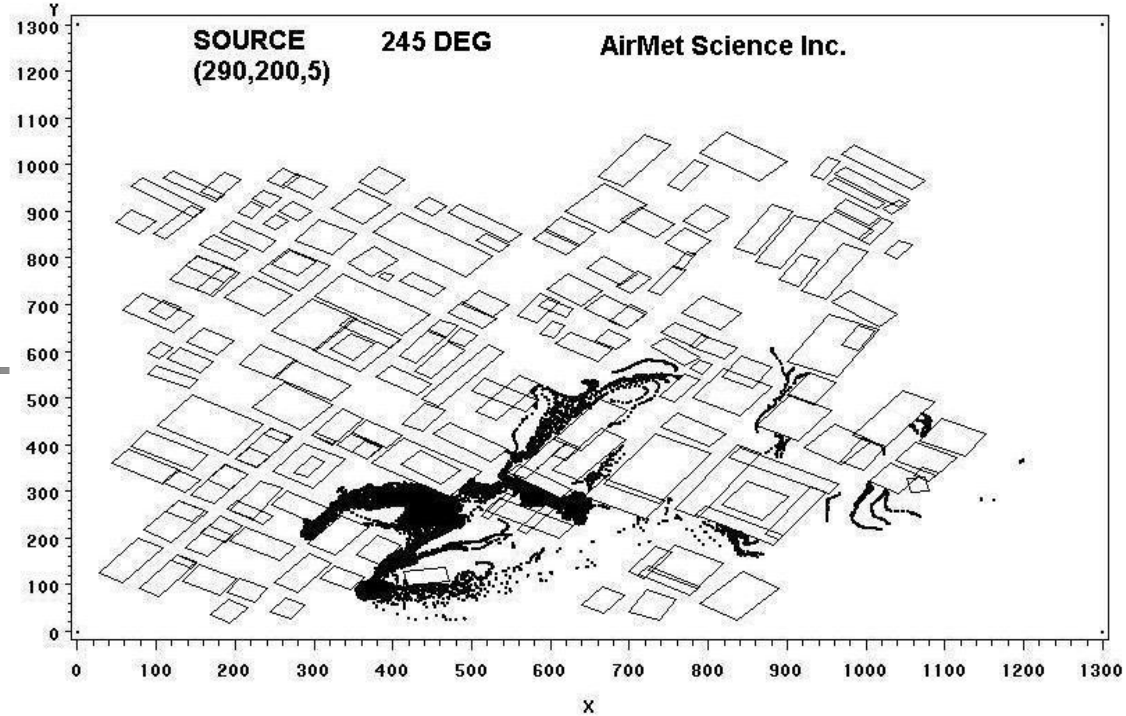


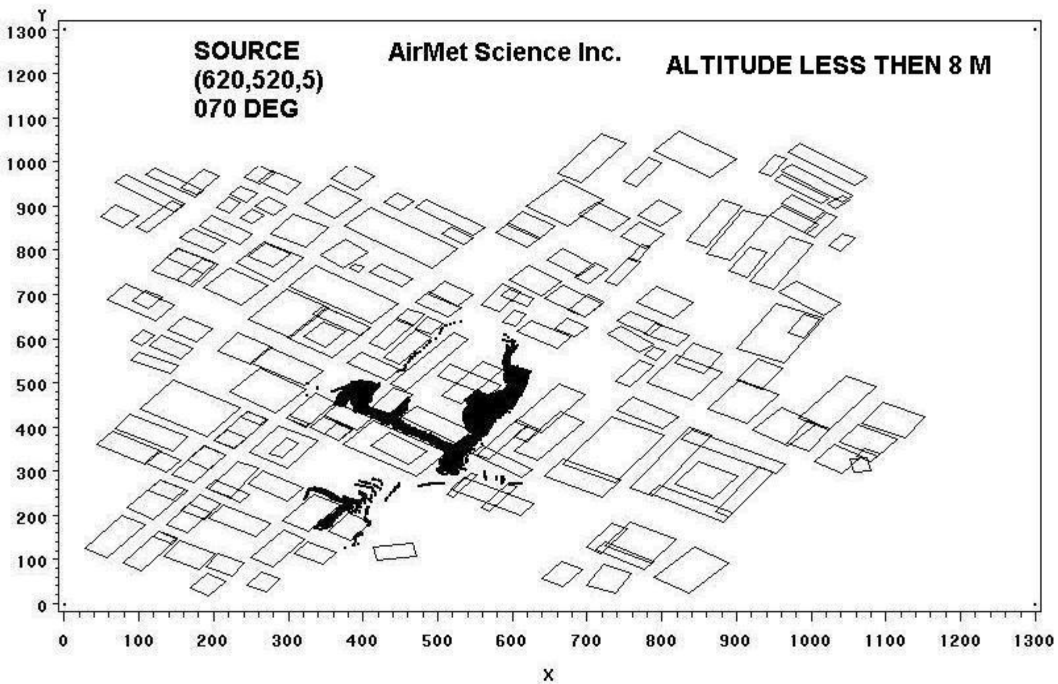


bacteria can reach people and go far

Montréal, part of downtown (170 structures)
3D from AERMOD View







complex circulation patterns

Ongoing and future works

- Vegetation effect
- Lagrangian fluctuations to calculate exceedances probabilities
- Topography
- Roof circulation
- Validation with wind tunnel experiments
- Improve code performance
- Migration to a better performing FORTRAN compiler
- Visual interface
- Wind field solution is still under questionning (CFD?)

Conclusion

- Development of this model (up to this point) required non negligeable efforts
- Further development appears interesting

THANKS

Lakes Environmental

olfactoexpert inc.

AirMet SCIENCE aer scientia

Day 1 – Session 1

Andrew Parker – Tetra Tech Inc.

BIOGRAPHY

Mr. Parker is a Vice President with Tetra Tech's Water Resources Group. He supervises a team of engineers and scientists focusing on watershed planning and management, environmental model development and application, and environmental monitoring and assessment. In his 16 years with Tetra Tech, he has managed more than 50 water resources management and modelling projects in Alberta, over 25 of the United States, Korea, and the Caribbean. He has extensive experience implementing a range of models for planning and regulatory purposes including TMDLs, Implementation plans, climate change studies, Environmental Impact Statements, NPDES permitting, mixing zone analyses, and criteria development. Recent projects include: Chesapeake Bay Total Maximum Daily Load (TMDL) and Watershed Implementation Plan (WIP) development; national scale climate change modelling; and basin-wide modelling studies for the North Saskatchewan River (Canada), Klamath River (USA), Nakdong River (Korea), and Lake Champlain (USA/Canada).

Day 1 – Session 1

Andrew Parker – Tetra Tech Inc.

ABSTRACT

Modelling is an effective tool for supporting water resources management. A wide range of models have been developed and applied in the public and private realms to evaluate surface hydrology, groundwater, hydrodynamics, sediment transport, and water quality. Models are generally designed to focus on a limited aspect of the built or natural environment; however they are frequently coupled to support water management and planning. Indeed, linked models take full advantage of models' individual strengths and avoid oversimplification.

Different models are coupled depending on the primary objectives of a study. Watershed and receiving water models are commonly coupled to support Cumulative Effects, Total Maximum Daily Load (TMDL), and comprehensive watershed management studies. These studies take advantage of the strengths of the different modelling platforms. Watershed models predict time-variable hydrology and water quality conditions throughout a variety of land surface categories, typically for surface and groundwater. They enable land-based, climate change, and other scenarios to be evaluated, as well as determination of source-based load distribution. Receiving water models focus only on water bodies, such as rivers, streams, lakes, and reservoirs, and typically simulate hydrodynamics and/or water quality processes. Commonly coupled non-proprietary watershed models include the Loading Simulation Program in C++ (LSPC), Hydrologic Simulation Program Fortran (HSPF), Soil and Water Assessment Tool (SWAT), and Storm Water Management Model (SWMM), while receiving water models include the Environmental Fluid Dynamics Code (EFDC), CE-QUAL-W2, and the Water quality Analysis Simulation Program (WASP).

In recent years, a focus on watershed implementation has resulted in linkage of watershed and BMP models. Advanced BMP models, such as System for Urban Stormwater Treatment and Analysis IntegratioN (SUSTAIN), simulate combinations of structural management practices and enable users to optimize selection and placement of these practices based on hydrology, water quality, and economic targets. Linked watershed-BMP modelling applications have become a powerful tool to evaluate the potential benefits of costly infrastructure before spending limited resources to construct them.

This presentation will explore a number of coupled watershed-receiving water and watershed-BMP model applications in Alberta and the United States, including the North Saskatchewan River LSPC-EFDC modelling system.

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Water Resources Management Using Coupled Models in Alberta and the U.S.

Andrew Parker
Water Resources Modeling Group
Fairfax, Virginia, USA

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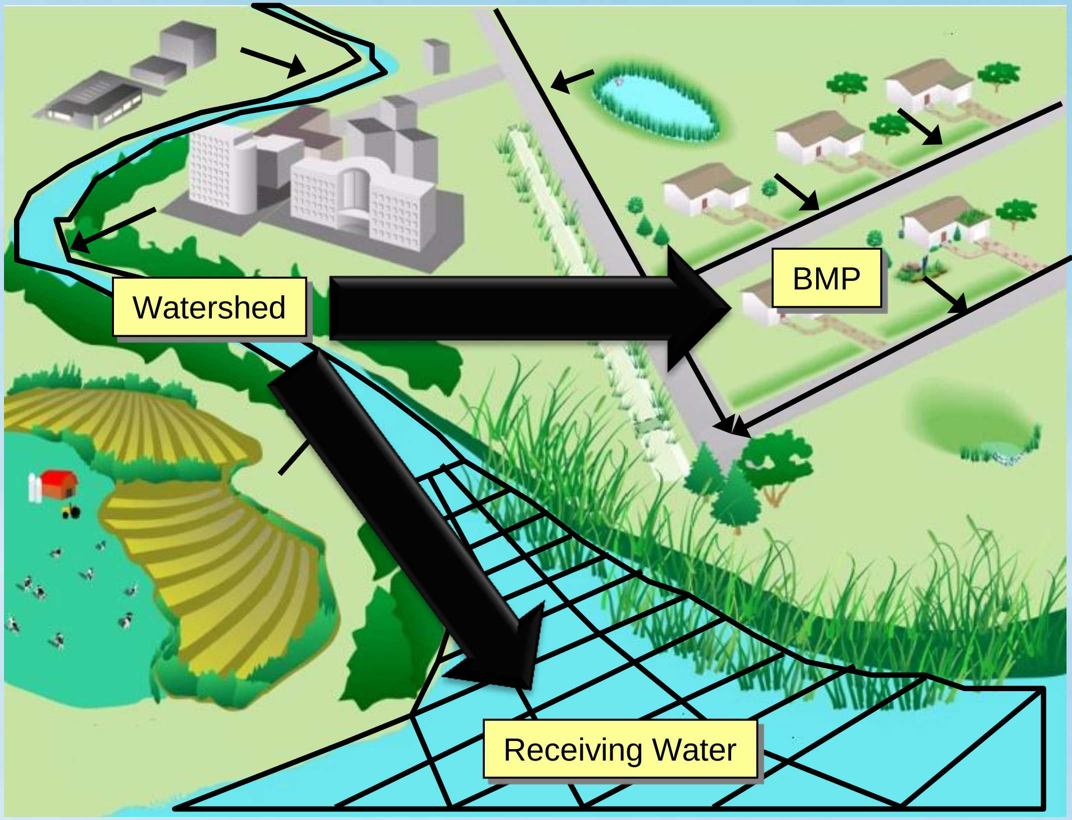
Environmental Modelling

- ▶ Effective tool for water resources management
- ▶ Coupling takes advantage of individual model strengths
- ▶ Focus on:
  - Watershed-Receiving Water
  - Watershed-BMP



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Watershed-Receiving Water Models

- Cumulative Effects, Total Maximum Daily Load (TMDL), and comprehensive watershed management studies
- Watershed models
  - Predict time-variable hydrology and water quality for various land surface categories (typically surface and groundwater)
  - Evaluate land-based, climate change, and other scenarios
  - Determine source-based load distribution
  - Non-proprietary examples include LSPC, HSPF, SWAT, and SWMM
- Receiving water models
  - Simulate hydrodynamics and/or water quality processes in water bodies
  - Non-proprietary examples include EFDC, CE-QUAL-W2, and WASP

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Watershed-BMP Models

- Watershed implementation driven
- Advanced BMP models
  - Simulate combinations of structural management practices
  - Enable users to optimize selection and placement of practices based on hydrology, water quality, and economic targets
  - Example: System for Urban Stormwater Treatment and Analysis IntegratioN (SUSTAIN)
- Evaluate potential benefits of costly infrastructure before spending limited resources on construction

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Commonly Coupled USEPA Models

- LSPC (Watershed)
  - Snow, flow, temperature, sediment, water quality (HSPF routines)
  - Object-oriented environment and relational database
  - Tailored for large-scale watershed modelling and TMDLs
- EFDC (Receiving Water)
  - Fully integrated hydrodynamics, sediment, and water quality
  - 1, 2, or 3-dimensional simulation of rivers, lakes/reservoirs, estuaries
- SUSTAIN (BMP)
  - Implementation planning framework
  - Determine cost-effective mix of BMPs to meet flow/load goals
- All are public domain – freely available at http://www.epa.gov

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Case Studies

LSPC → EFDC

- **Watershed Management and Cumulative Effects Assessment**
  - *North Saskatchewan River*

LSPC → EFDC

- **Reservoir Management**
  - *Lake Lanier, Georgia*

LSPC → SUSTAIN

- **Optimal Implementation Planning**
  - *Milwaukee, Wisconsin Metropolitan Sewer District*

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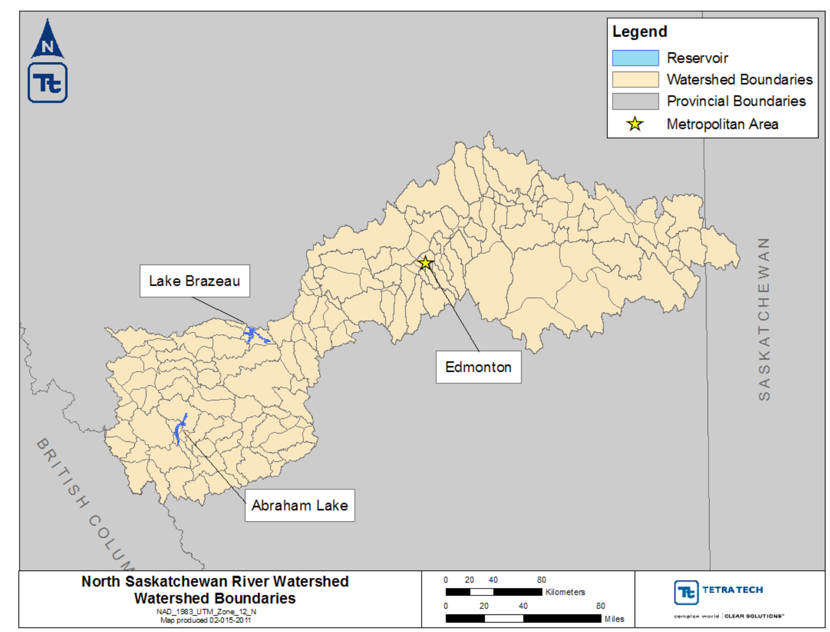
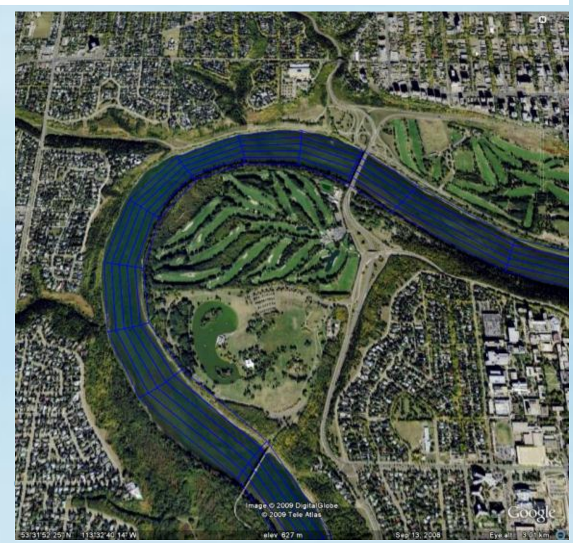
North Saskatchewan River



LSPC → EFDC

- Developed coupled watershed-receiving water models for AESRD
- Hydrology, hydrodynamics, and water quality
- LSPC for basin-wide simulation
- EFDC for main-stem river, Lake Brazeau, and Abraham Lake



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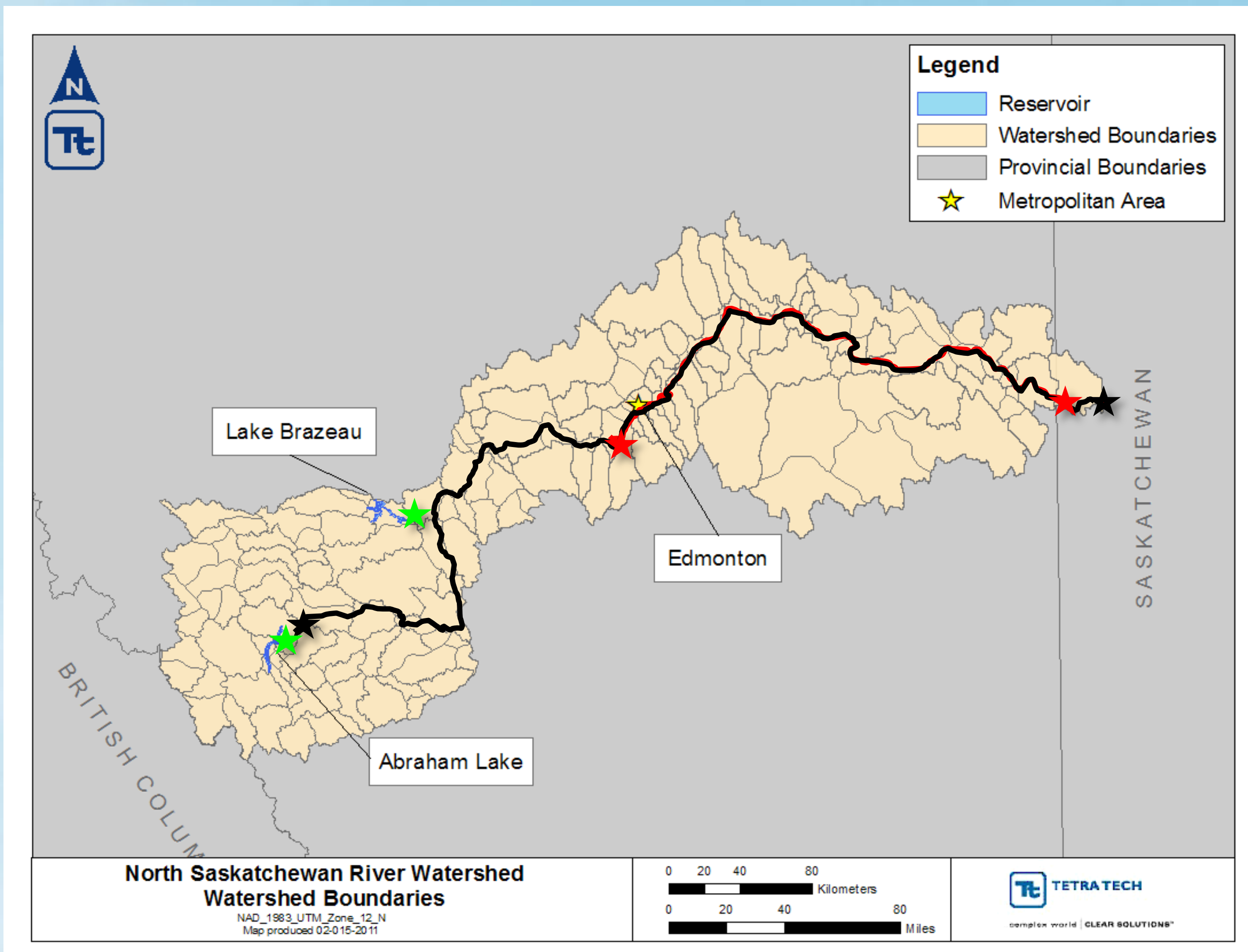
Phased Modelling Process

- 2D/1D model of NSR
  - Devon to Saskatchewan
- 1D model of NSR
  - Abraham Lake to Saskatchewan
- Watershed model
- 3D models of lakes
  - Abraham Lake
  - Lake Brazeau
- Watershed model enhancements



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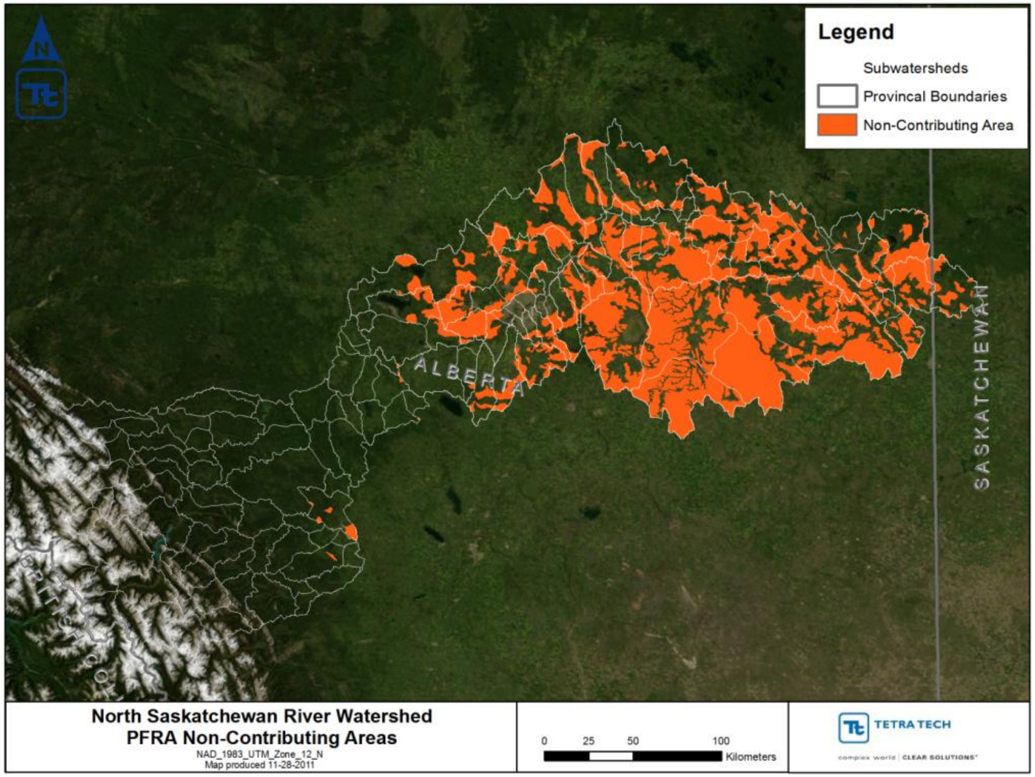
LSPC Enhancements

- ► Improved meteorological input data/snow representation
- ► Increased number of calibration locations
- ► Quantified impact and modelled behavior of hydrologically non-contributing areas
- ► Multi-faceted water quality calibration



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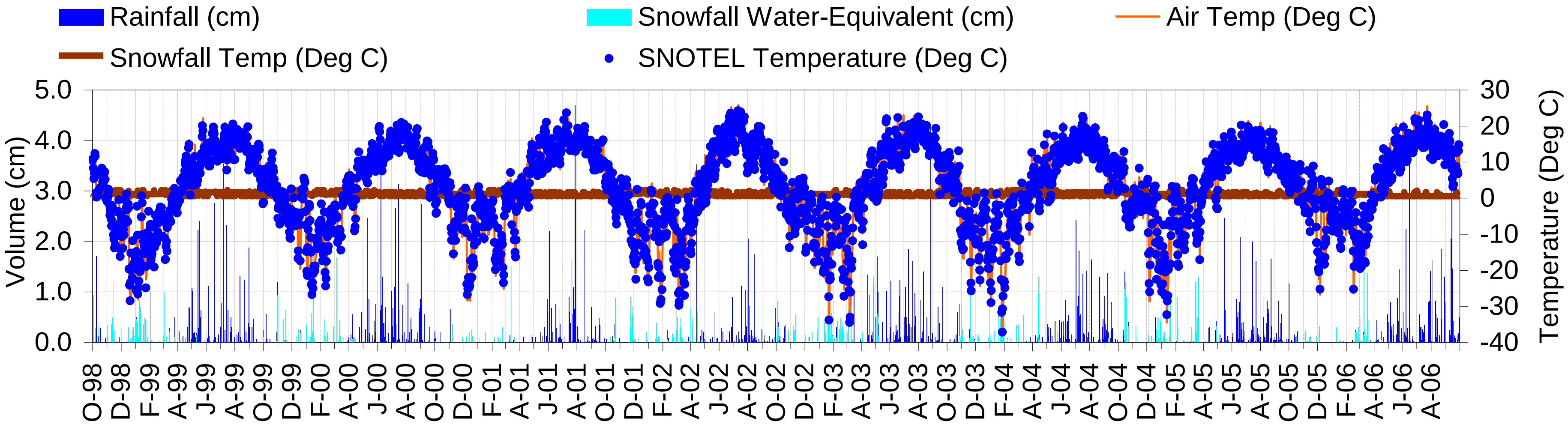

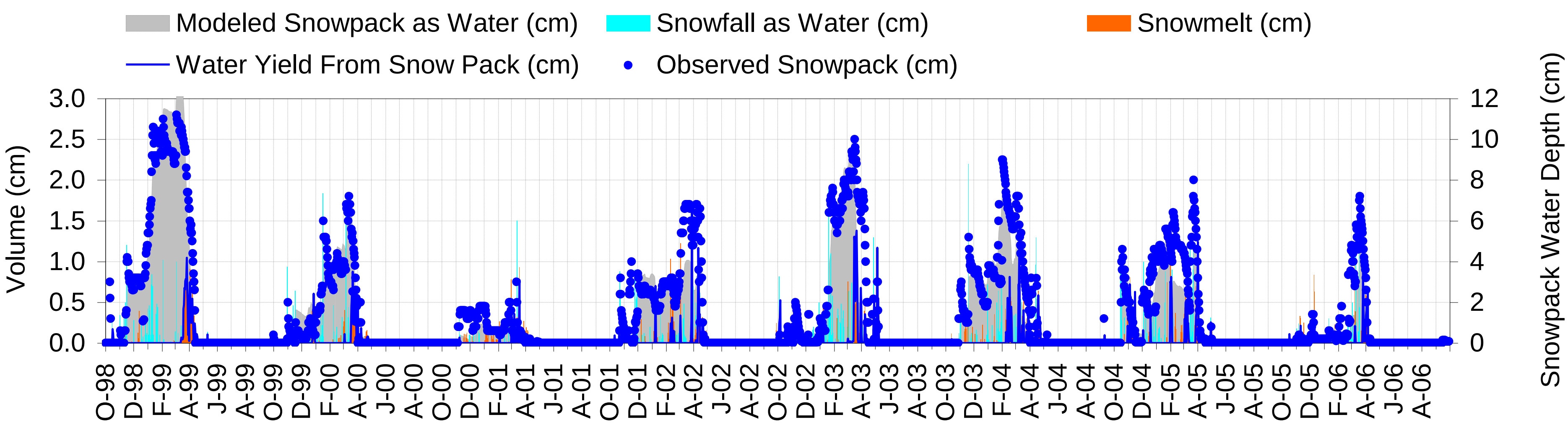

LSPC snow calibration at Edmonton Woodbend (10/1/1998 to 9/30/2006)

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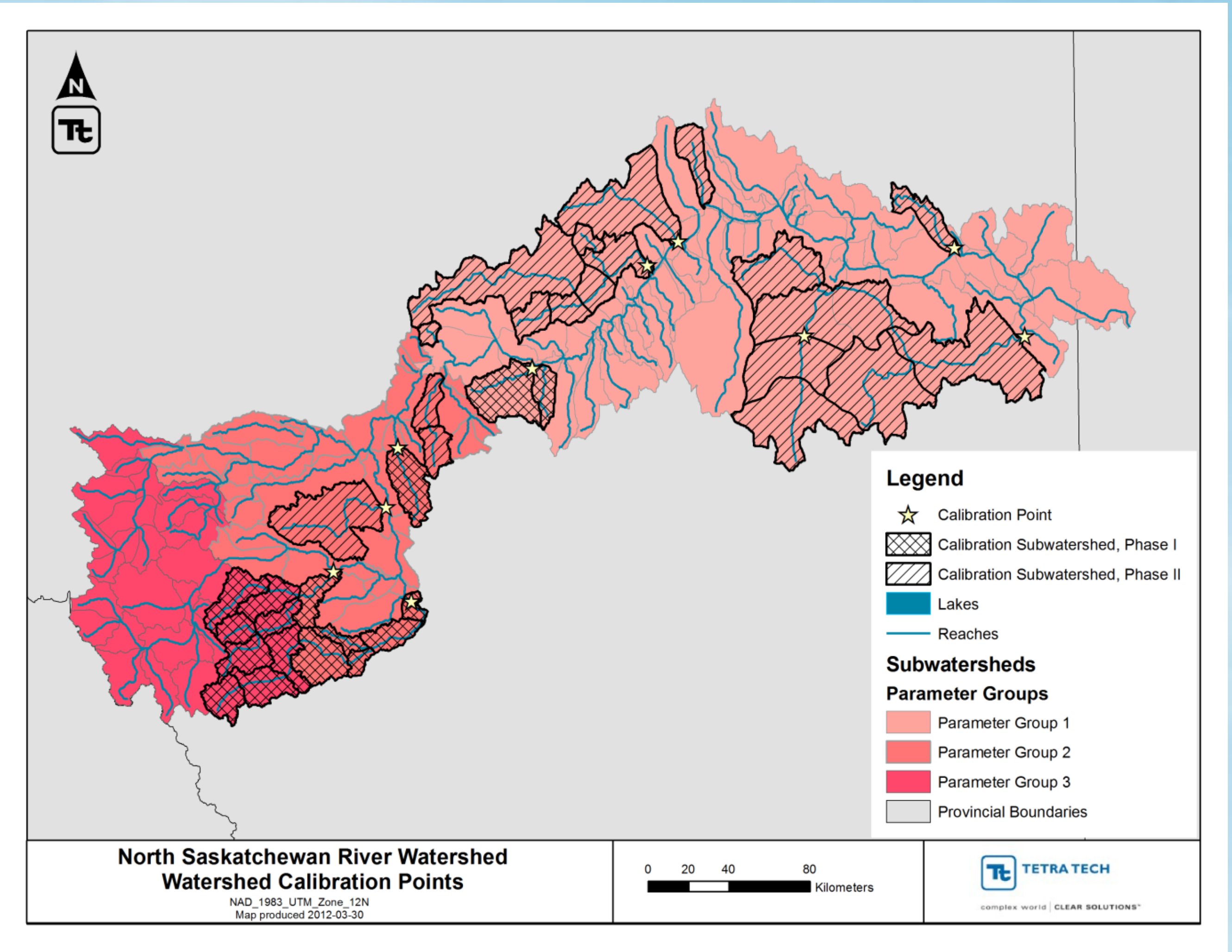
Calibration Locations



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Summary of Seasonal Flow Patterns in NSR Basin

NSR Tributary		Average Elevation (m)	Percent NCA	Peak Flow Month	Percent of Observed Annual Flow	
Name	Gage ID				March-**April**-May	May-**June**-July
Ram River	05DC006	1,807	0.0%	June	20%	61%
Clearwater River	05DB006	1,731	0.0%	June	19%	51%
Baptiste River	05DC012	1,106	0.010%	June	30%	58%
Rose Creek	05DE007	974	0.004%	May	49%	62%
Modeste Creek	05DE911	893	0.0%	April	63%	50%
Tomahawk Creek	05DE009	799	0.0%	April	72%	41%
Strawberry Creek	05DF004	798	0.19%	April	71%	47%
Sturgeon River	05EA001	715	27%	April	82%	37%
Vermillion River	05EE009	673	77%	April	84%	41%
Vermillion River	05EE007	666	74%	April	96%	17%
Waskatenau Creek	05EC002	664	37%	April	92%	14%
Redwater River	05EC005	661	26%	April	90%	34%

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TETRA TECH

NCA – Evaluation of Physical Processes

- Frozen Ground
  - Spring: runoff occurs because ground acts impervious
  - Summer: surface depressions contain most runoff when ground thaws
- Deep Aquifer Recharge
  - Summer/fall: baseflow in streams dissipates
  - Performed full mass balance
    - Maximum potential evapotranspiration had little effect
    - Groundwater recharge was most effective

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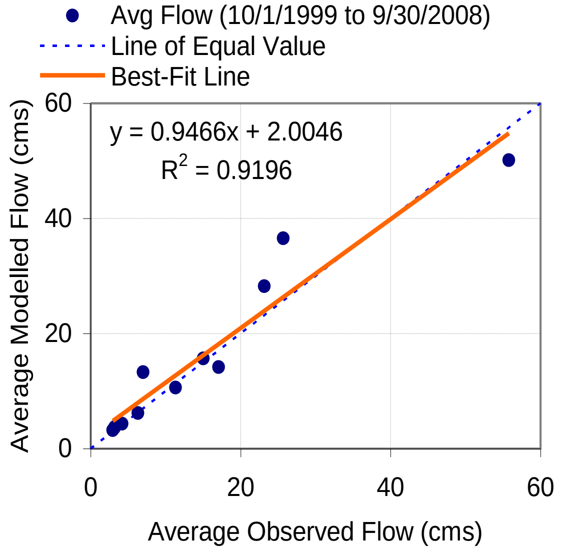
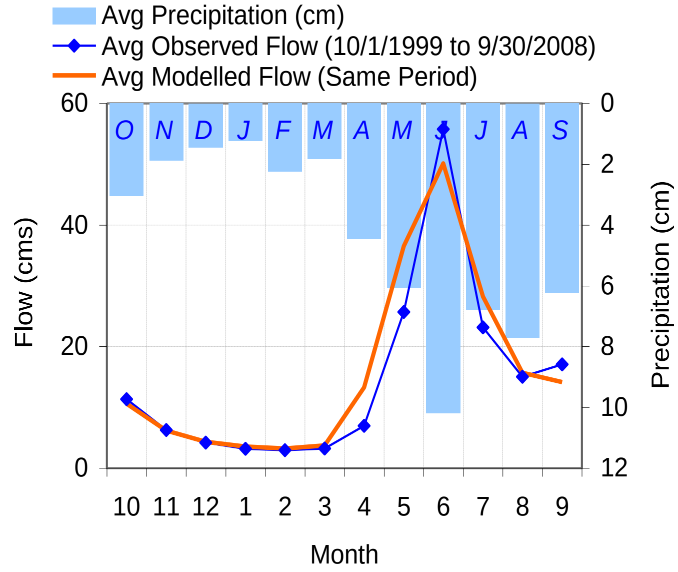
Ram River Gage (05DC006)

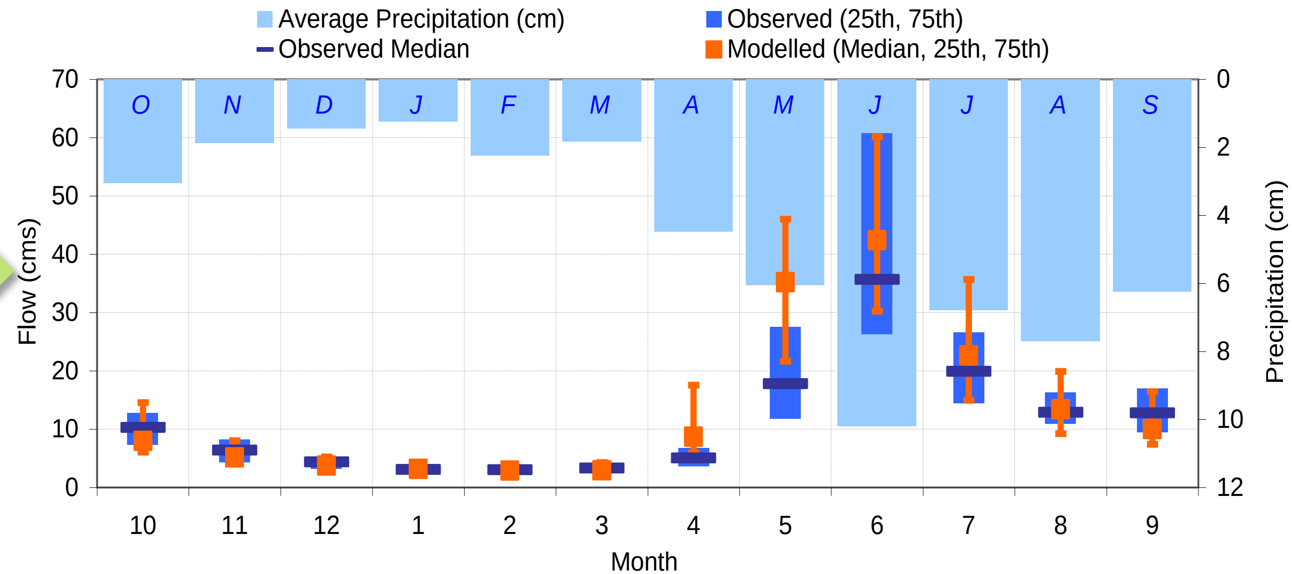
Streamflow Observed vs. Modelled

seasonal / monthly flow





quartile variation



TETRA TECH

Error Statistics: Ram River (LSPC)

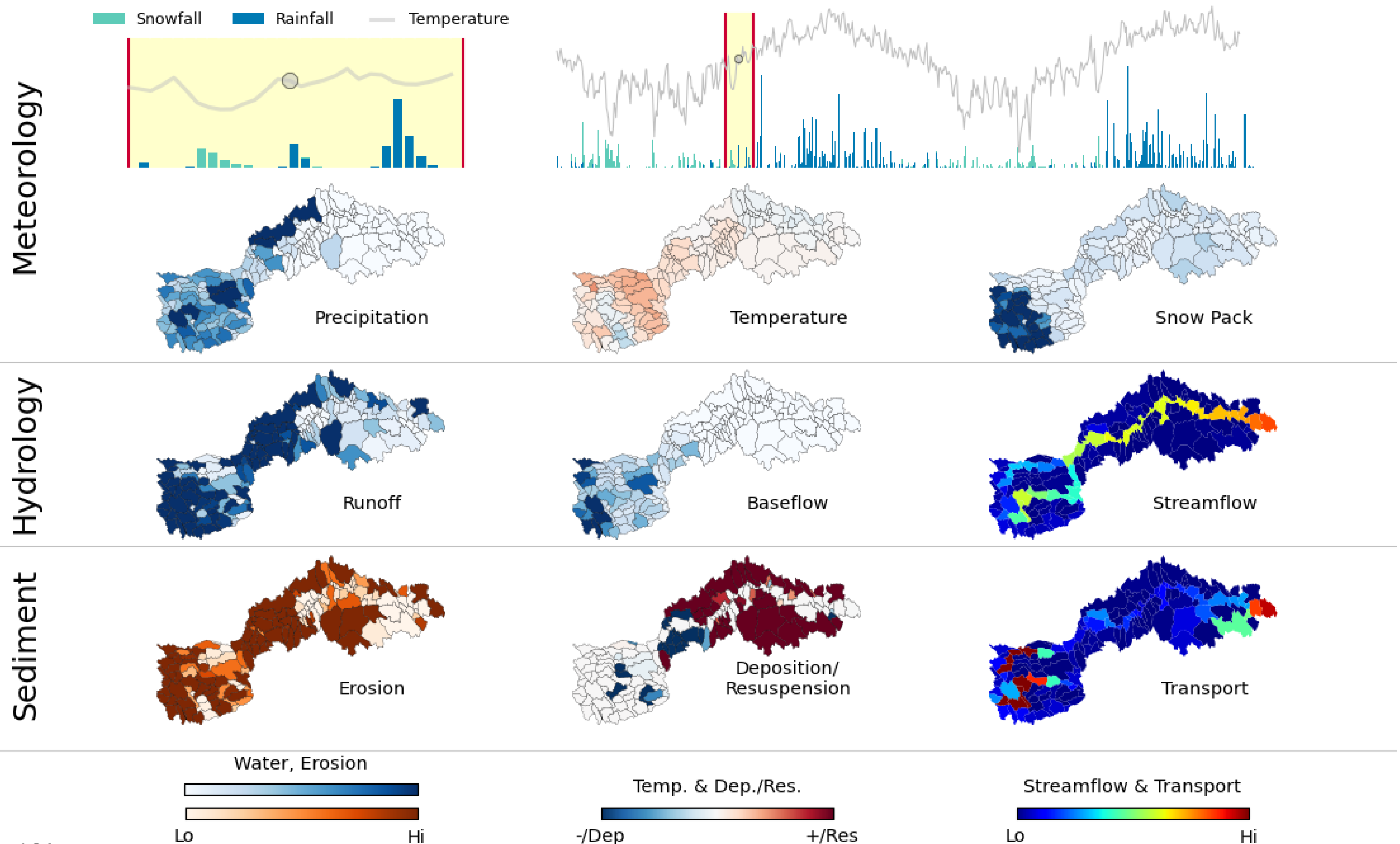
Hydrologic Indicator	Observed (cm/year)	Simulated (cm/year)	Error Statistics	
			Error (%)	Goal (%)
Total In-stream Flow:	24.34	26.43	8.60	±10
Total of lowest 50% flows:	3.35	3.60	7.51	±10
Total of highest 10% flows:	10.90	10.41	-4.55	±15
Summer (months 7-9):	7.75	8.16	5.31	±30
Fall (months 10-12):	3.06	2.96	-3.21	±30
Winter (months 1-3):	1.29	1.45	12.50	±30
Spring (months 4-6):	12.24	13.86	13.22	±30
Total Storm Volume:	5.18	4.56	-11.89	±20
Summer Storm Volume (7-9):	1.16	1.20	3.43	±50
Nash-Sutcliffe Coefficient of Efficiency, E:		0.54	Model accuracy increases	
Baseline adjusted coefficient (Garrick), E':		0.44	as E or E' approaches 1.0	

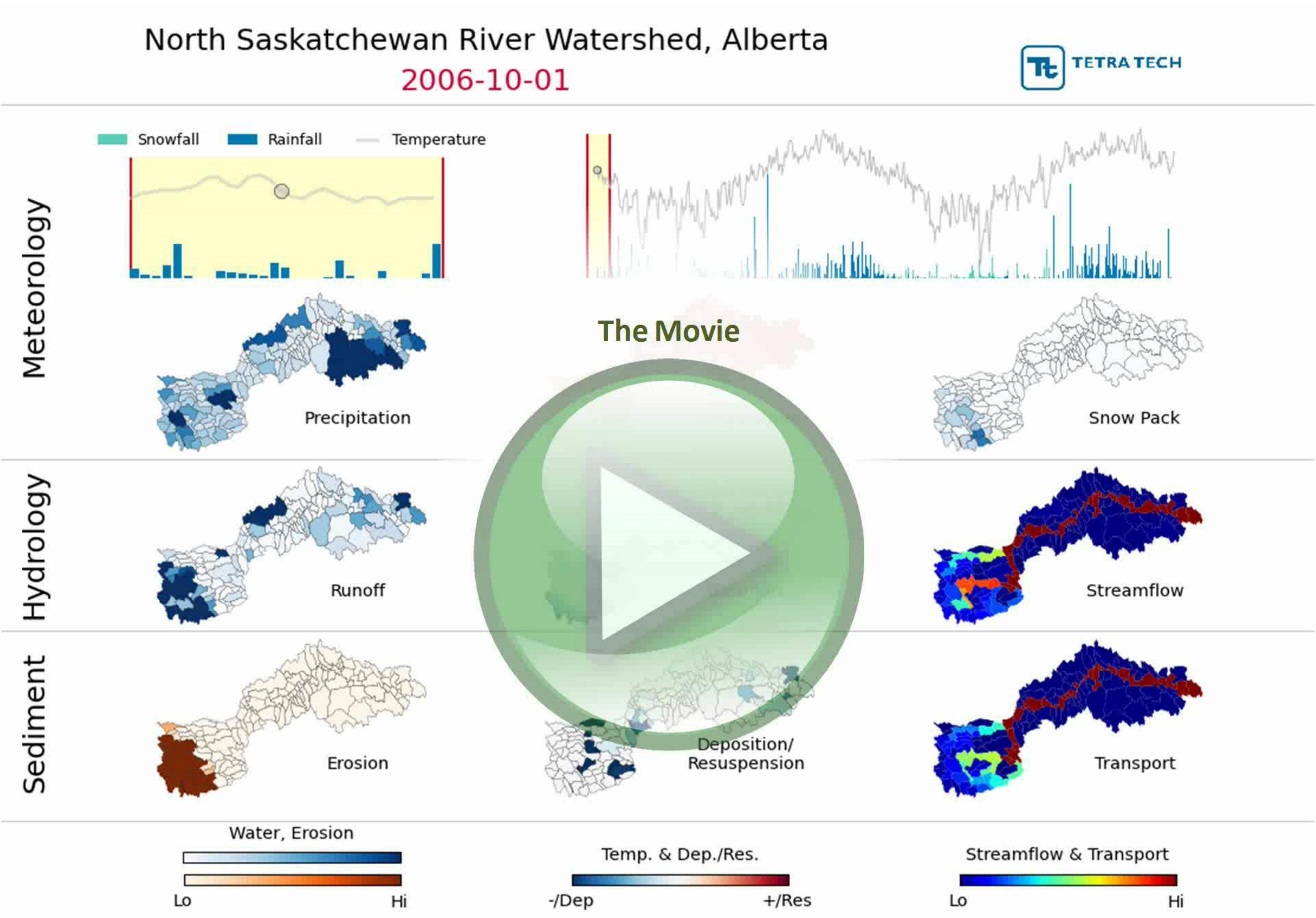
Metrics: HSPEXP, Nash-Sutcliffe, Garrick

North Saskatchewan River Watershed, Alberta

2007-04-09

TETRA TECH



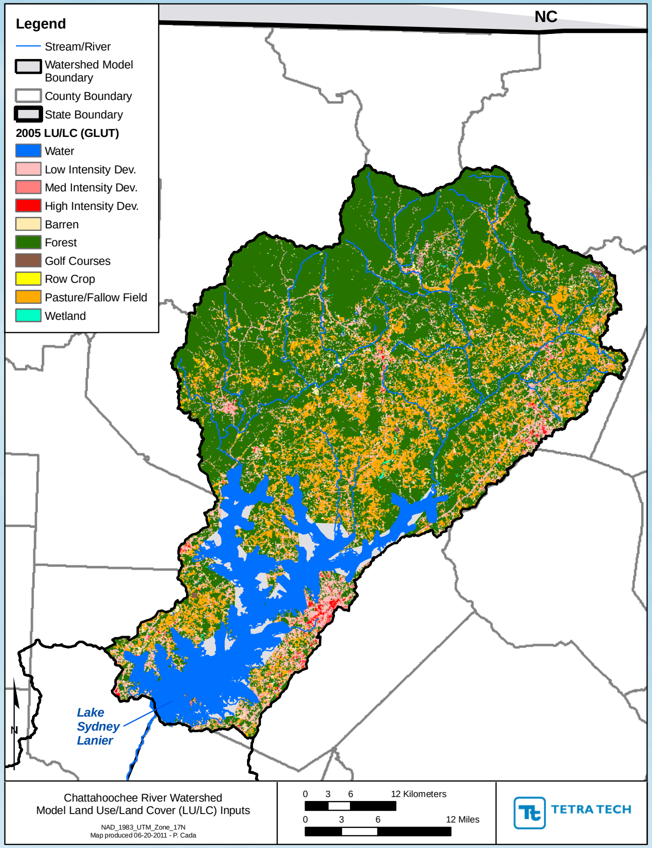

North Saskatchewan River Watershed, Alberta
2006-10-01
TETRA TECH
Snowfall
Rainfall
Temperature
Meteorology
Precipitation
Snow Pack
The Movie
Hydrology
Runoff
Streamflow
Sediment
Erosion
Deposition/
Resuspension
Transport
Water, Erosion
Lo
Hi
Temp. & Dep./Res.
-/Dep
+/Res
Streamflow & Transport
Lo
Hi

TETRA TECH

Lake Lanier

LSPC → EFDC

- Multi-purpose application
- Reservoir operations (Army Corps of Engineers)
- TMDL and wasteload allocations (Georgia EPD and USEPA)
- Landuse management for development



TETRA TECH

Concentrations:
Chl-a, TN, NH_3, NOx, OrgN, TP, PO_4, OrgP, BOD, DO, Temp, TSS, Fecal

LSPC

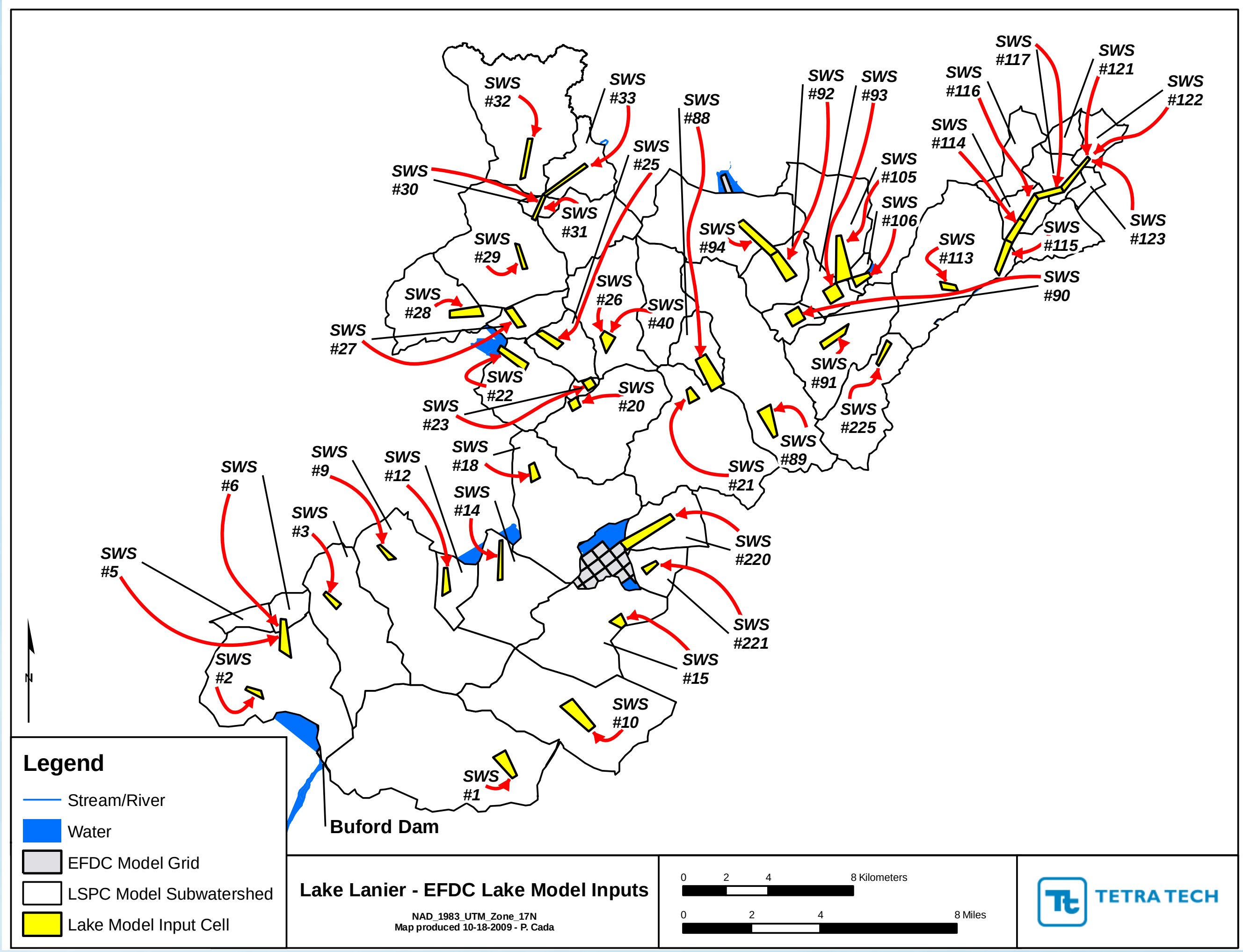
↓

Flows
Temperatures
Concentrations

↓

EFDC

Lake/Harbor – Water Surface
River/Lakes – Temperatures
River/Lake/Harbor
Concentrations:
(Chl-a, TN, NH_3, NOx, OrgN, TP, PO_4, OrgP, BOD, DO, Temp)



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TETRA TECH

Scenarios

- Historical and current conditions
- Current conditions with allowable permits
- Current conditions w/ point sources/withdrawals removed
- All forested/natural
- Future land use full build-out
- Future land use w/ point sources/withdrawals removed
- Nonpoint source management practices
- TMDL to meet water quality criteria
  - Landuse and point source-specific reductions
- Reservoir operational changes

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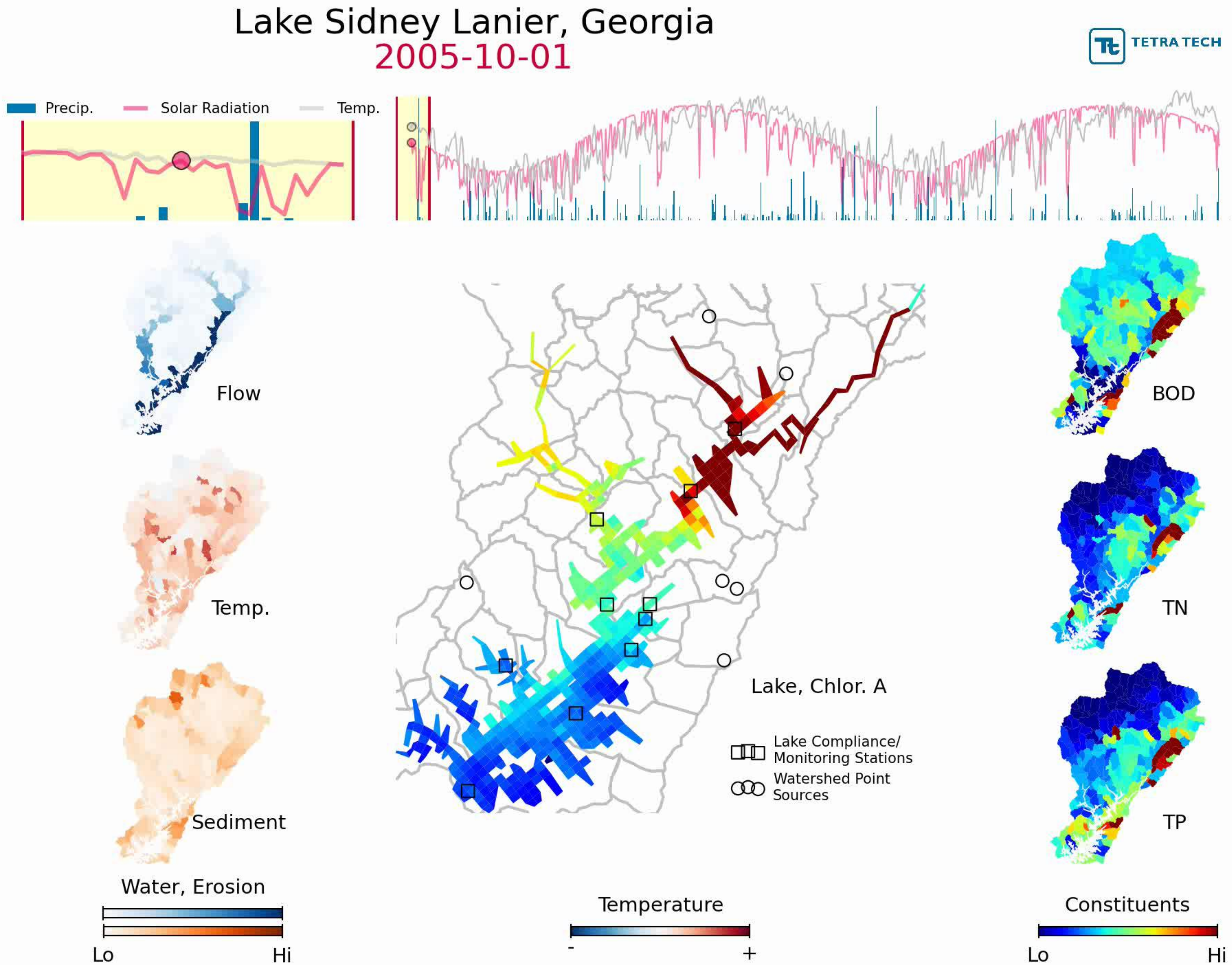
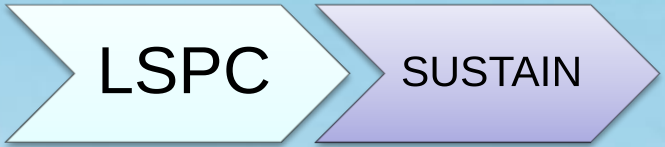

Lake Sidney Lanier, Georgia
2005-10-01
TETRA TECH
Precip.
Solar Radiation
Temp.
Flow
Temp.
Sediment
Water, Erosion
Lo
Hi
Lake, Chlor. A
Lake Compliance/
Monitoring Stations
Watershed Point
Sources
Temperature
-
+
BOD
TN
TP
Constituents
Lo
Hi

TETRA TECH

Milwaukee Metropolitan Sewer District



- Explored ability of green infrastructure to reduce combined sewer overflows
- Benefits measured by:
  - Environmental outcomes (pollution reductions)
  - Economic and social outcomes (triple bottom line)
- Applied SUSTAIN linked to LSPC

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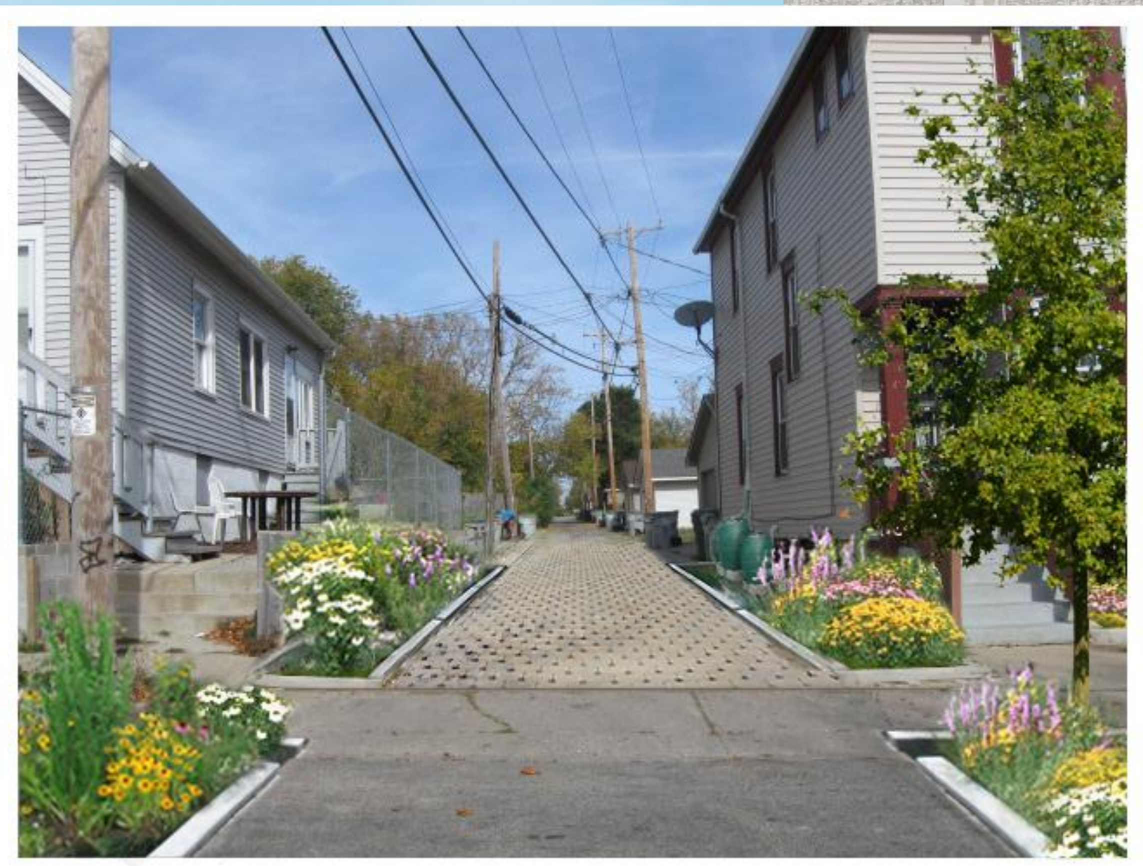
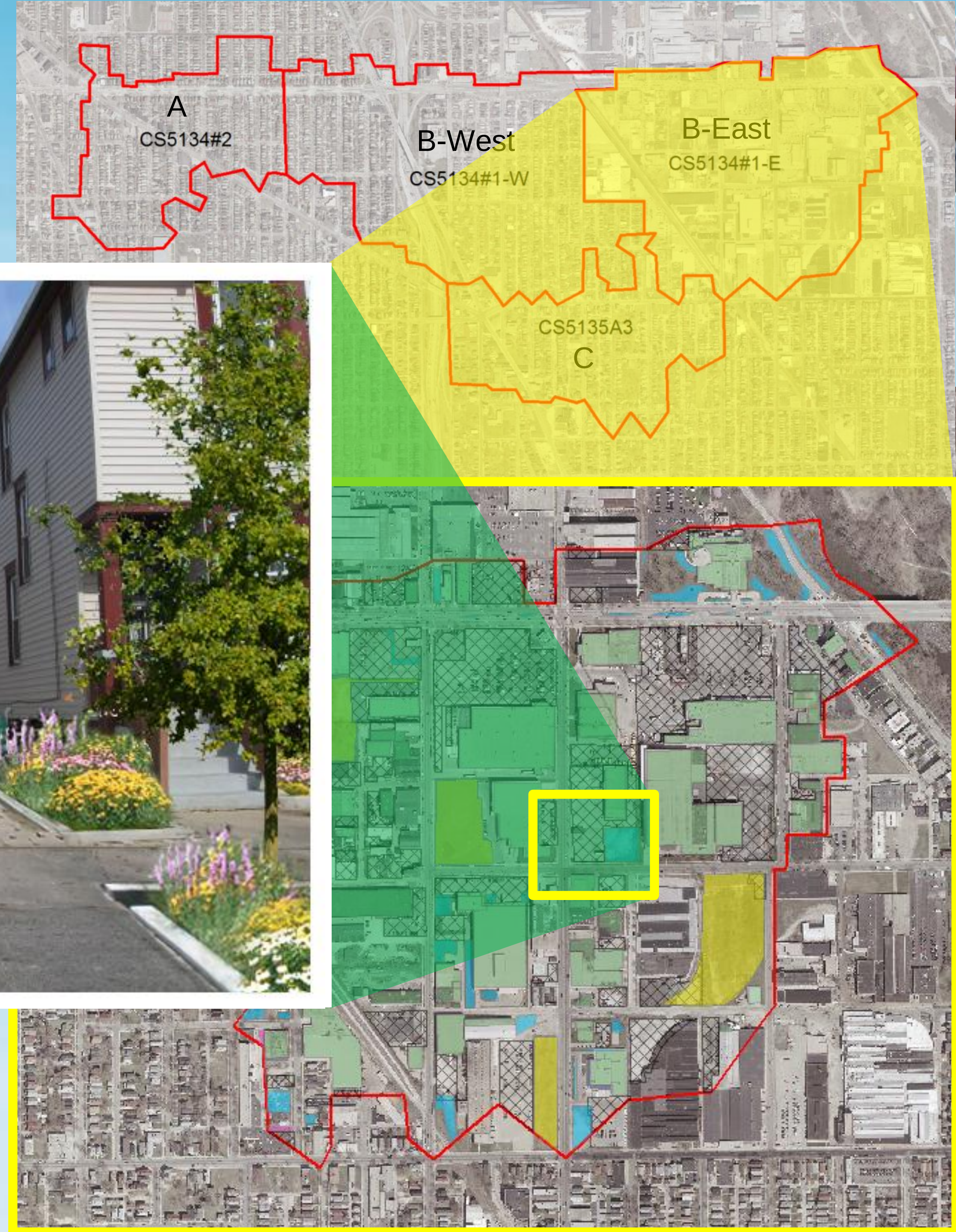
TETRA TECH



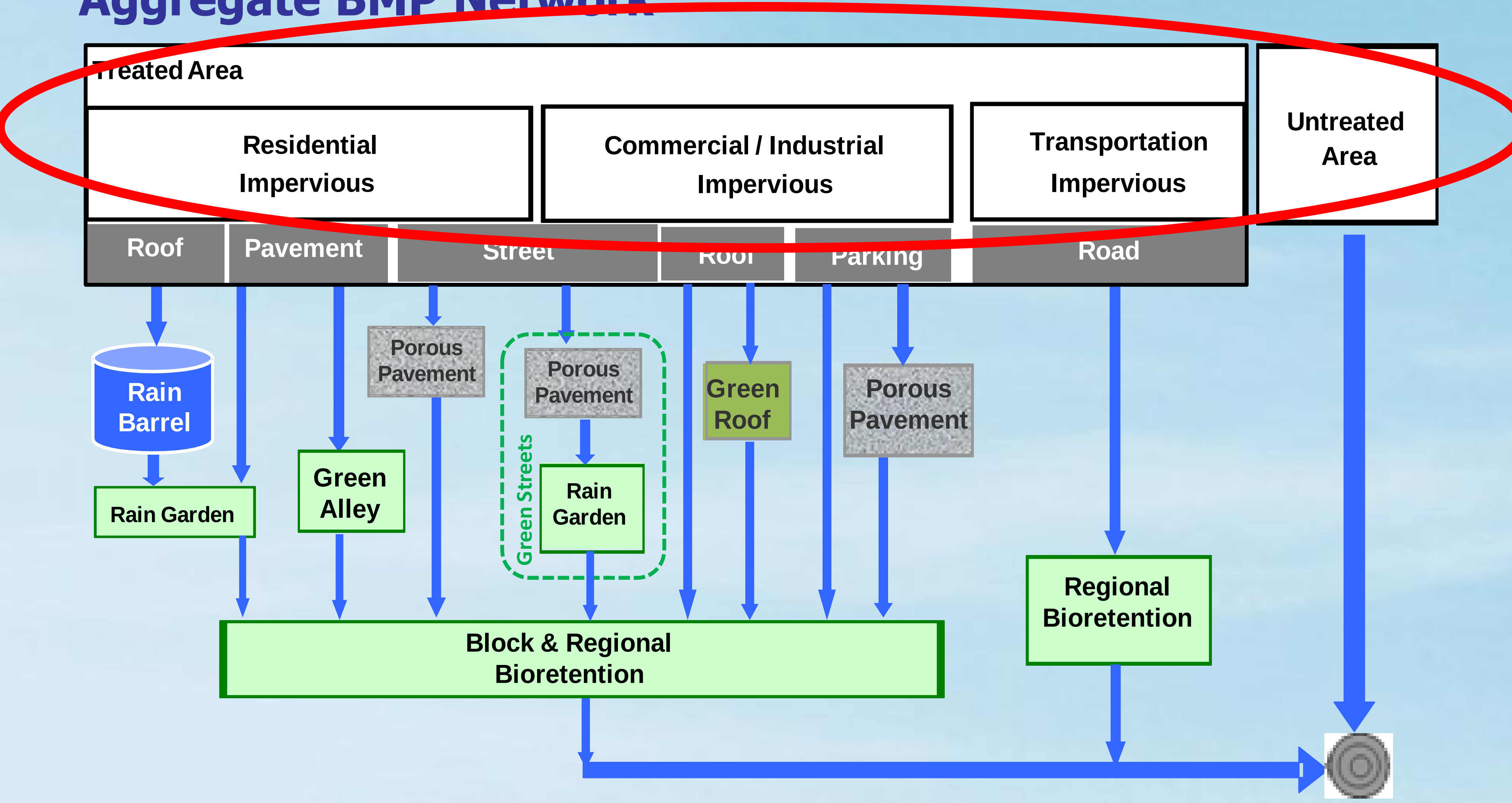


Potential Types and Locations

TETRA TECH

BMP Configuration:
Aggregate BMP Network

From LSPC model



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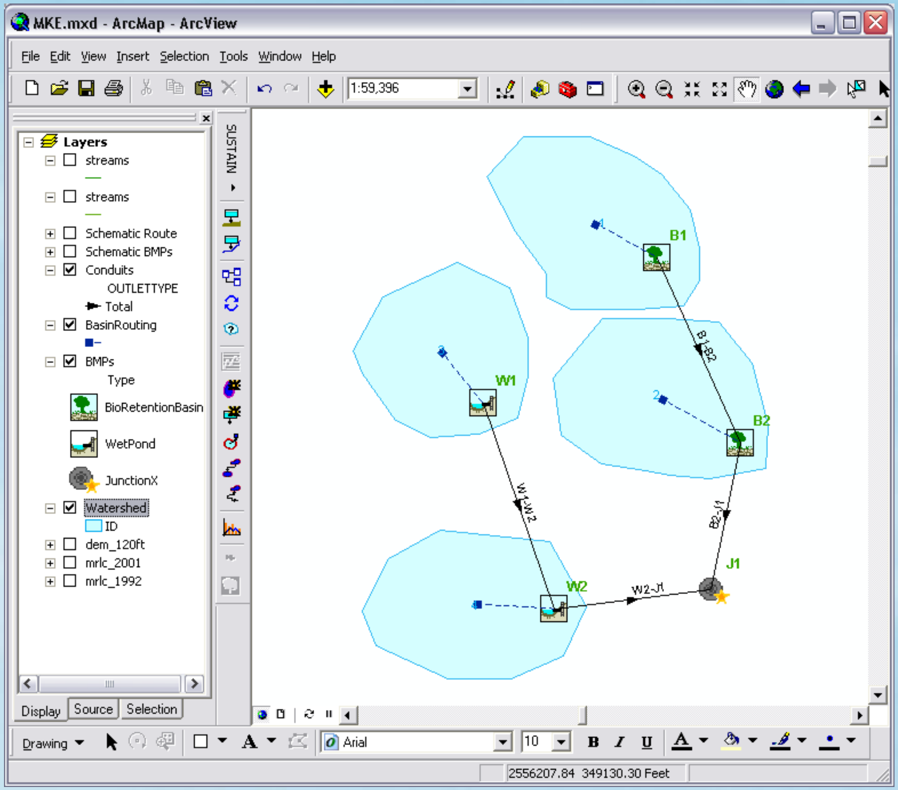
TETRA TECH

Selection and Placement Optimization

- BMP Configuration
  - Map all potential locations
  - Typical routing configuration
  - Unit cost (scalable)
- Decision Variables
  - BMP Size (0 to maximum)
  - BMP Location (on or off)
- Objectives
  - Minimize Cost
  - Maximize Volume Reduction



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TETRA T

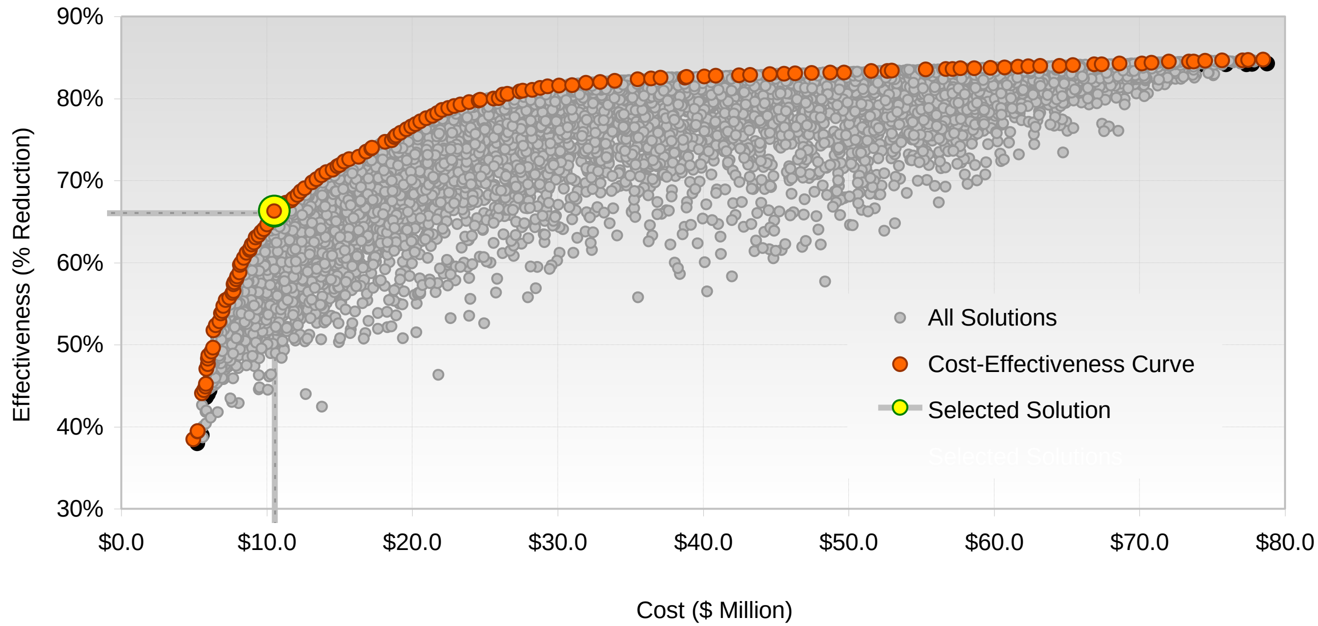
Cost-effective Solutions

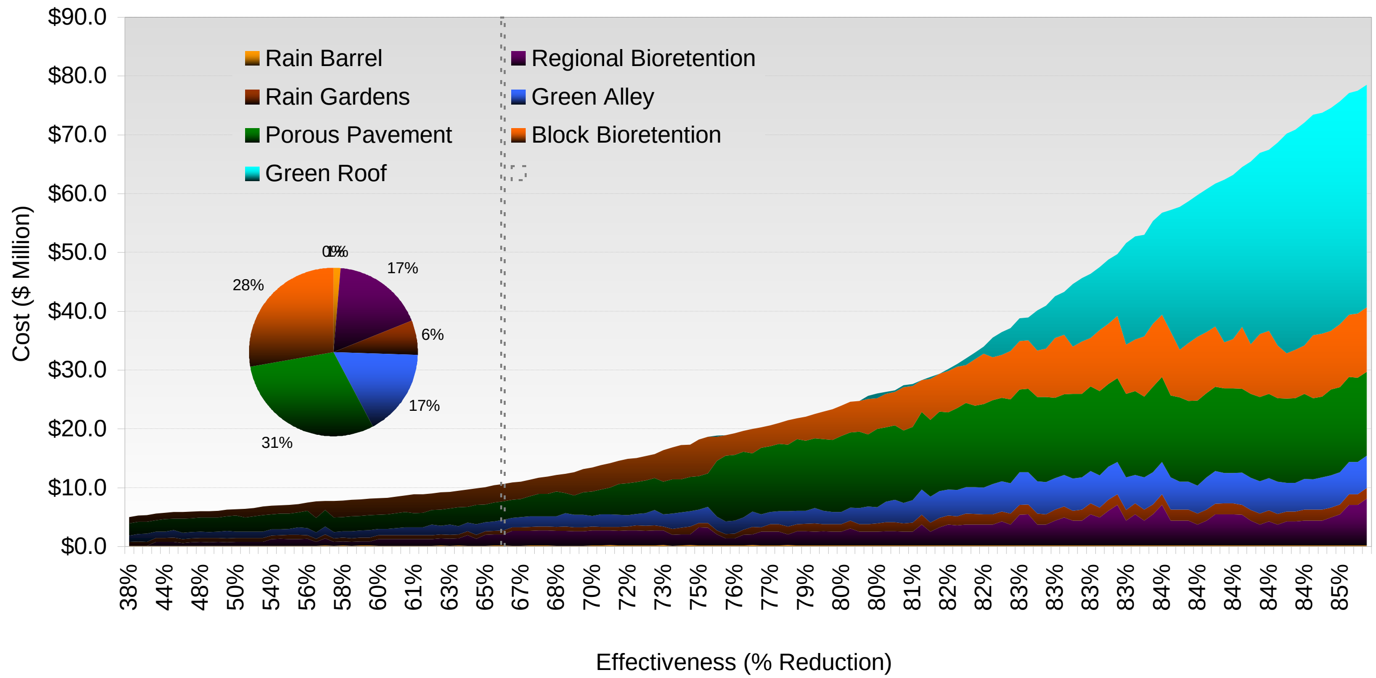
- Reduction:

  66.0%

- Cost:

  $10.6 Mil





TETRA TECH

Thank you!

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Brandon Wood

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Day 1 – Session 1

Dan Sheer – Hydrologics

BIOGRAPHY

Dan Sheer earned his Ph.D. at the Johns Hopkins University in 1975. At the Interstate Commission on the Potomac River Basin, he helped resolve the long standing water supply dispute between Maryland, Virginia, The District of Columbia, and the U.S. Government concerning Washington Metro Area water supply. He developed and applied a range of water resources systems techniques, including collaborative modelling and gaming, to achieve this award winning success. In 1985 he left his position as Technical Director to found HydroLogics, in order to expand the application of those techniques to other basins. HydroLogics now helps manage water in river basins containing about 20% of the US population. The firm has been instrumental in the resolution of some of the most complex water disputes of the last 30 years, and has worked internationally, particularly in China and Canada. Clients include the Delaware and the Susquehanna River Basin Commissions, the South Florida Water Management District, the Southern Nevada Water Authority, many states and cities, The Nature Conservancy, several hydropower utilities, and many others. HydroLogics OASIS software is one of the most widely used water management planning and management tools.

Day 1 – Session 1

Dan Sheer – Hydrologics

ABSTRACT

Water management is about obtaining the most appropriate and beneficial mix of multiple types of benefits from water resources. Social and governmental values determine what constitutes an appropriate benefit and how the achievement of those benefits should be balanced to provide the best mix. Science cannot determine what values are appropriate nor how they should be balanced.

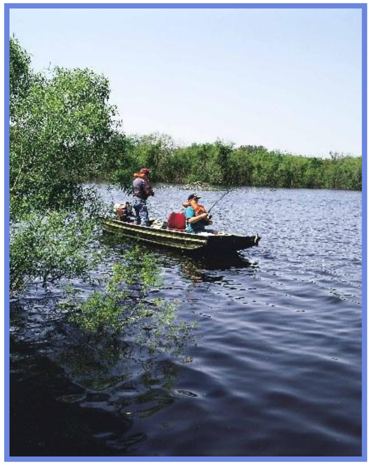
Science, largely through the use of management models, can predict with some limited accuracy and precision the effect that existing and proposed management actions will have on benefits derived from water resources. The focus of this presentation will be on how models can be designed or chosen and then used for this function, and how modelling results can be made most useful and informative to water managers, decision makers, and the public. The talk will draw on examples from the author's long experience in the field.

It will cover:

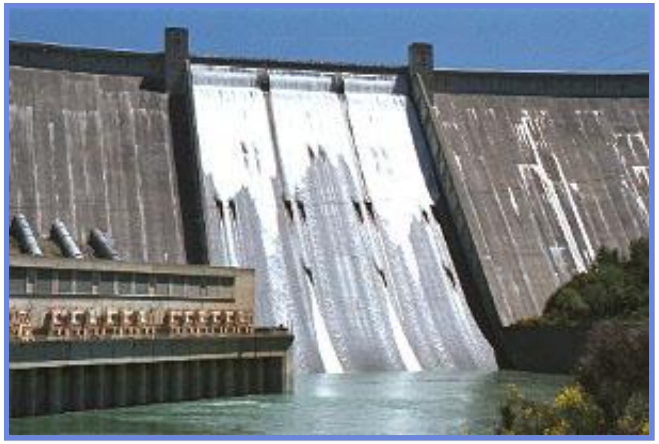
· developing performance metrics
· designing models and post-processors to display those metrics
· ensuring model credibility
· ensuring that models can evaluate all candidate alternatives
· the modeler's responsibility to ensure that, in so far as possible, alternatives that provide the most effective (non-inferior) mixes of possible benefits are identified

HYDROLOGICS

Advancing the management of water resources



Using Models in Water Management:
Philosophy, Principles and Practice



Daniel P. Sheer, Ph.D., P.E.

President, HydroLogics Inc.

March 13, 2013

Presenter
Daniel P. Sheer
June 24, 2002

HydroLogics, Inc. Office Locations

10440 Shaker Dr., Ste. 104
Columbia, MD 21046
410-715-0557

811 Mordecai Dr., Ste. 200
Raleigh, NC 27604
919-856-1288

1851 Heritage Lane, Ste. 130
Sacramento, CA 95815
916-920-1811

Management is about Values

- We manage to achieve the things we want, i.e. to advance our VALUES
- “What do we WANT?” is NOT a scientific question
- “What can we GET by managing” IS a scientific question
- MODELS can help determine what we can GET and HOW we can get it

Management Models:

- Predict the likely OUTCOME of human actions
- Produce output that relates the outcome to human VALUES
- Use scientific cause and effect or empirical relationships to make the predictions and to produce the output

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Management Models vs. Research Models

- Research models try to simulate history in order to determine how the world works
- Management models assume that we know how the world works, and try to evaluate the impacts of actual and potential human actions on the future

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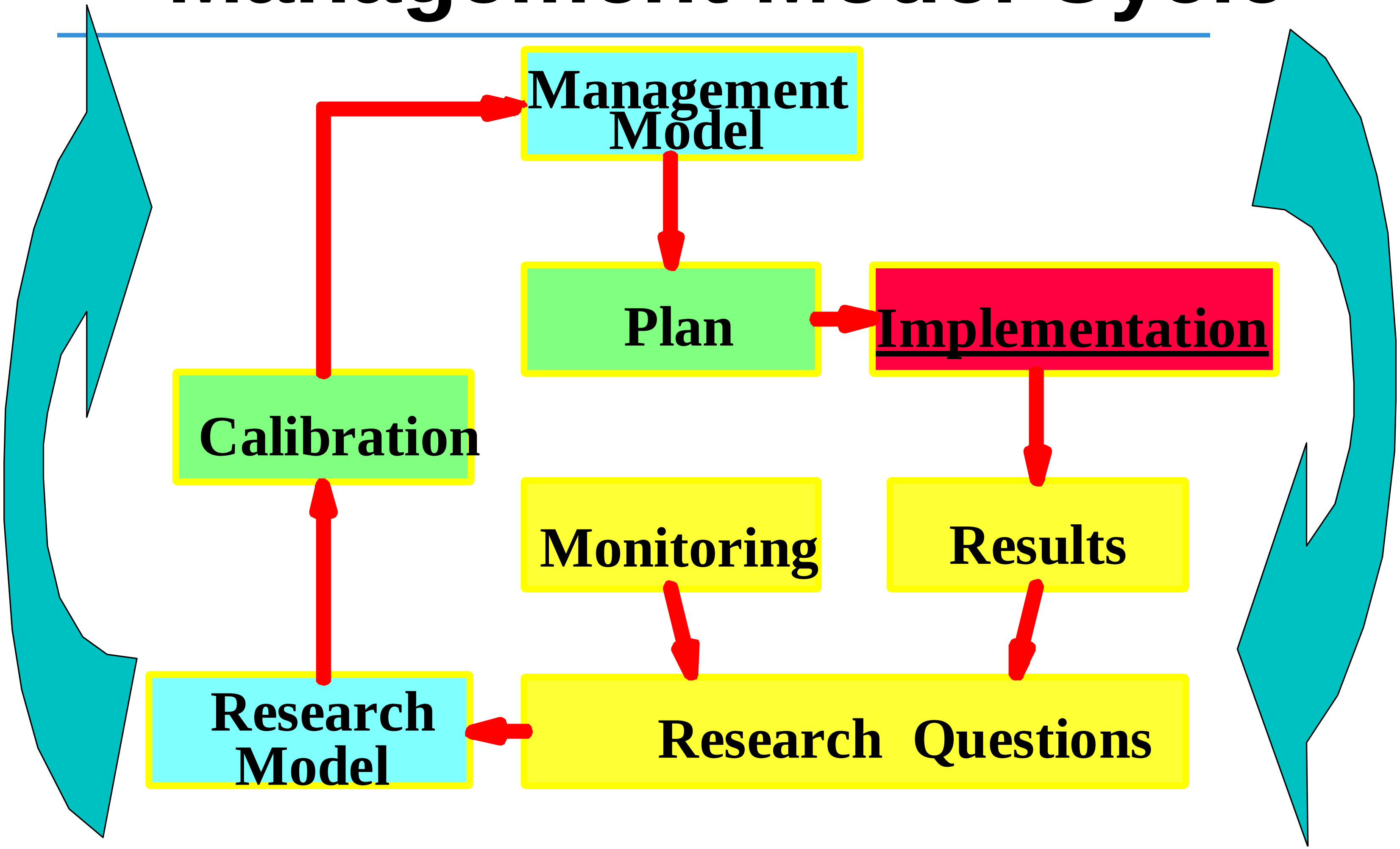
The Research Model - Management Model Cycle



Models are “Needy Beasts”

- Models require care and feeding
  - Data
  - Methods
  - This must be provided
- Models need the ability to simulate different kinds of human behavior
  - Users can’t give this to models – they have to be born this way

Management is a Form of Human Behavior

- Rational (linking actions to desired outcomes), one would hope
- Management models must let us test alternative human behaviors
  - Different operating policies
  - Building and operating new things
  - Changing values
  - Leaving things alone

A “Model” of Human Behavior

- Short-term objectives and constraints
  - Determined by current factors
- Rules set short-term objectives and constraints
- Rules evolve (or are designed) to obtain long-term objectives
- Actions affect the environment which then determines current factors……..

A Management Model Has

- Time series of external data that “drive” the model (boundary conditions)
- Science that links the drivers and human responses to determine what happens (system state)
- Rules that dictate human reactions, including short-term optimization

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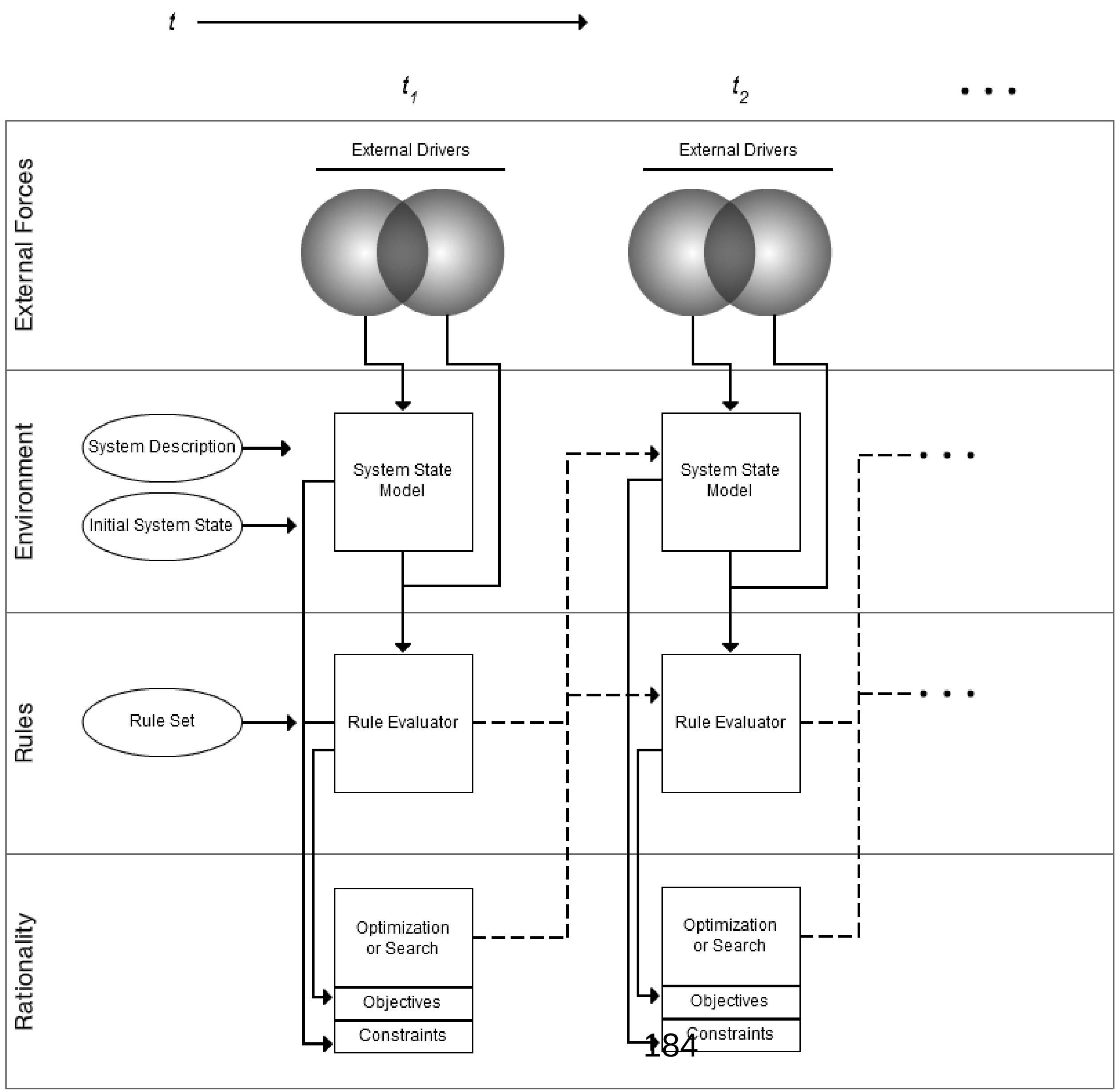
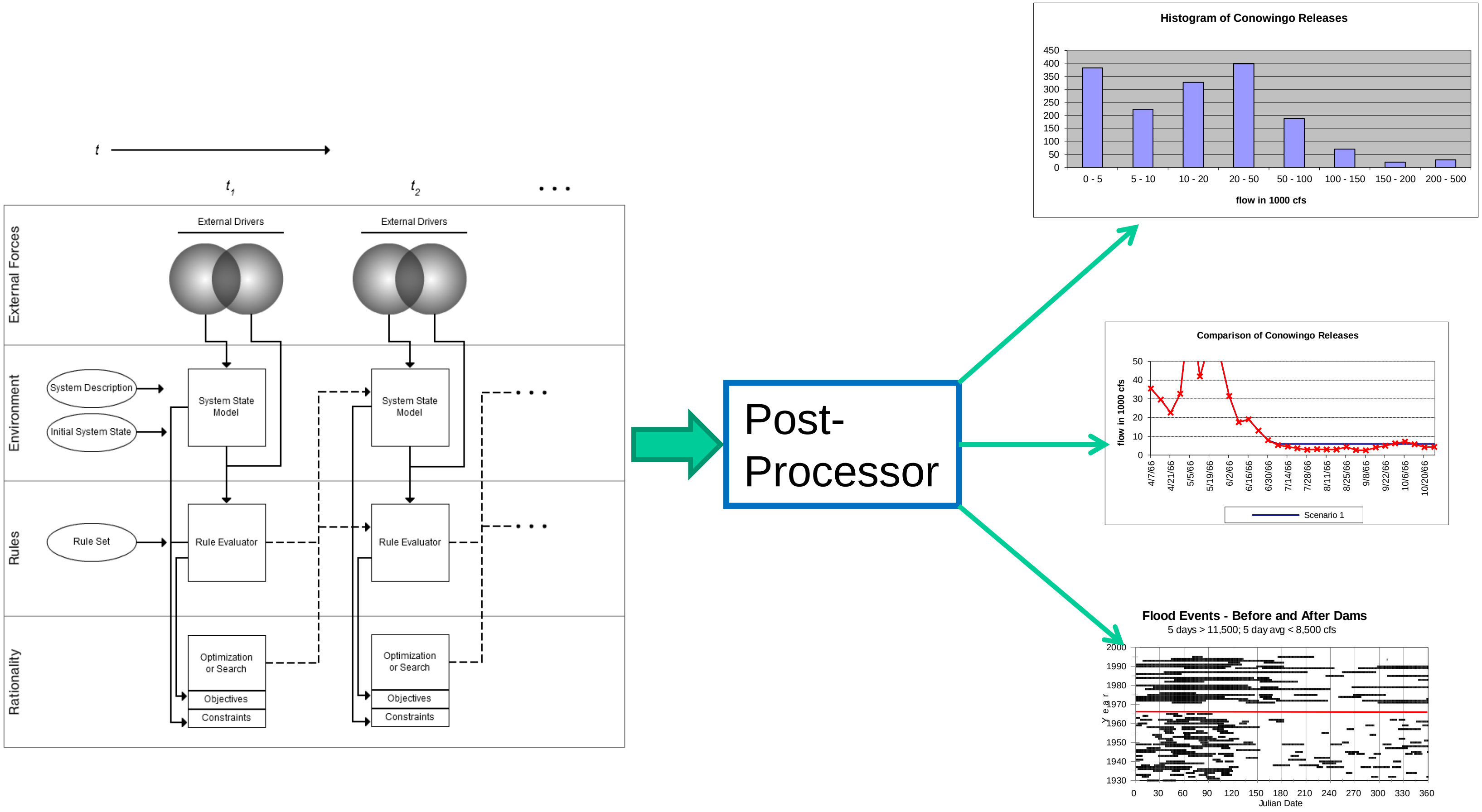
Generalized Management Model Schematic



Post-Processors Convert Model Output to PMs Based on Science



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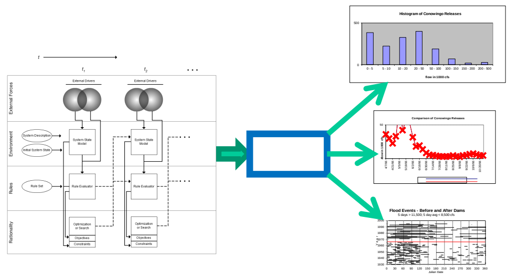
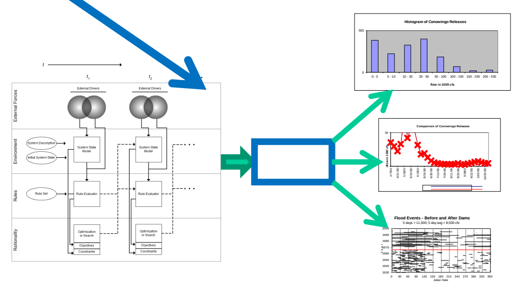
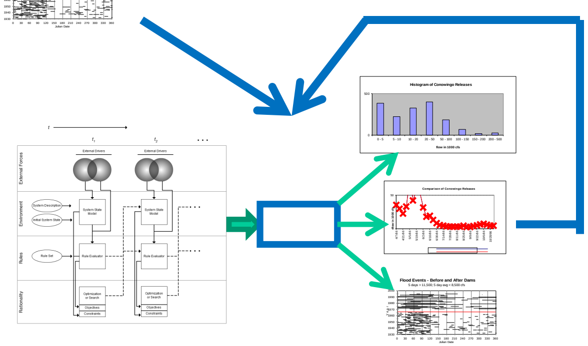
Using Management Models



1. Evaluate natural/current base case(s)



2. Evaluate alternative that improves PMs



3. Lather, rinse and repeat until satisfied (or exhausted)

HYDROLOGICS

Rule Inputs

- Rules have both forms and parameters
- Rules can be static or dynamic
  - FITFIR
  - Reservoir Rule Curves
  - Minimum Flows
  - Conservation practices
  - Habitat creation
  - Objectives and constraints for optimization

New Rule Forms are Important

- Imagination is limited by tools
- Models should accommodate the widest reasonable range of rule forms
- Dynamic rules depend on system state and external drivers
- Optimization rules require an optimizer
- Some sort of scripting language is needed to change the forms of rules

Management Model Output (PMs)

- Surrogates for short- and long-term objectives
- Most management PMs long-term, but not all
- Most benefits from water resources are local, so PMs for water resources are unique to locale

HYDROLOGICS

Human Behavior Targets Values (Performance Measures)

- PM design is the most intellectually demanding part of the modeling process
- Management Models must produce PMs
- Managers generally try to achieve short term PMs as surrogates for improving long term performance

What Is A Performance Measure?

- A display
- Compares alternatives for one management objective
- Needs only to distinguish "better" and "worse"
- Water management is multi-objective
- Multiple performance measures are required

Performance Measures Must Be:

- Meaningful and Understandable
- Credible
- Reproducible

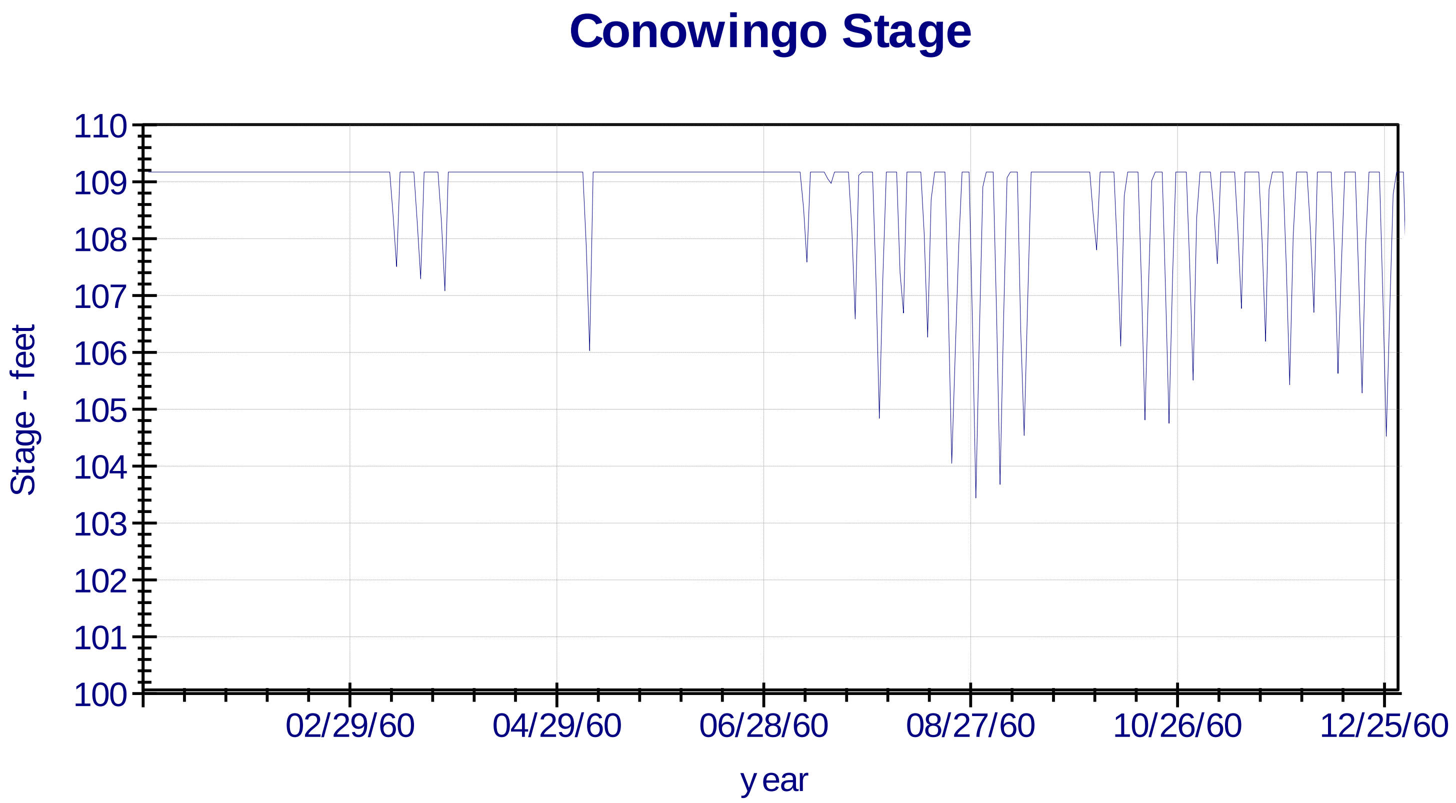
HYDROLOGICS

Performance Measures

- Providing meaningful ways to compare alternatives is very challenging
- Biological issues are often the most difficult
- HydroLogics has a process for producing such displays

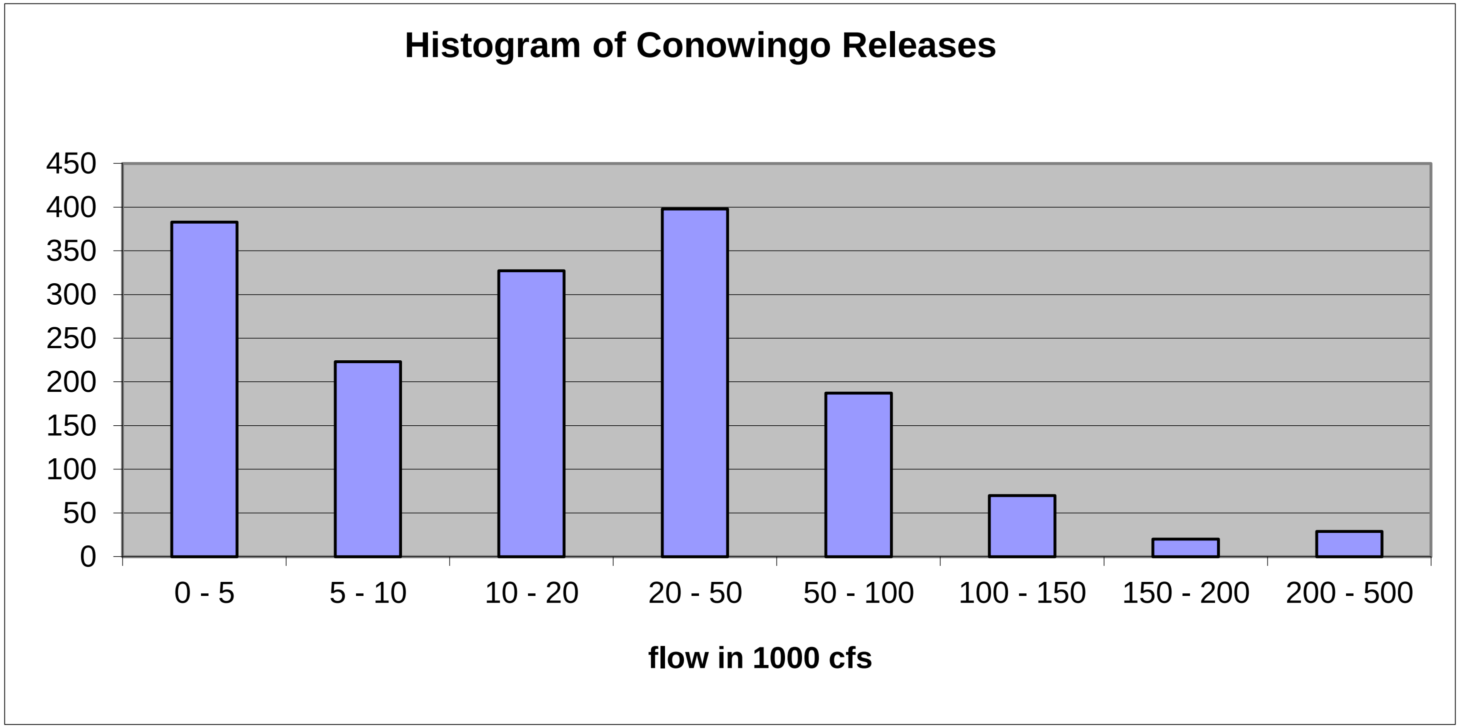
HYDROLOGICS

Performance Measures

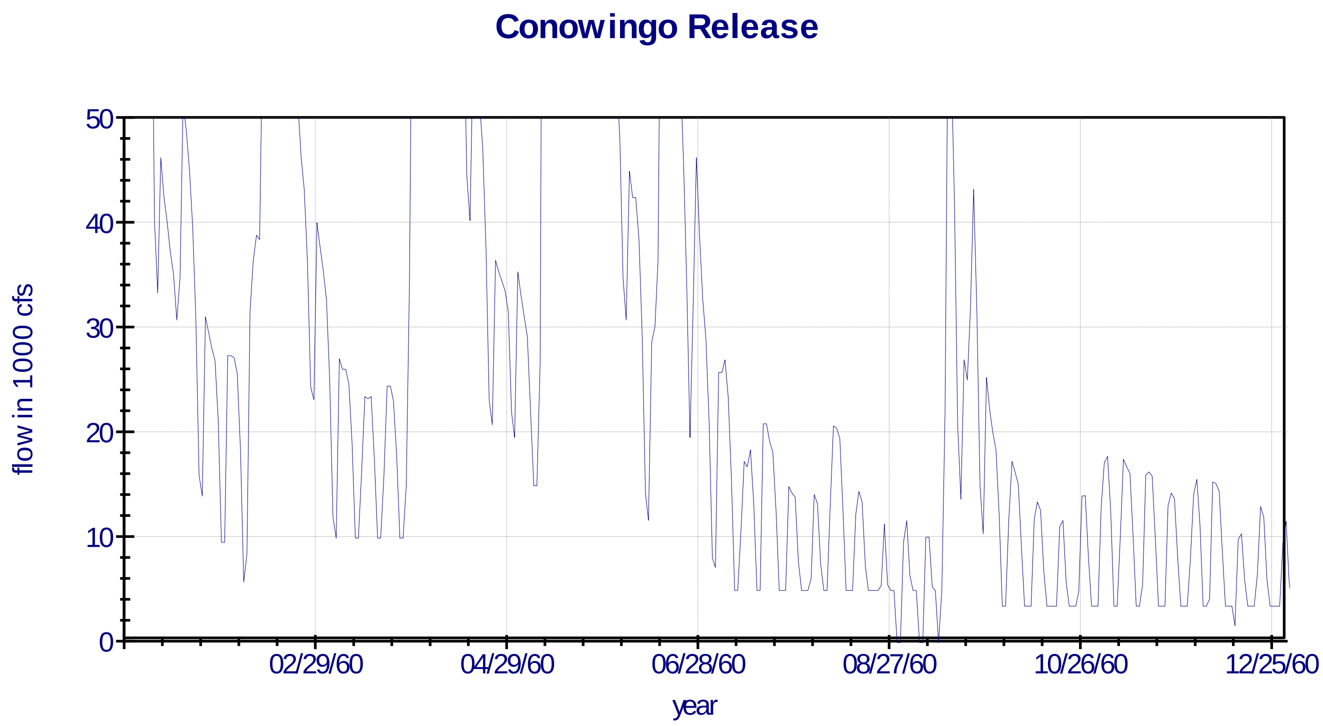


HYDROLOGICS

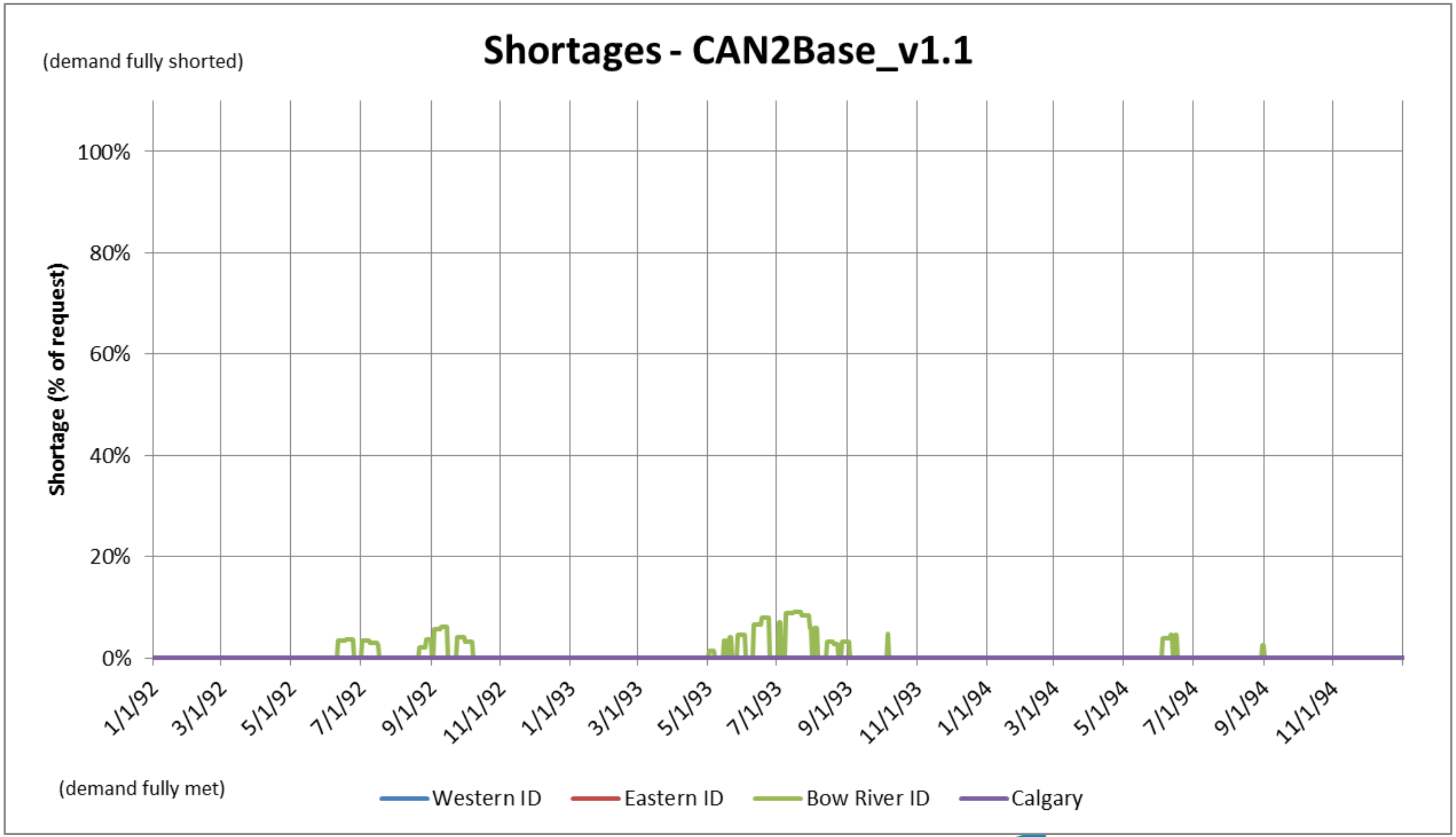
Performance Measures



Performance Measures

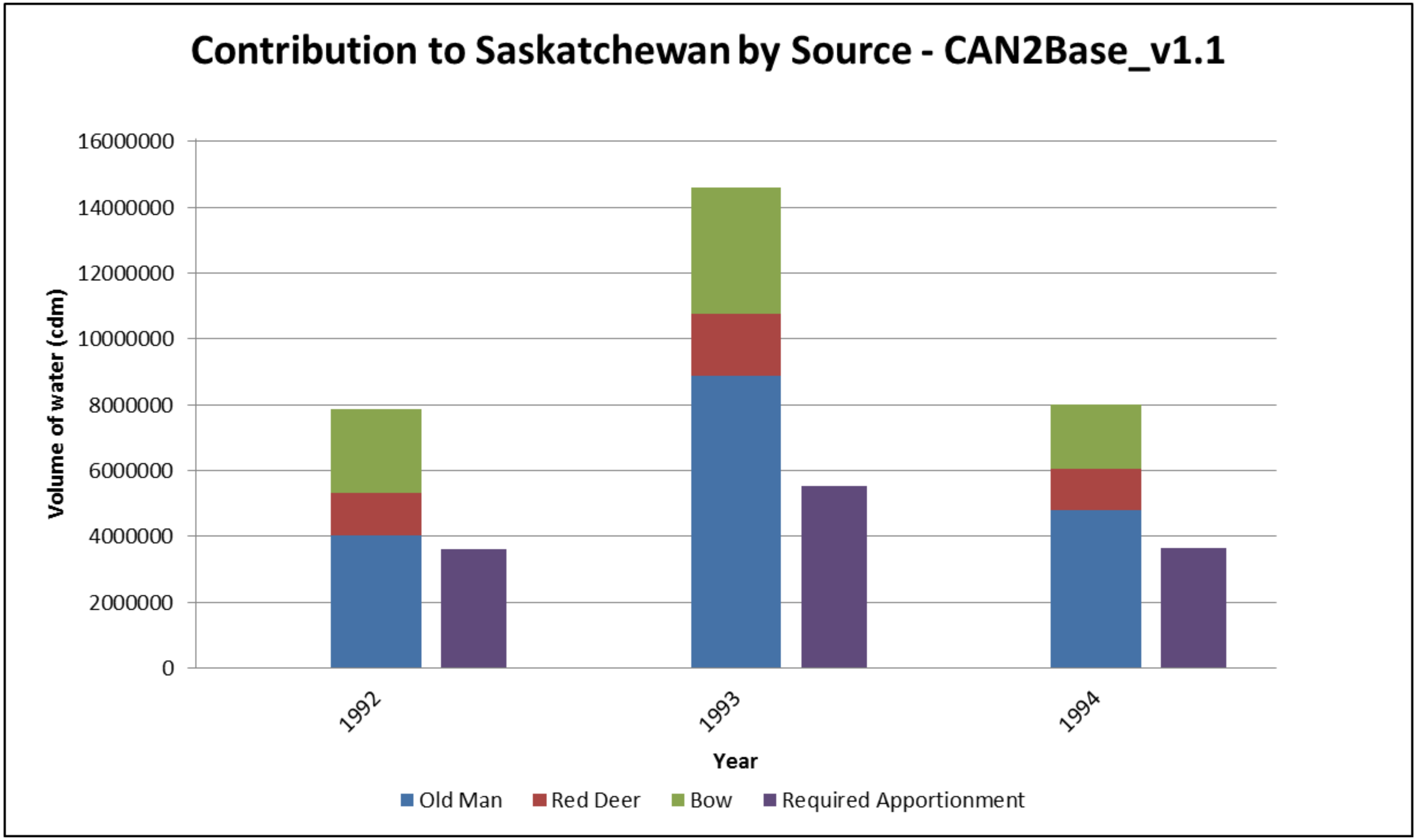


Performance Measures



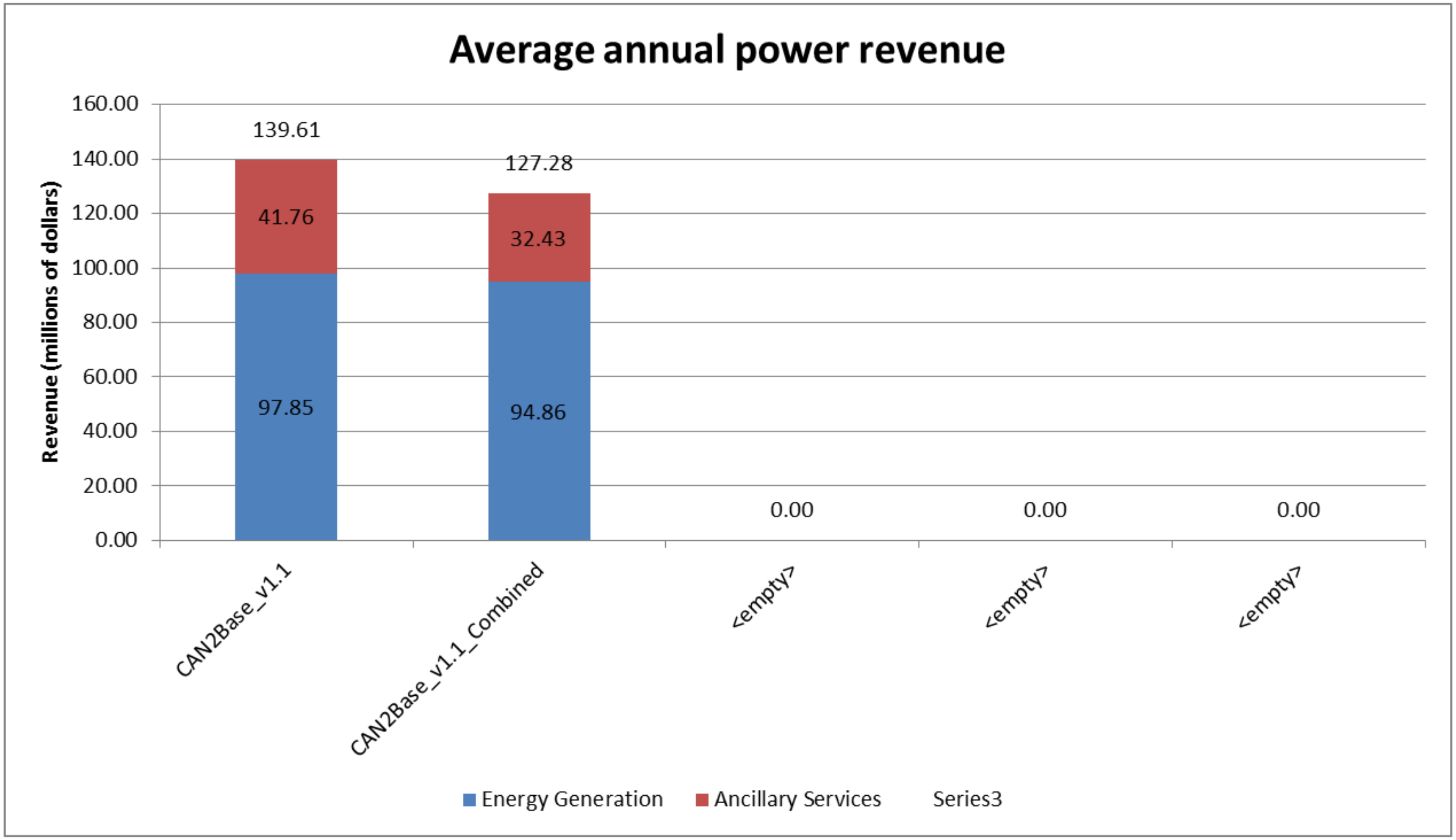
HYDROLOGICS

Performance Measures



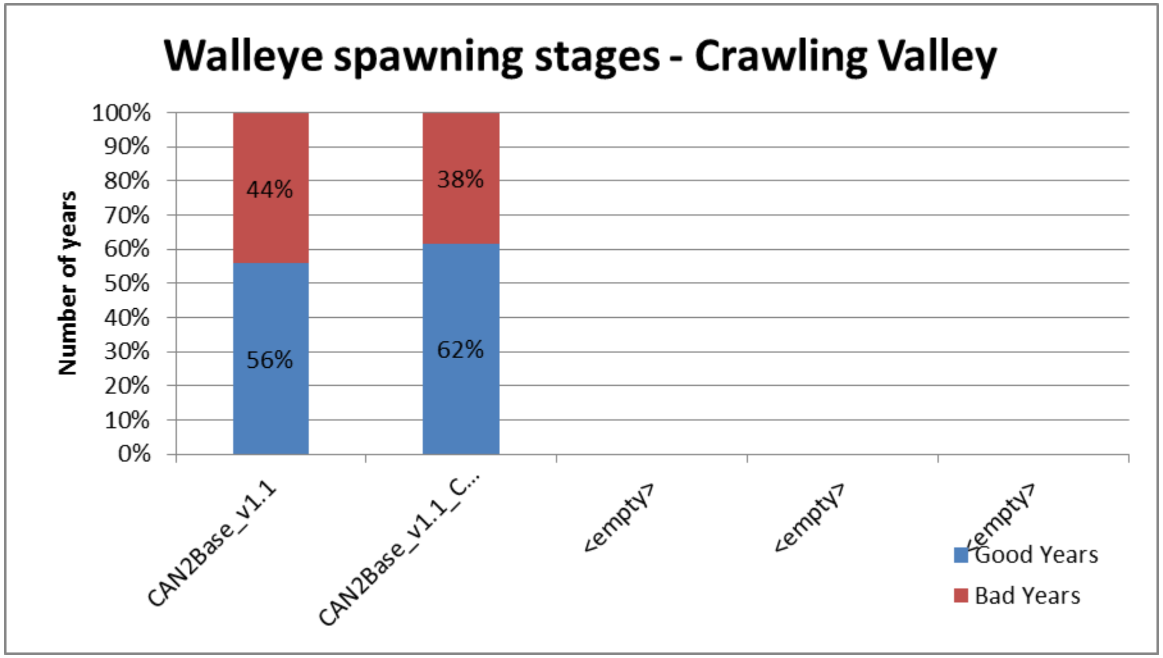
HYDROLOGICS

Performance Measures



HYDROLOGICS

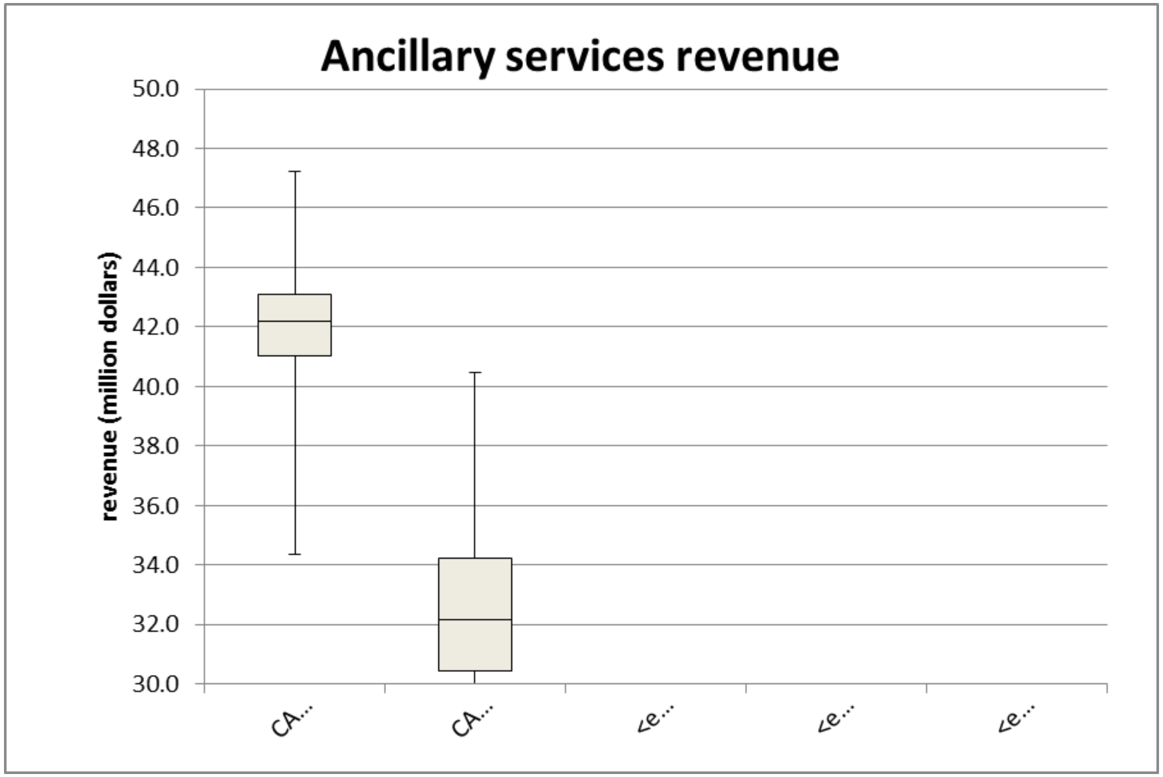
Performance Measures



If the stage on June 1 is lower than that on April 1 then the walleye eggs have not been protected and the year is considerd bad for walleye spawning. Pike spawning needs are similar to walleye.

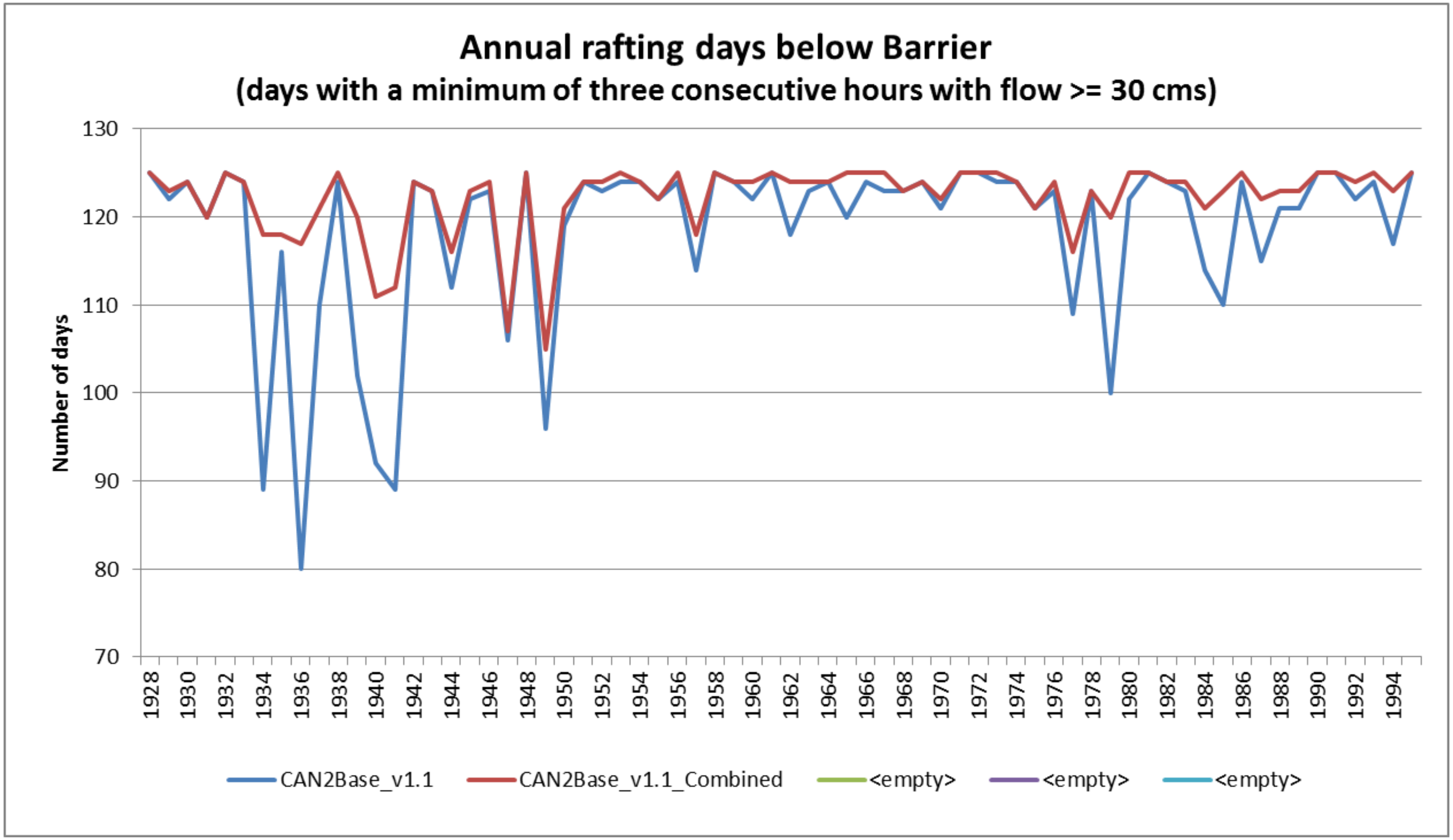
HYDROLOGICS

Performance Measures



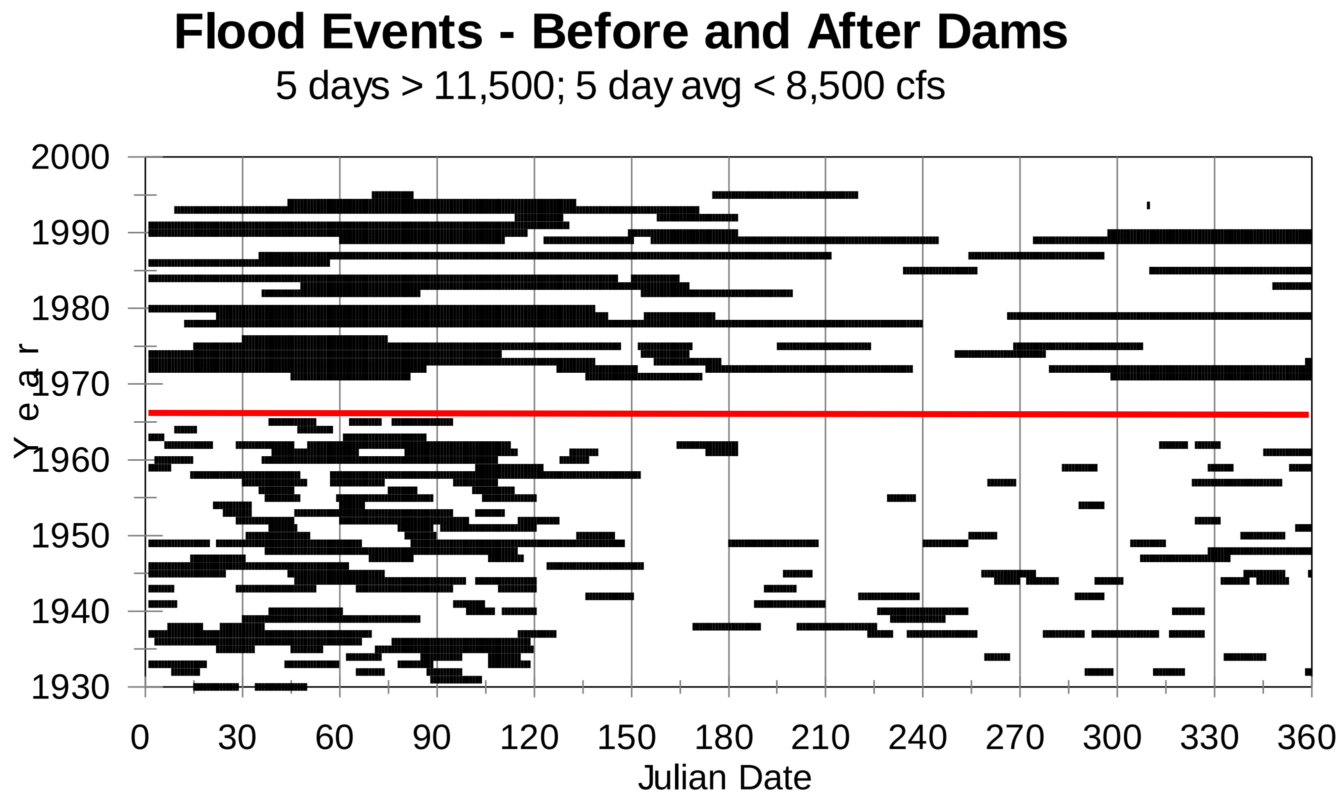
HYDROLOGICS

Performance Measures - Surrogates



HYDROLOGICS

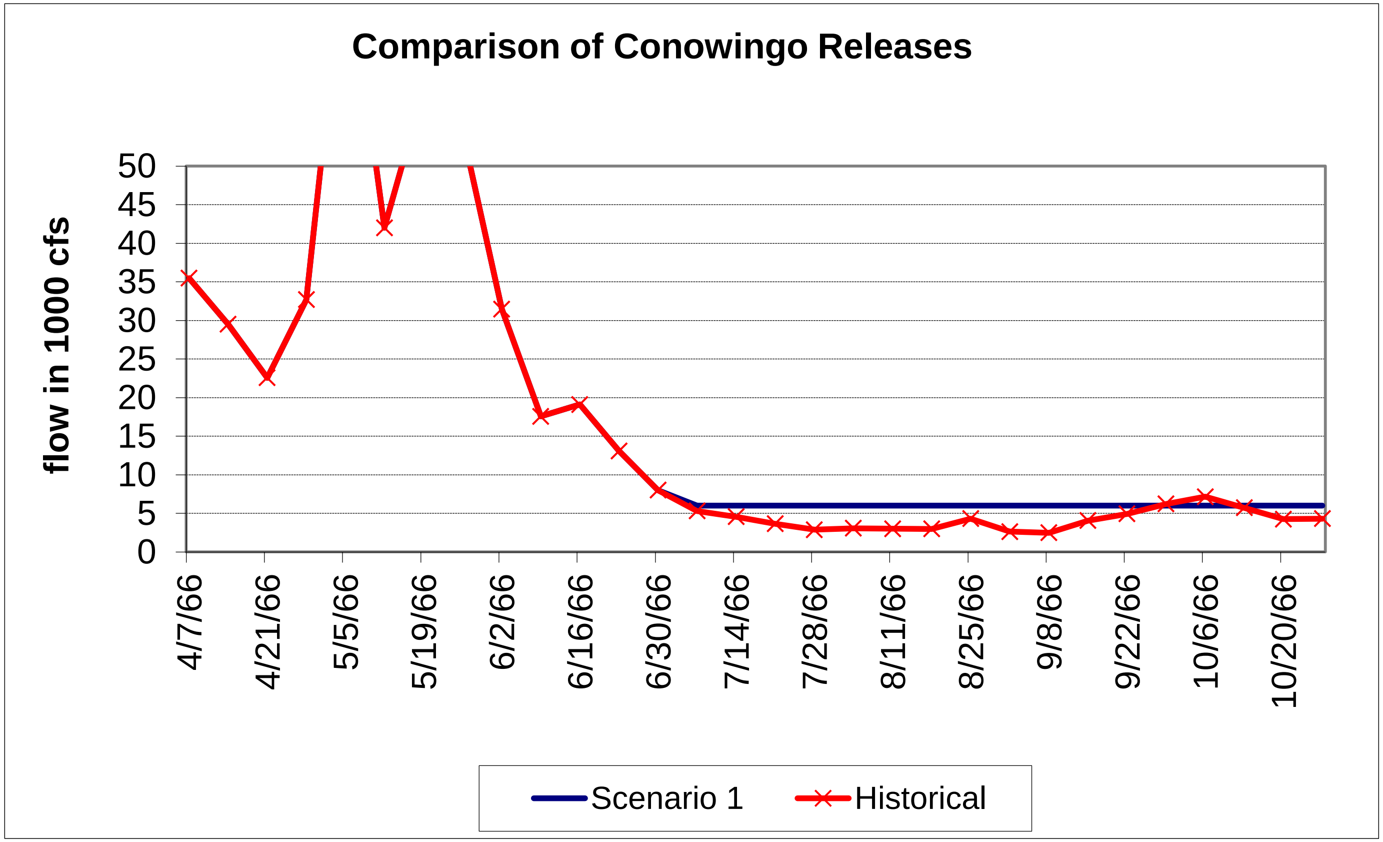
Performance Measures - Surrogates



Performance Measures

Scenario	Number of Days in Water Restriction	Number of Years with Water Restrictions	Volume of Water Not Delivered (million gallons)
1	10	1	25
2	16	3	30
3	5	5	5
4	25	3	140
5	30	6	130
6	18	2	65

Performance Measures - Surrogates



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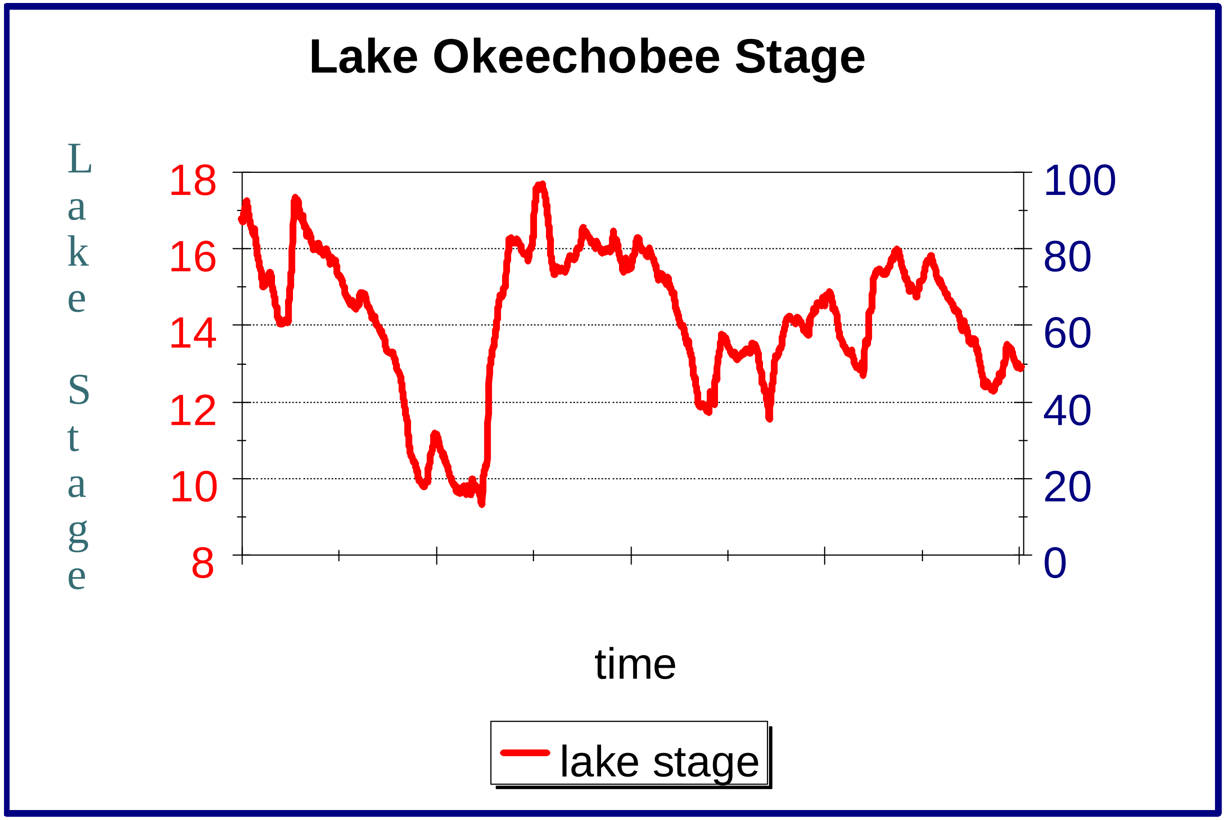
Planning and Operations Measures

- Planning Measures - Long term performance, statistics, historical "worst case," expected duration
- Operations Measures - Given "current conditions" - shorter term performance, statistical measures, conditional "worst case" and duration

HYDROLOGICS

Performance Measures - Operations

Process for Developing Performance Measures



8 1997 Water Resources Management Inc.

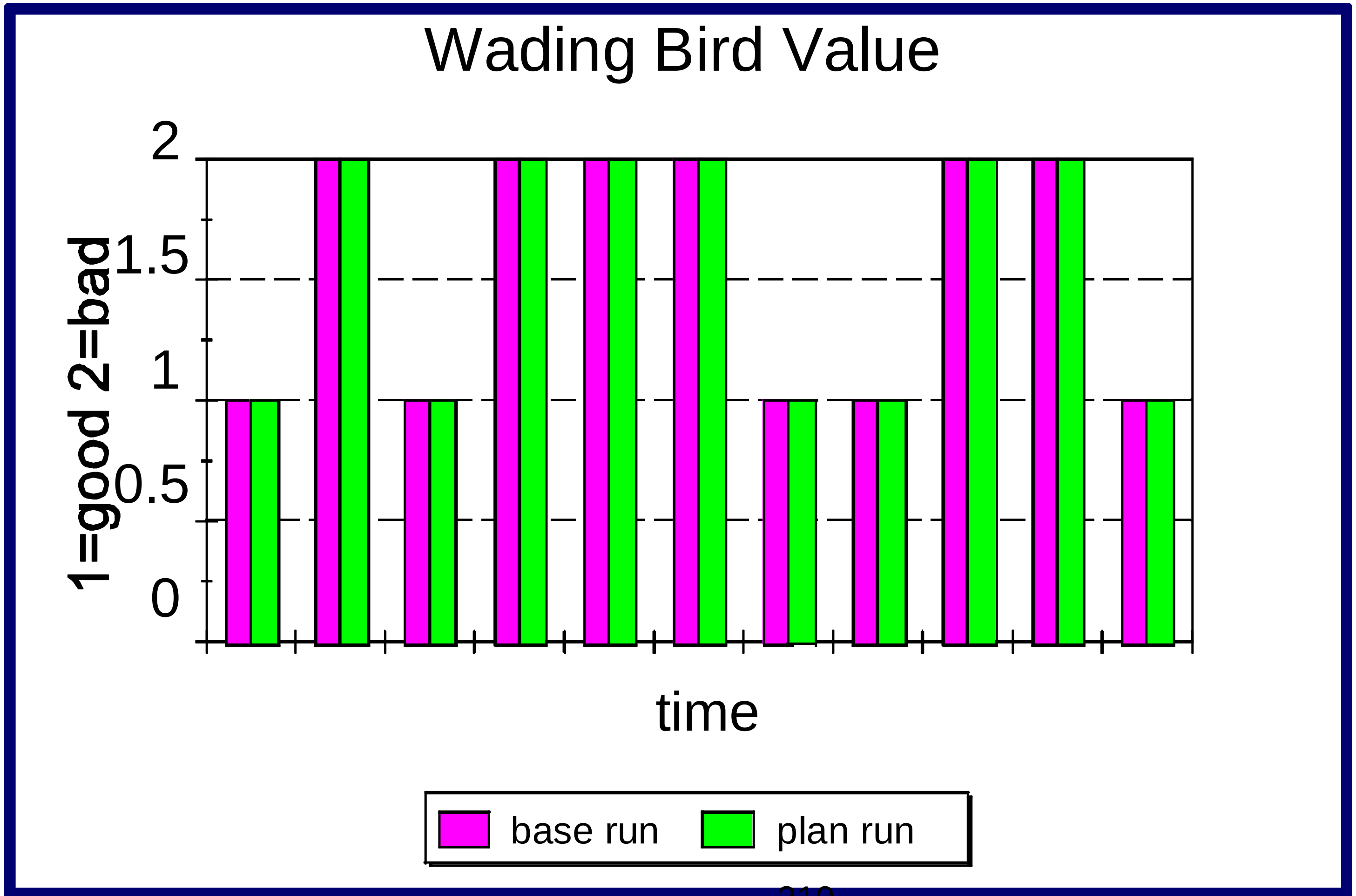
HYDROLOGICS

Scientific Rationale

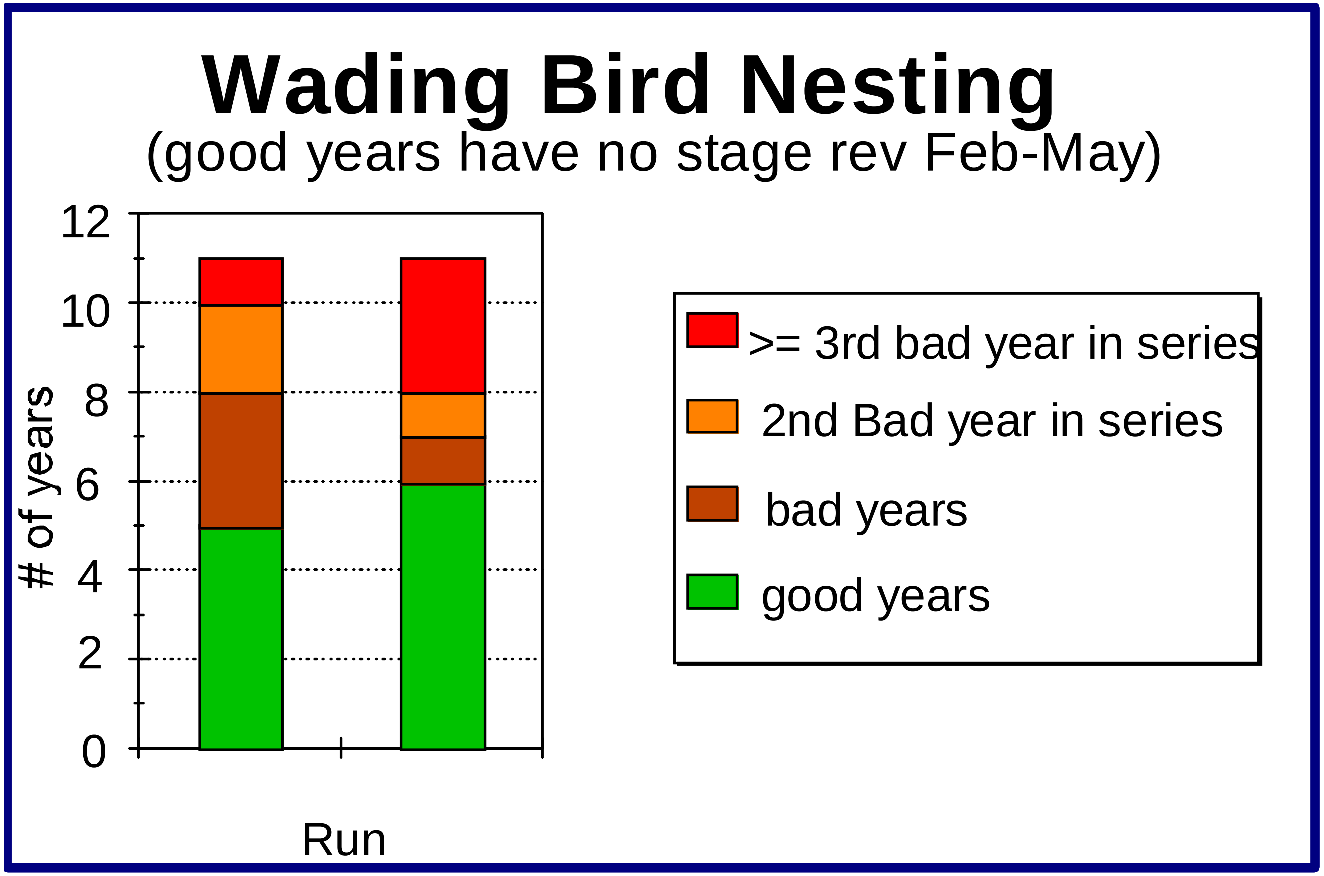
- No habitat if lake stage exceeds 15 feet
- No forage if lake stage reverses by more than 6 inches

HYDROLOGICS

Performance Measure
First Attempt



Performance Measure Revised



Model Care and Feeding

- Models must be updated to reflect new data, science, and values, to add functionality and to upgrade technology
- Scientific models get updated immediately
- Management models, particularly regulatory models update infrequently- provide a stable regulatory environment

Making Models Public

- Advantages
  - Reduced agency workload for permitting
  - Free model review
  - Better public understanding of requirements
  - Transparency
- Disadvantages
  - Maintenance
  - Transparency

HYDROLOGICS

Conclusions

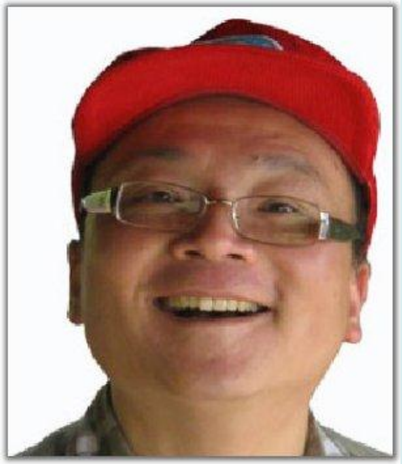
- Management is about values
- Management uses rules
- Management models make it possible to use science to evaluate the performance of rules in terms of values
- Management models must be flexible in terms of rules
- Output must show results in terms of values (PMs)

HYDROLOGICS

Day 1 – Session 1

Chiadih Chang – AESRD

BIOGRAPHY



Dr. Chiadih Chang has been working for Alberta Environment and Sustainable Resource Development (ESRD) since 2004. He is currently the Section Head of Evaluation and Reporting, Policy Division. Chiadih is a Professional Engineer as well as a GIS Professional. Chiadih obtained his Ph.D. degree in Water Resources Engineering (Hydrology) from the University of Calgary in 1992. Over the past 25 years, Chiadih has had a passion for developing GIS-based decision support tools by coupling GIS technology with environmental modelling, especially in the area of water resources. Before joining ESRD, Chiadih worked as a regional hydrologist for Ontario Ministry of Natural Resources for 10 years, a post-doctoral research fellow for Environment Canada for 2 years, and a water resources engineer for the Taiwanese Government in 1986 before he came to Canada for his Ph.D. study.

Day 1 – Session 1

Chiadih Chang – AESRD

ABSTRACT

Spatial assets and technologies to support the environmental modelling are required to be implemented and delivered within an enterprise maturity model. The objective of this presentation is to share a vision and demonstrate a prototype of an enterprise environmental spatial system for Alberta that integrates the following components:
Data access from multiple internal and external sources,
· Automation of thematic mapping at different scales
· Enabling/facilitating the use of spatial environmental evaluation applications, simulation models, and tools
· A spatially-searchable information and knowledge management superstore utilized by multidisciplinary environmental analysts and evaluators
· A web-based, spatial-enabled, open and transparent reporting system
The proposed integrated spatial system would allow regulatory agencies to manage the environment and natural resources in an effective, efficient, responsible, and transparent manner, which leads to the achievement of desired environmental outcomes and sustainable development of natural resources.

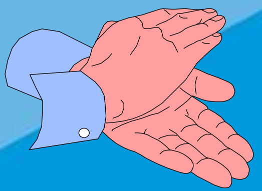
A Vision of Enterprise Environmental Spatial System $(ES)^2$ for Supporting Environmental Modelling

"Leadership is the capacity to translate vision into reality." (Warren G. Bennis)

Chiadih Chang, Ph.D., P.Eng., GISP
Science, Evaluation & Reporting
Policy Division, AESRD

Environmental Modelling Workshop 2013
Edmonton, March 13, 2013

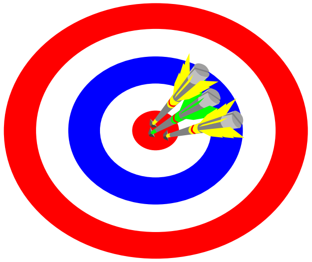
Acknowledgements



- Anil Gupta
- Barry Northey
- Brian Sawyer
- Bob Barraclough
- Curt Romaniuk
- Daryl McEwan
- Dave Junor
- Derek Nalder
- Don Page
- Geniene Sabila
- James Greengrass
- Jordan Erker
- Judy Heilman
- Justin Wilkes
- Kelsey Ayton
- Lee George
- Matthew Lynch
- Moses Bitew
- Patrick Vacca
- Phil Mackenzie
- Ray Keller
- Scott Kilborn
- Stuart Cruikshank
- Tom Davis
- Vernon Remesz
- More…

Purposes of the Presentation

- Share the (ES)^2 vision
- Receive your feedback
- Explore future engagement and collaboration opportunities



Presentation Outlines

1. Background
2. Challenges
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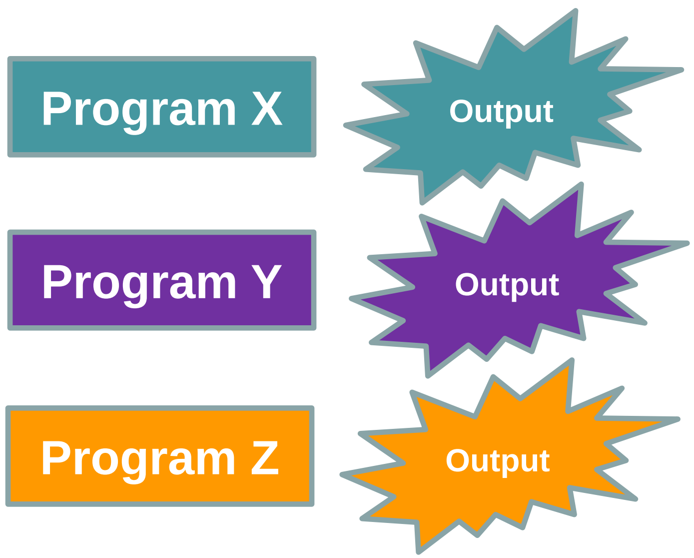
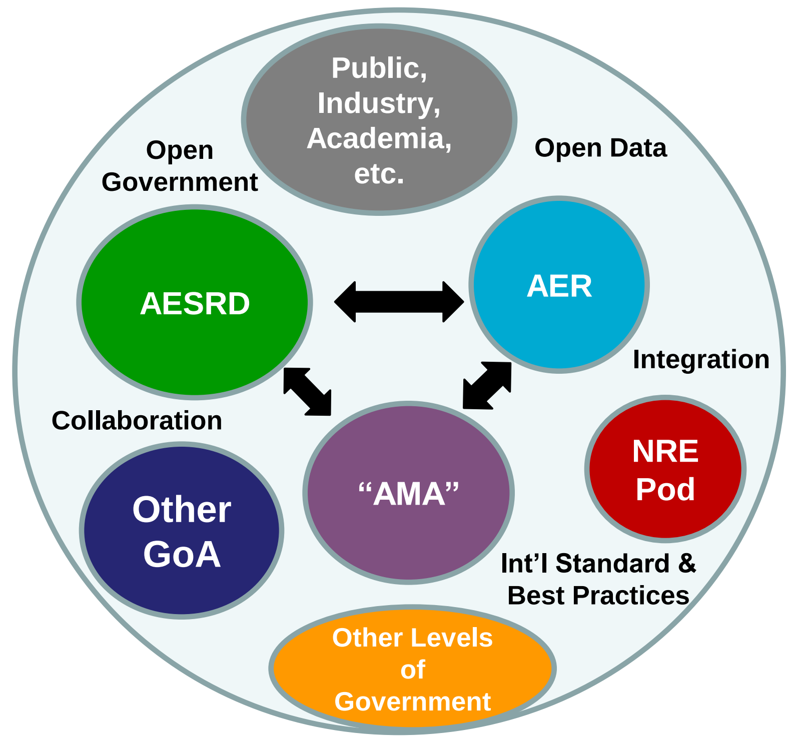
Old Paradigm vs. New Reality

The Old Paradigm



Program-centric with little to no perceived requirement for coordination or alignment between programs or departments.

The New Reality



A "System of Systems" delivering the <u>outcomes</u> of Integrated Resource Management (IRM) and Cumulative Effects Management (CEM).

* Modified based on ESRD draft informatics Program Governance (2013)

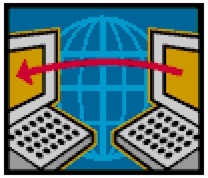
Data → Information → Knowledge

- "We are drowning in data and thirsting for information" (John Naisbitt, Megatrends, 2000)

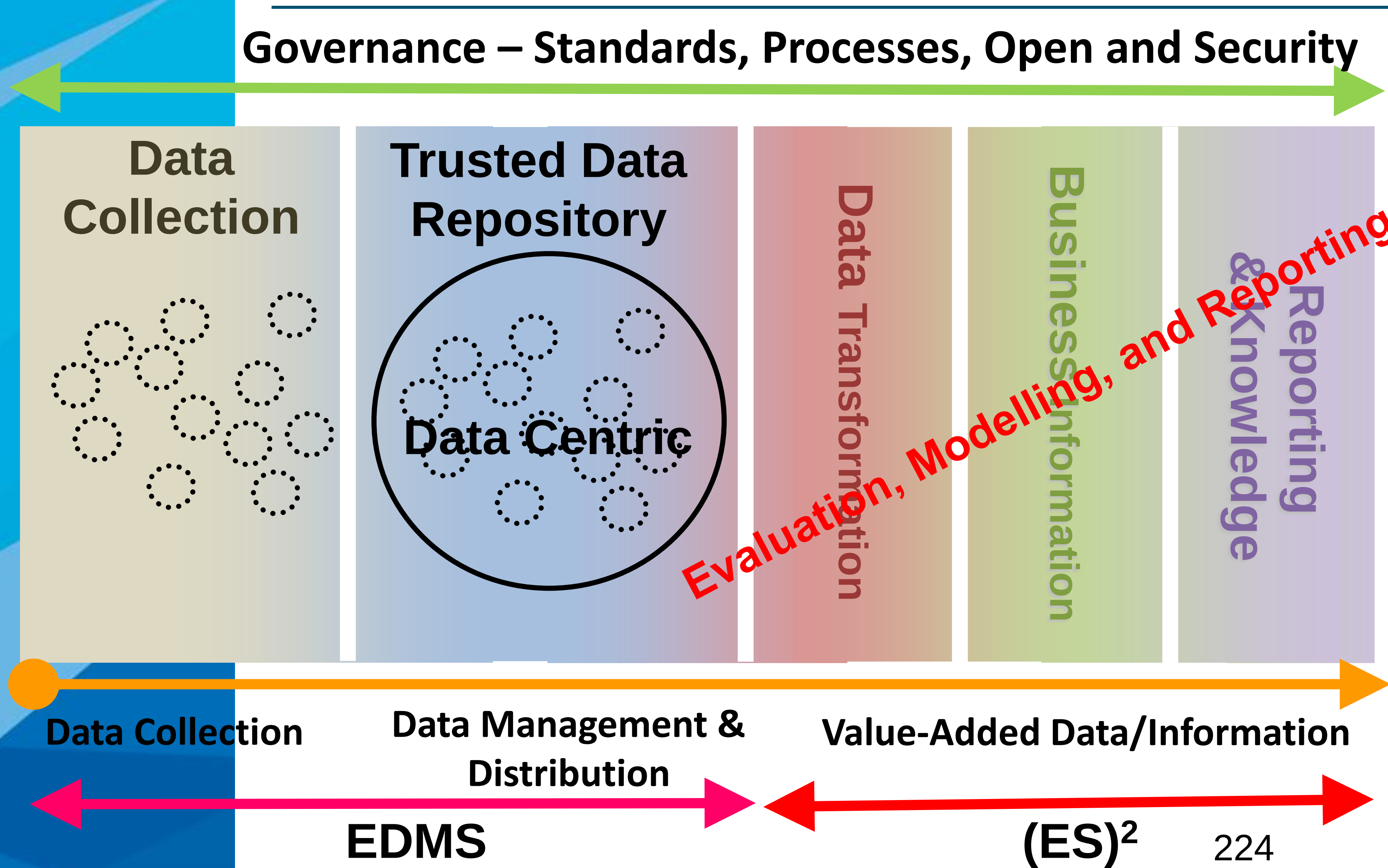
- 80% of all data contains some reference to geography (Franklin and Hane, 1992)

- Use a GIS to manage, visualize, explore, synthesize, and analyze the spatial data; and turn data into information into knowledge.

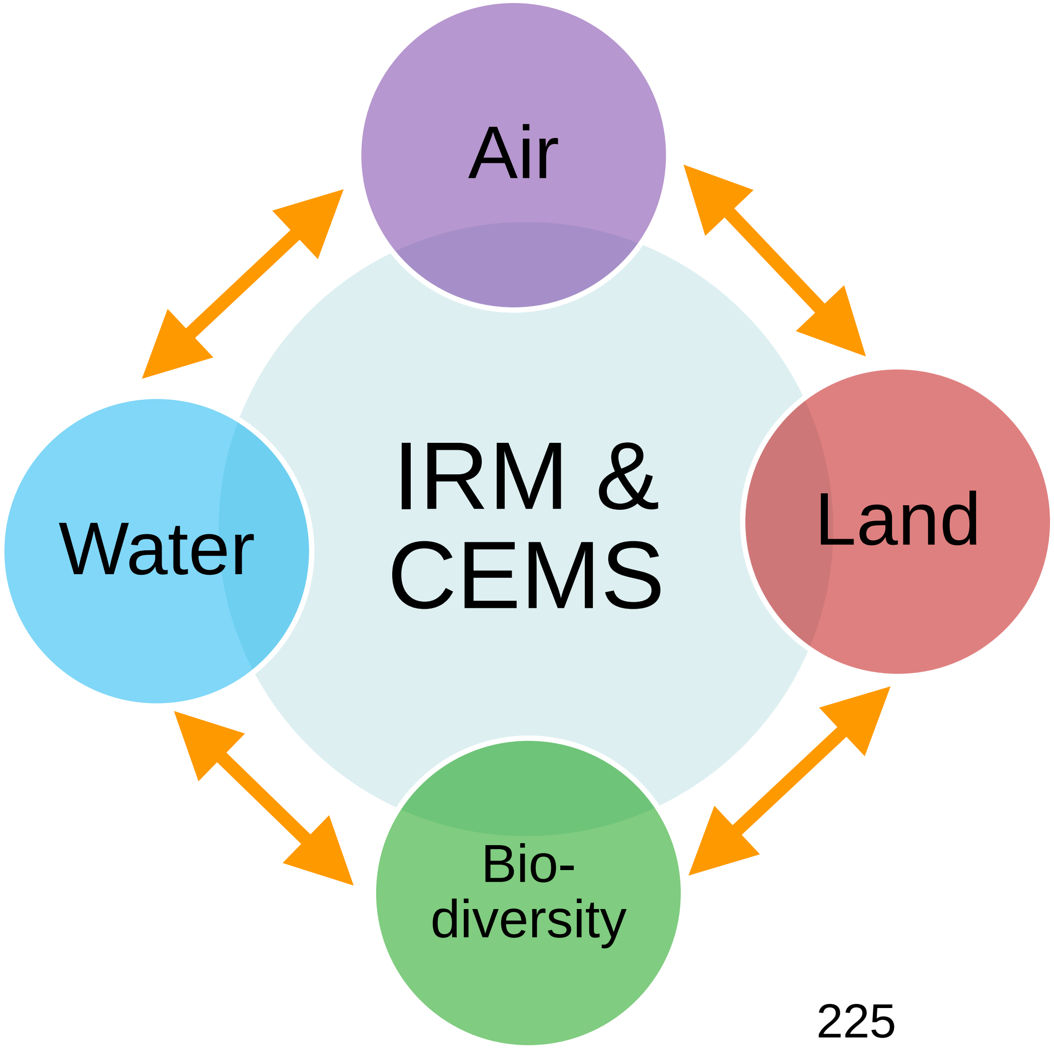
- Put the right data/information/knowledge, in the right format, in the right hands, at the right time - Informatics.



Enterprise Data Management System (EDMS) & $(ES)^2$



Need More Integrated and Collaborative Approach…



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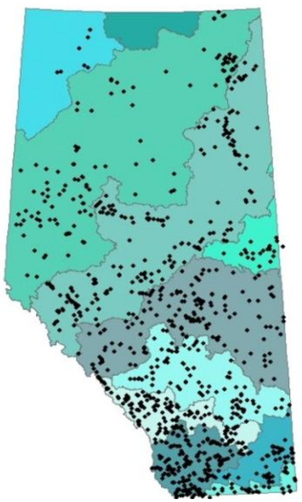
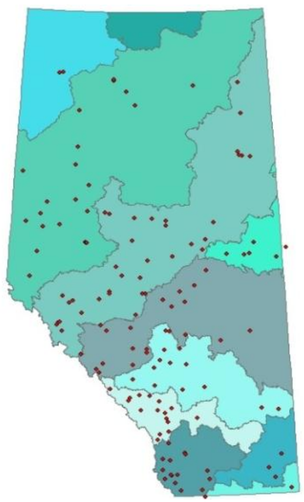
Challenge #1: Data Availability

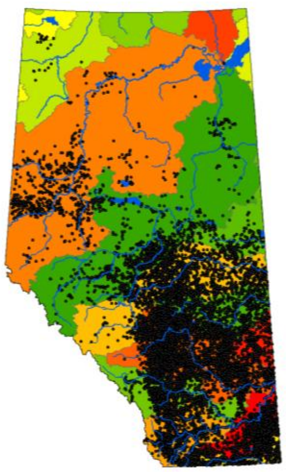
Data are often unavailable or insufficient for the area of interest. We simply cannot afford to monitor everything in everywhere, for example:



1,100 Hydrometric Stations



140 'Suitable' Hydrometric Stations

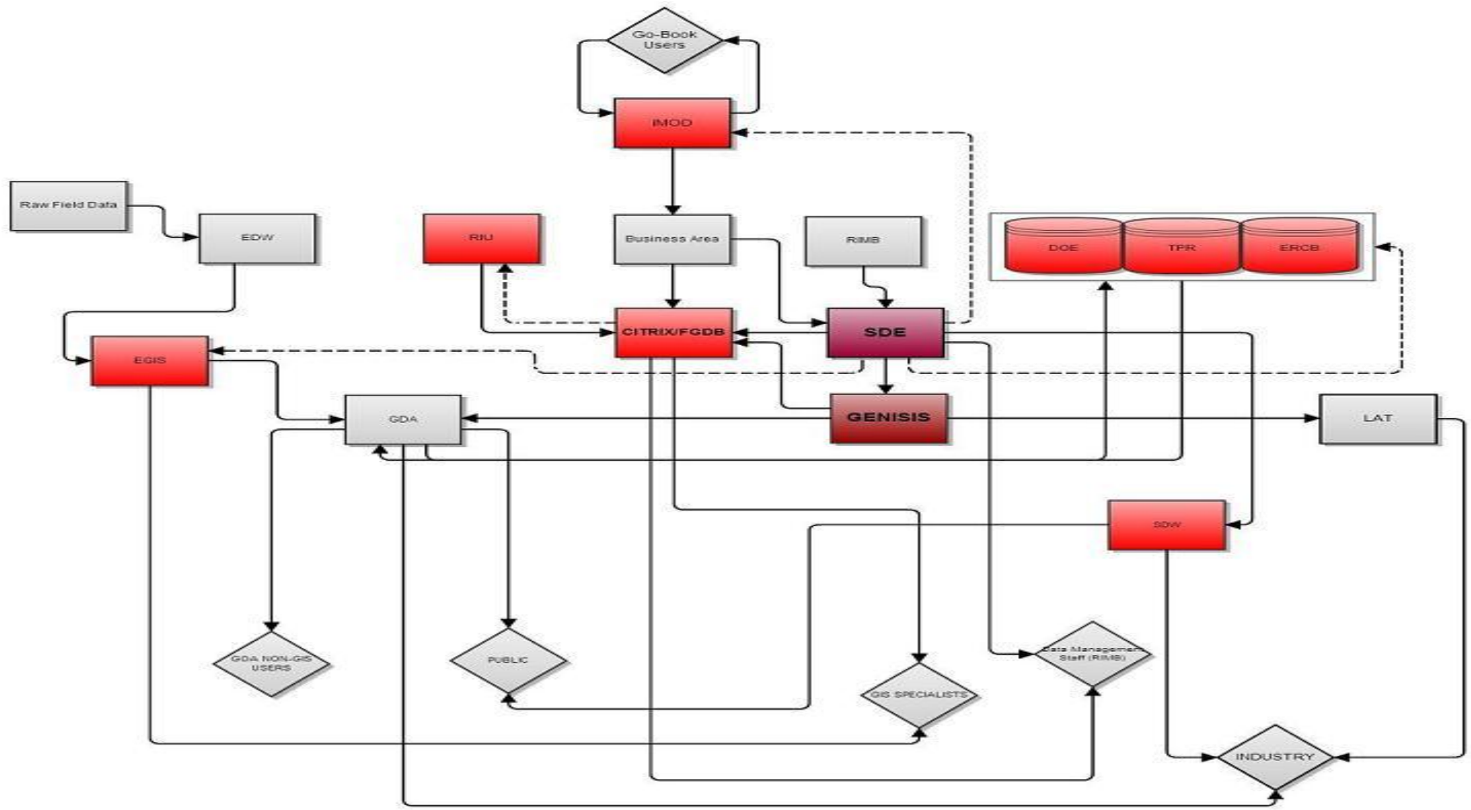


Water Management 'Challenge'

Need for environmental modelling

Challenge #2: Access to Authoritative Data Sources

The current status of GIS data in ESRD:



Need for accessing authoritative data sources

Challenge #3: Data Preparation

60 - 80% of the time spent on data analytics projects is spent preparing the data for analysis, which often is:

- Repetitive
- Time consuming
- Laborious
- Costly
- Error prone

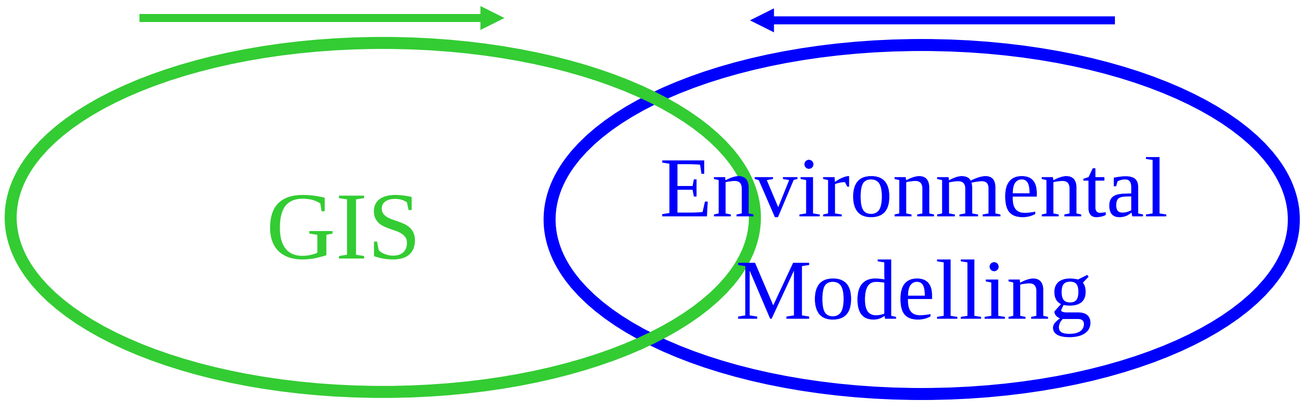
e.g. Watershed Modelling

Need for automation of data preparation

Challenge #4: Integration with GIS

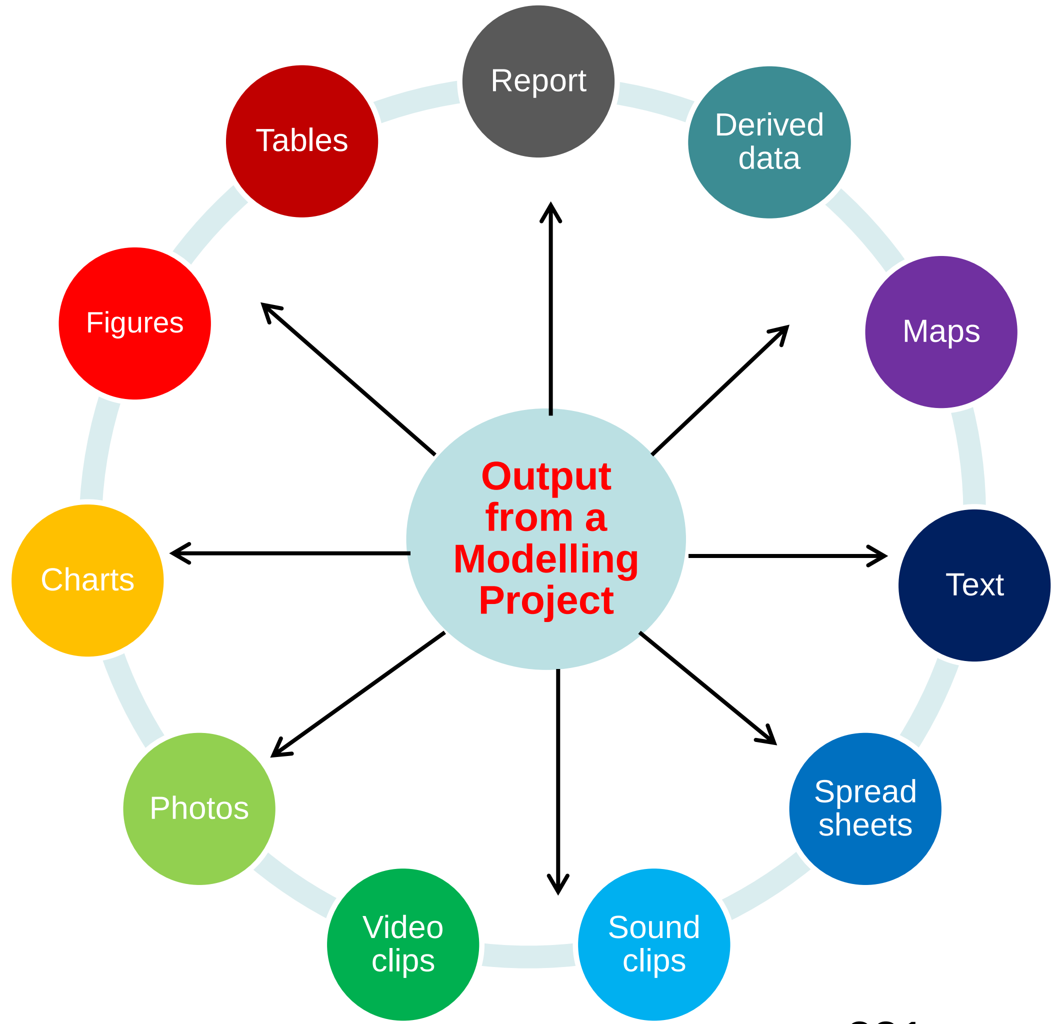
- There are trends in interfacing GIS with predictive water resource models. However, neither technology was initially developed to interact with the other (Martin et al., 2005).

- Lack of integration between spatial and temporal data/information.



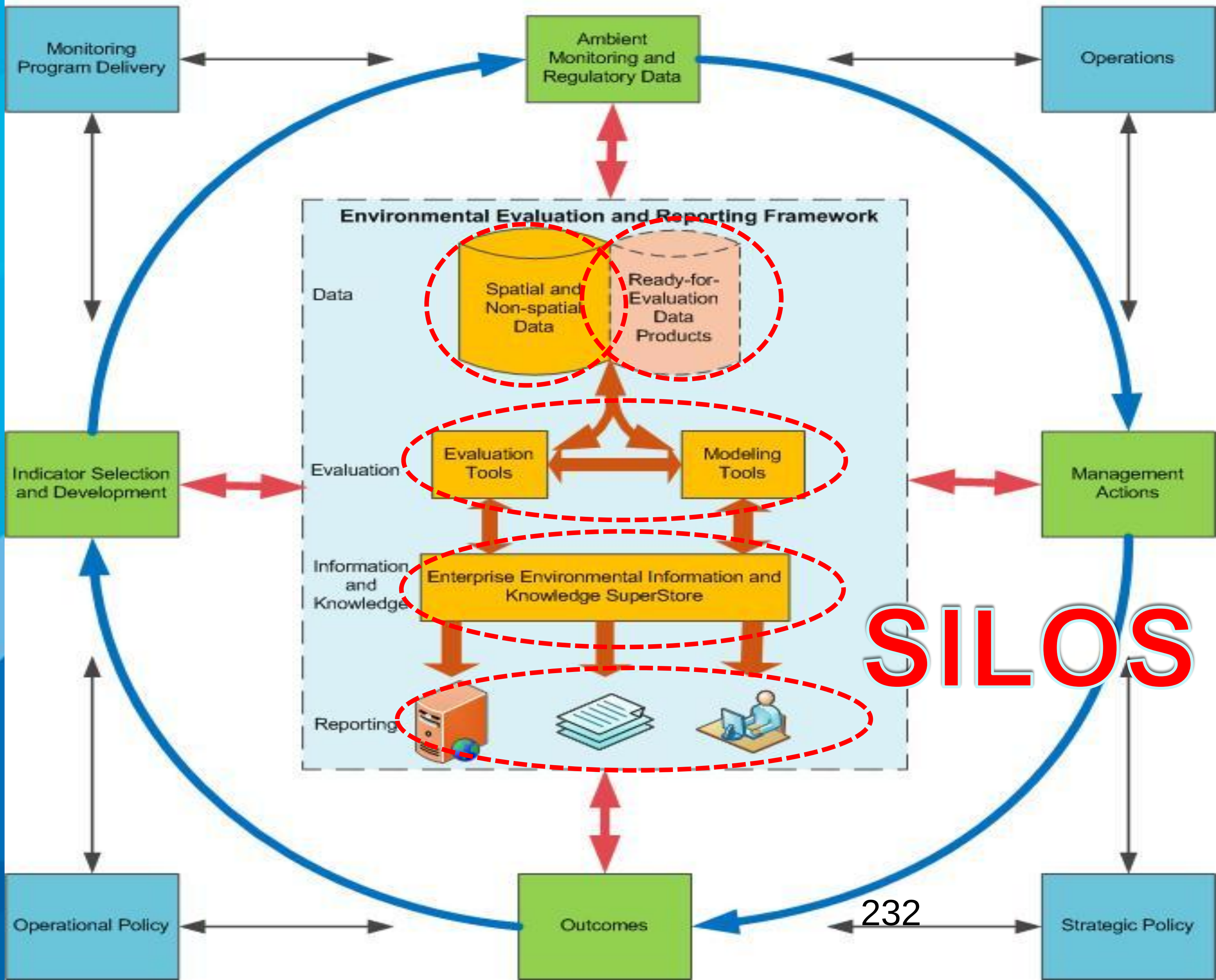
Need for GIS-Modelling Framework

Challenge #5: Is Information and/or Knowledge Generated from a Project Readily Available/Accessible to Others?



Need for Information & Knowledge Management

Challenge #6: Fragmented Silos



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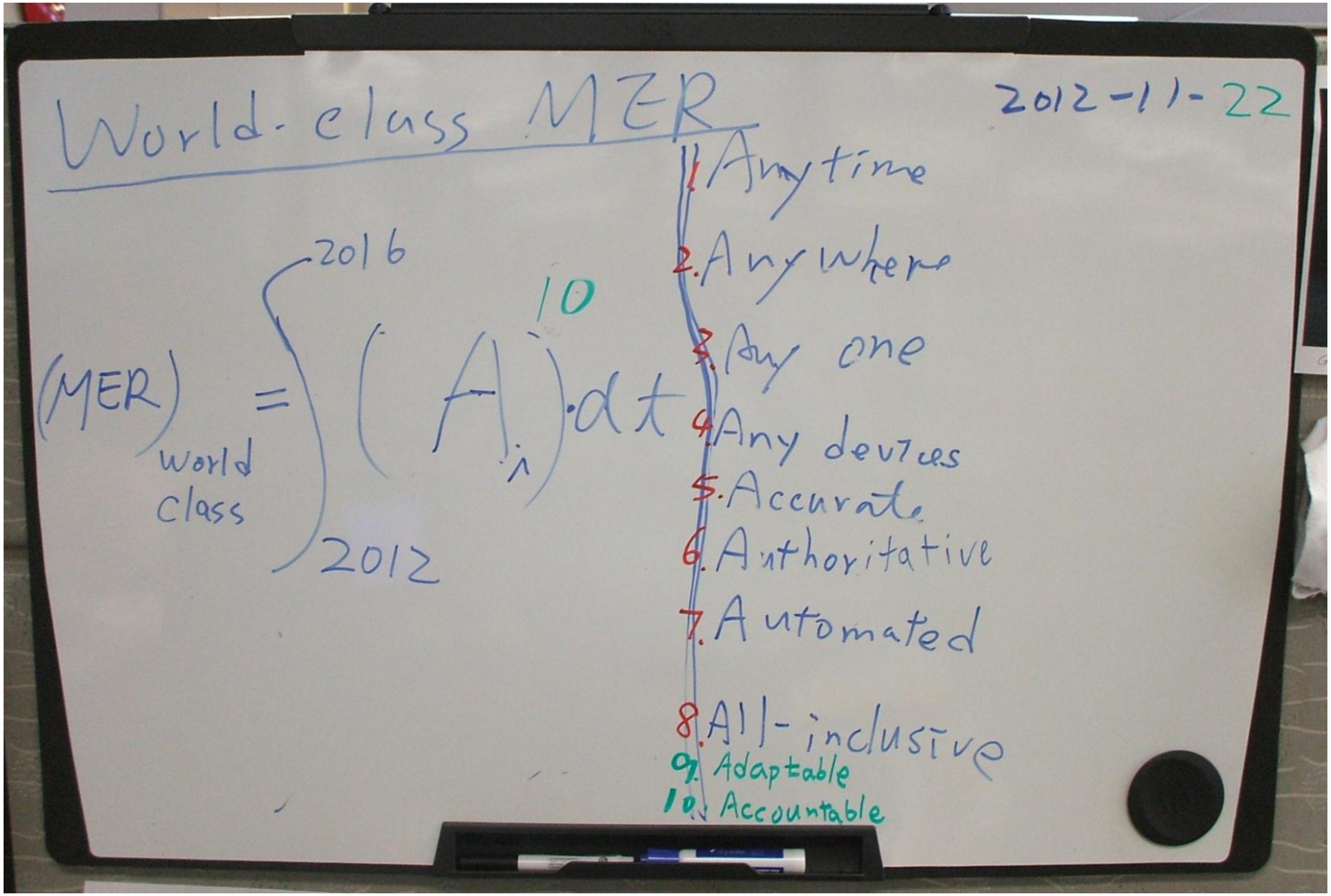
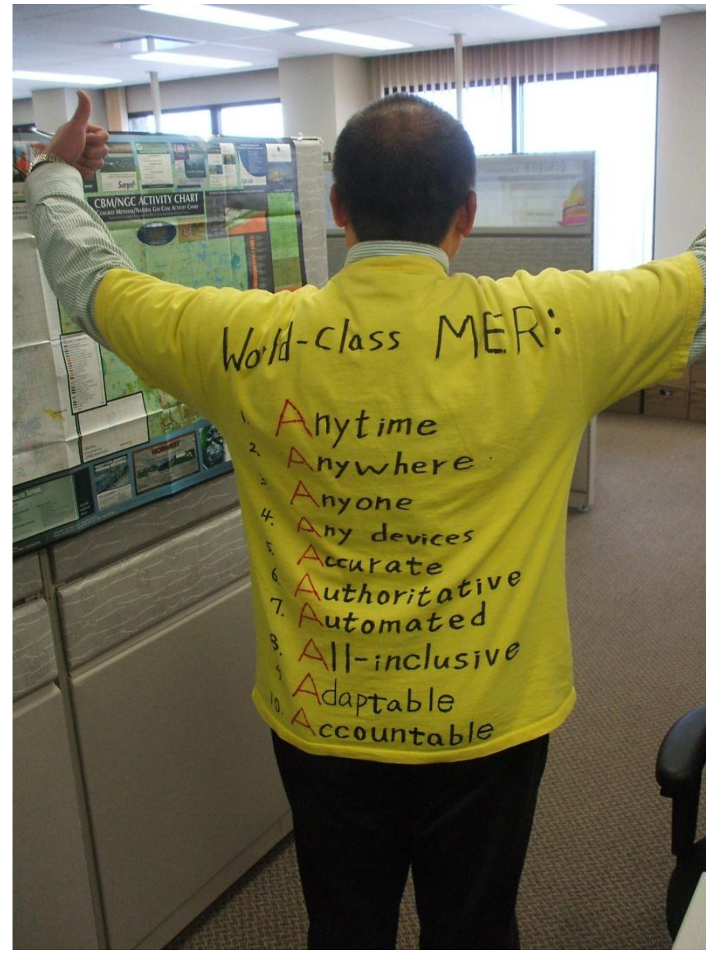
World-Class Monitoring, Evaluation and Reporting (MER)

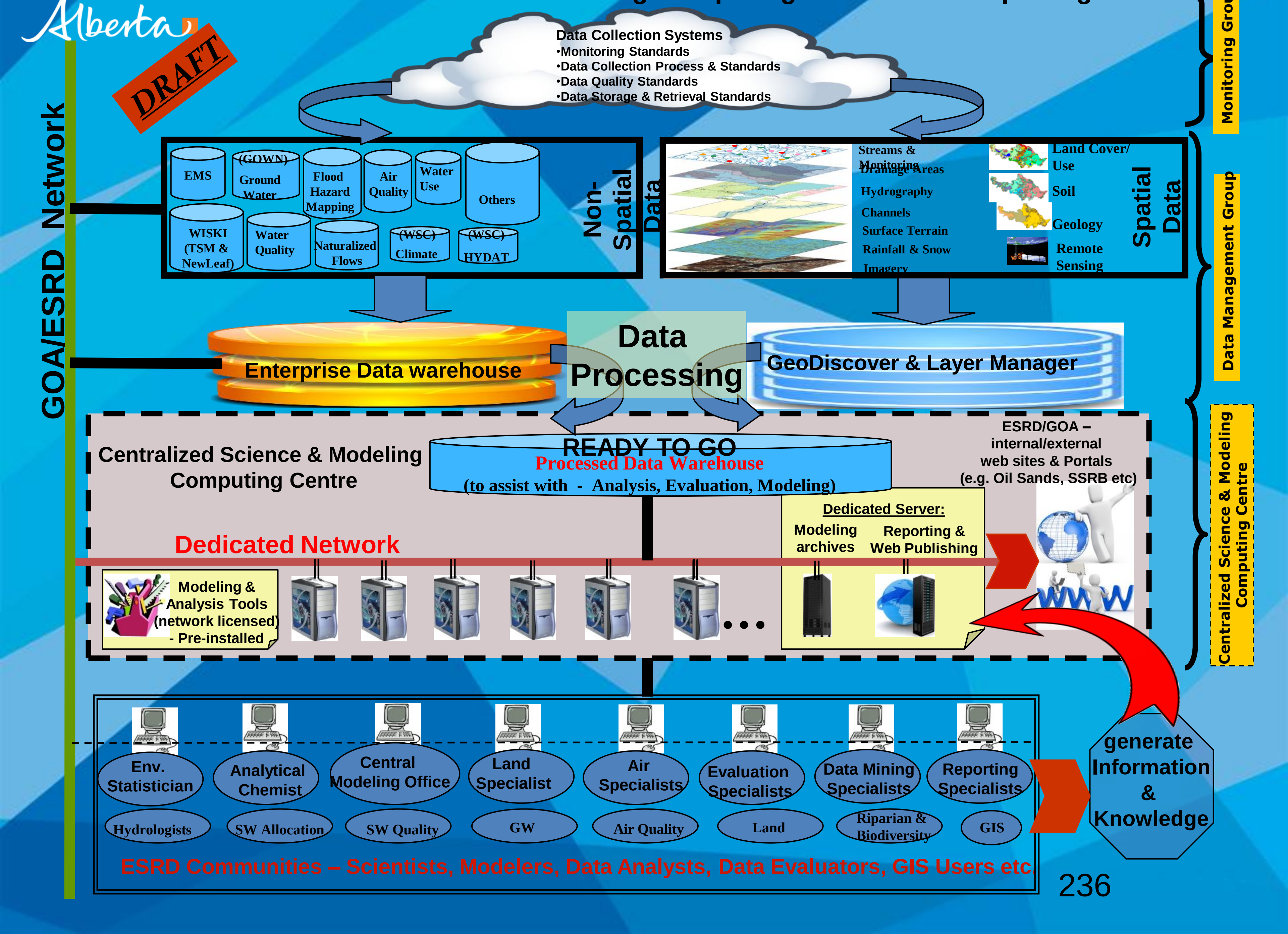
1. Anytime
2. Anywhere
3. Anyone
4. Any devices
5. Accurate
6. Authoritative
7. Automated
8. All-inclusive
9. Adaptable
10. Accountable



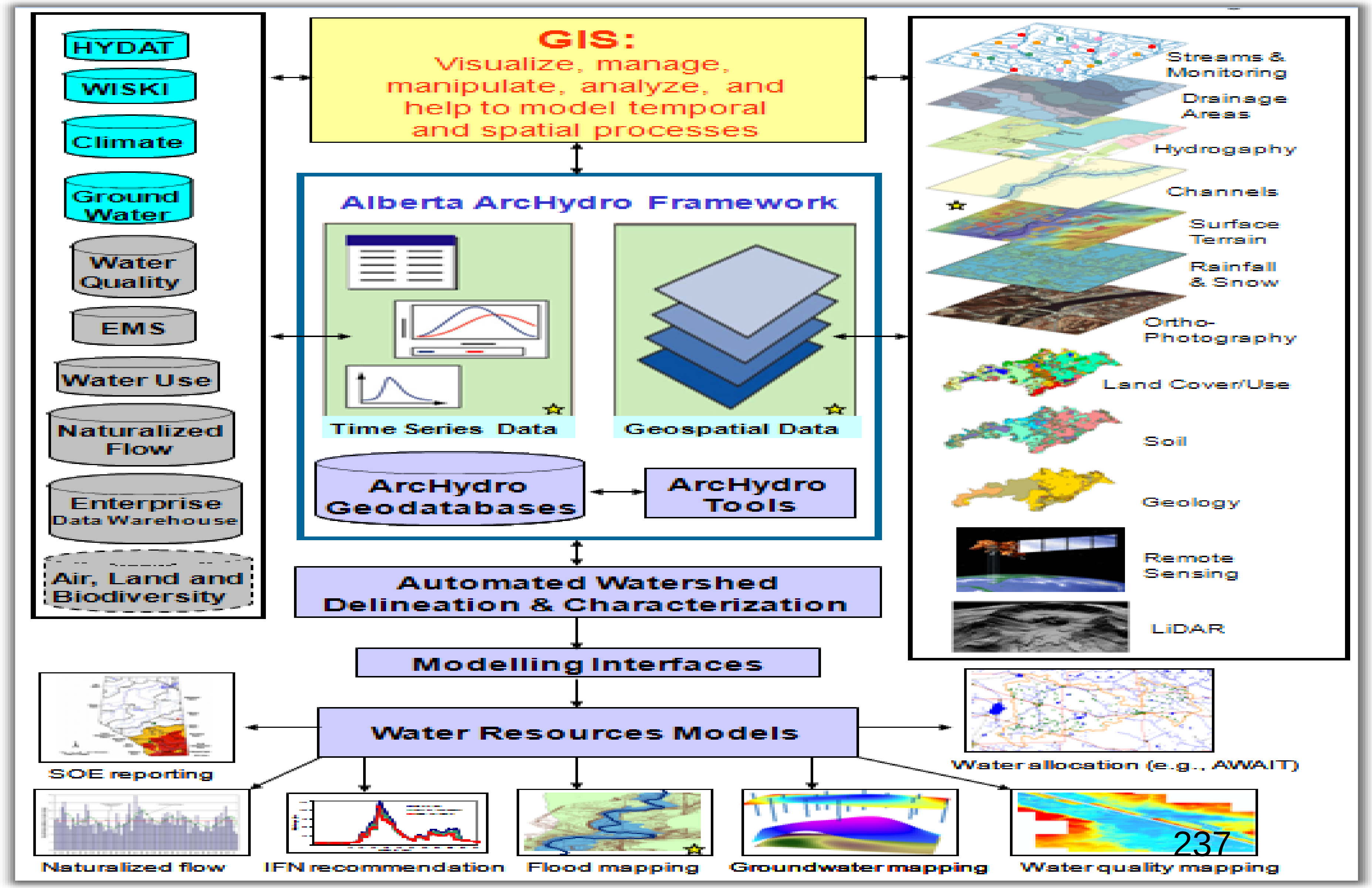
Walk the Talk!



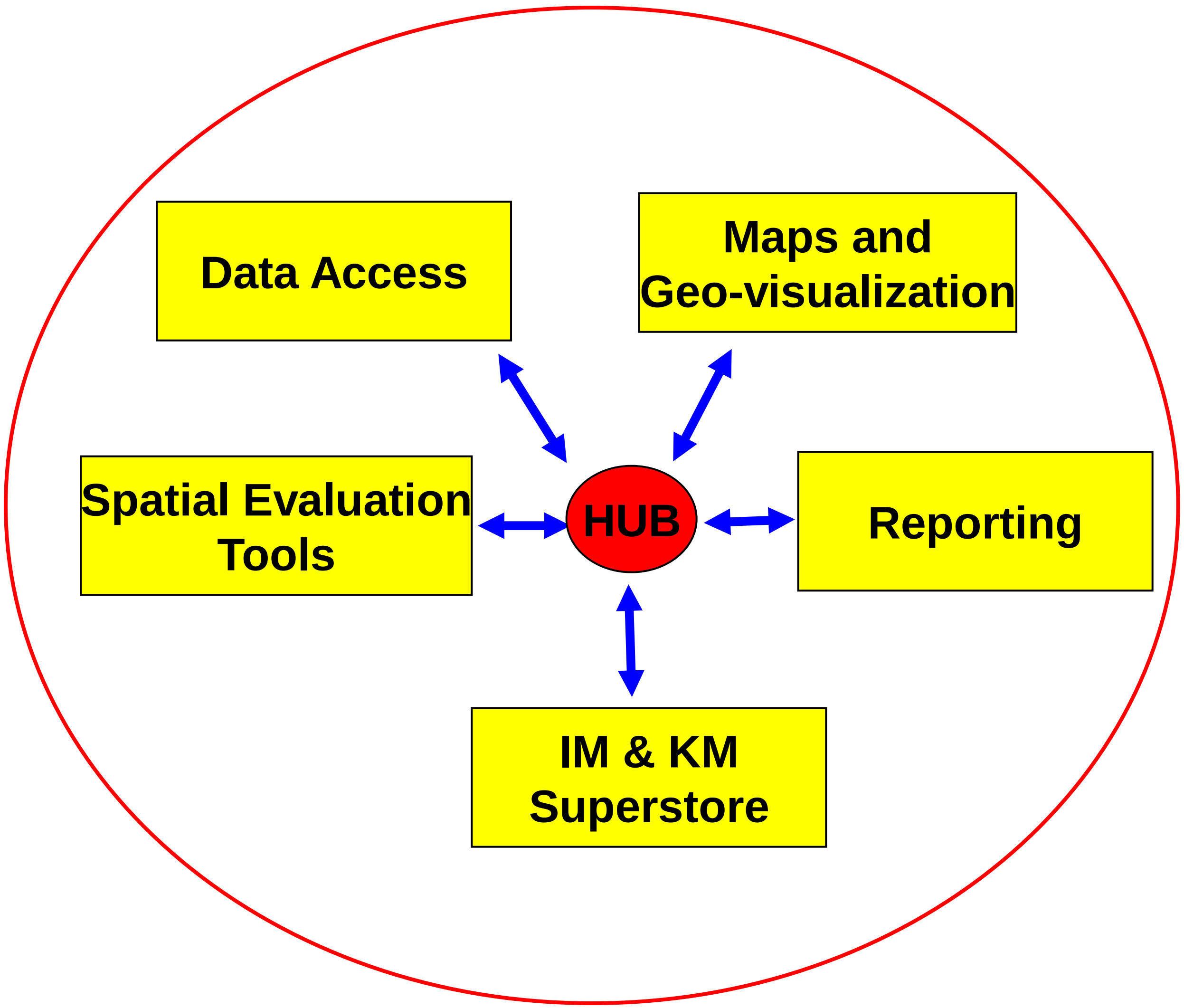
Centralized Science and Modeling Computing Centre – Concept Diagram



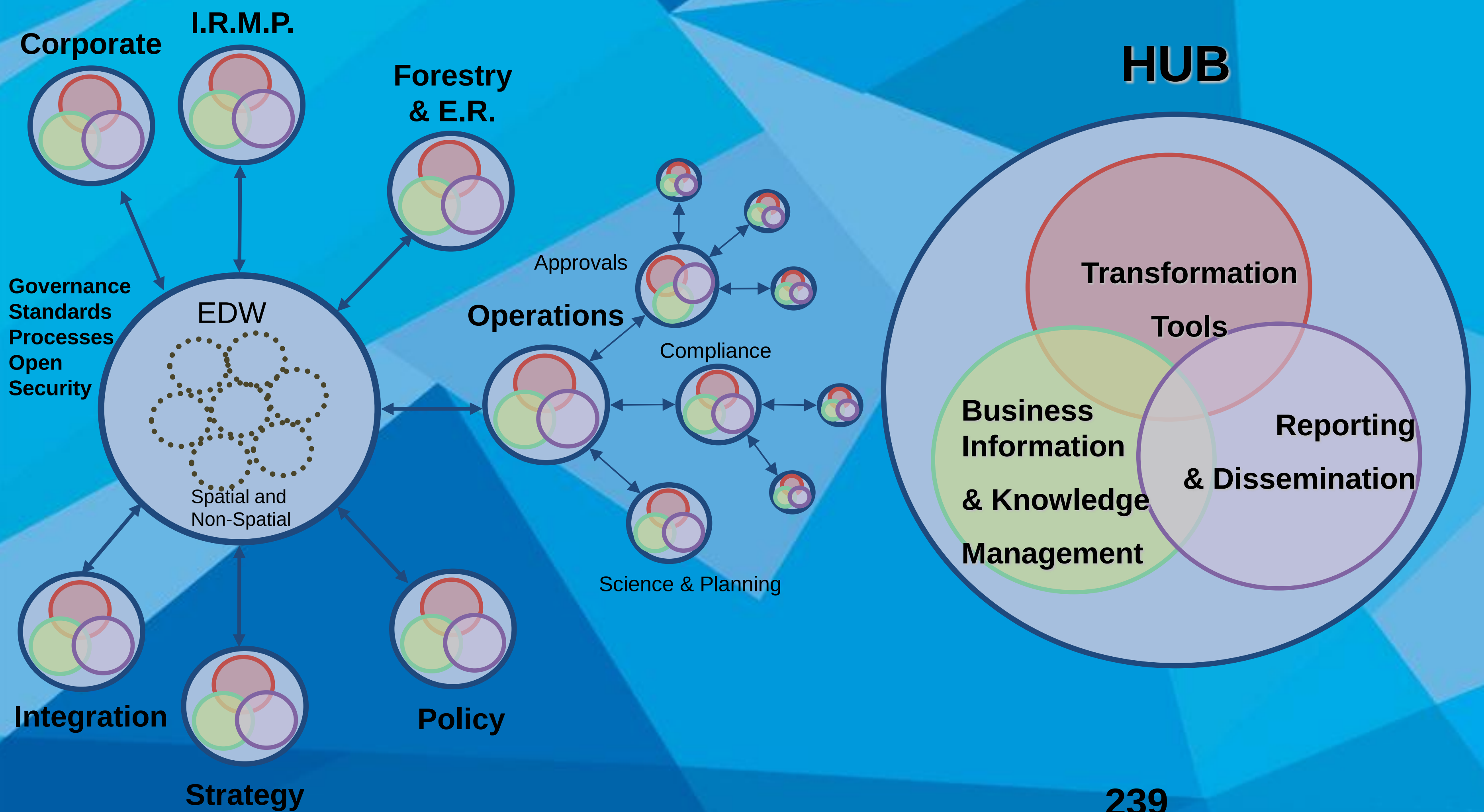
ArcHydro as a Ready-To-Go Data Framework for Water Resource-Related Models



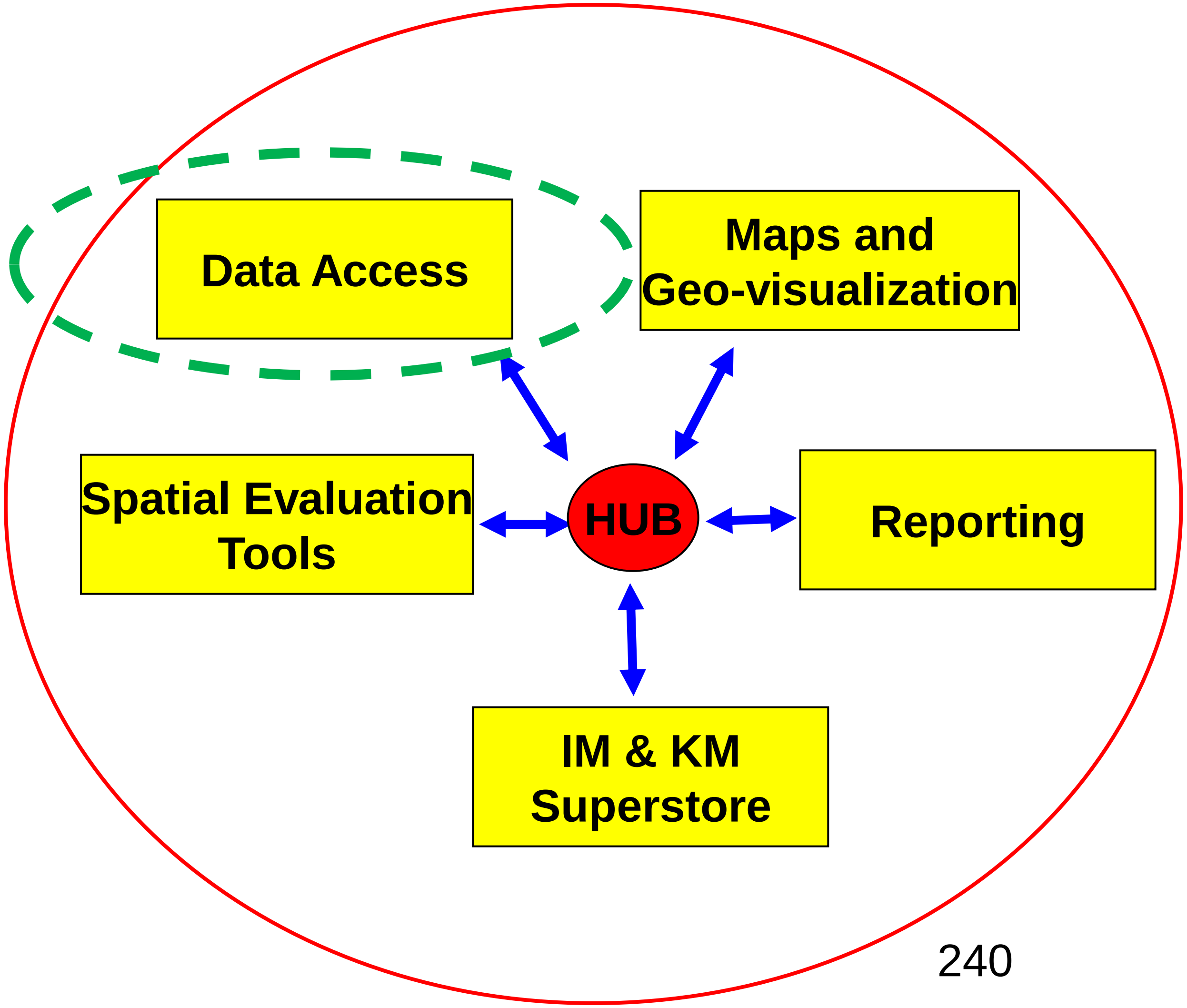
Vision of $(ES)^2$



$(ES)^2$ HUB

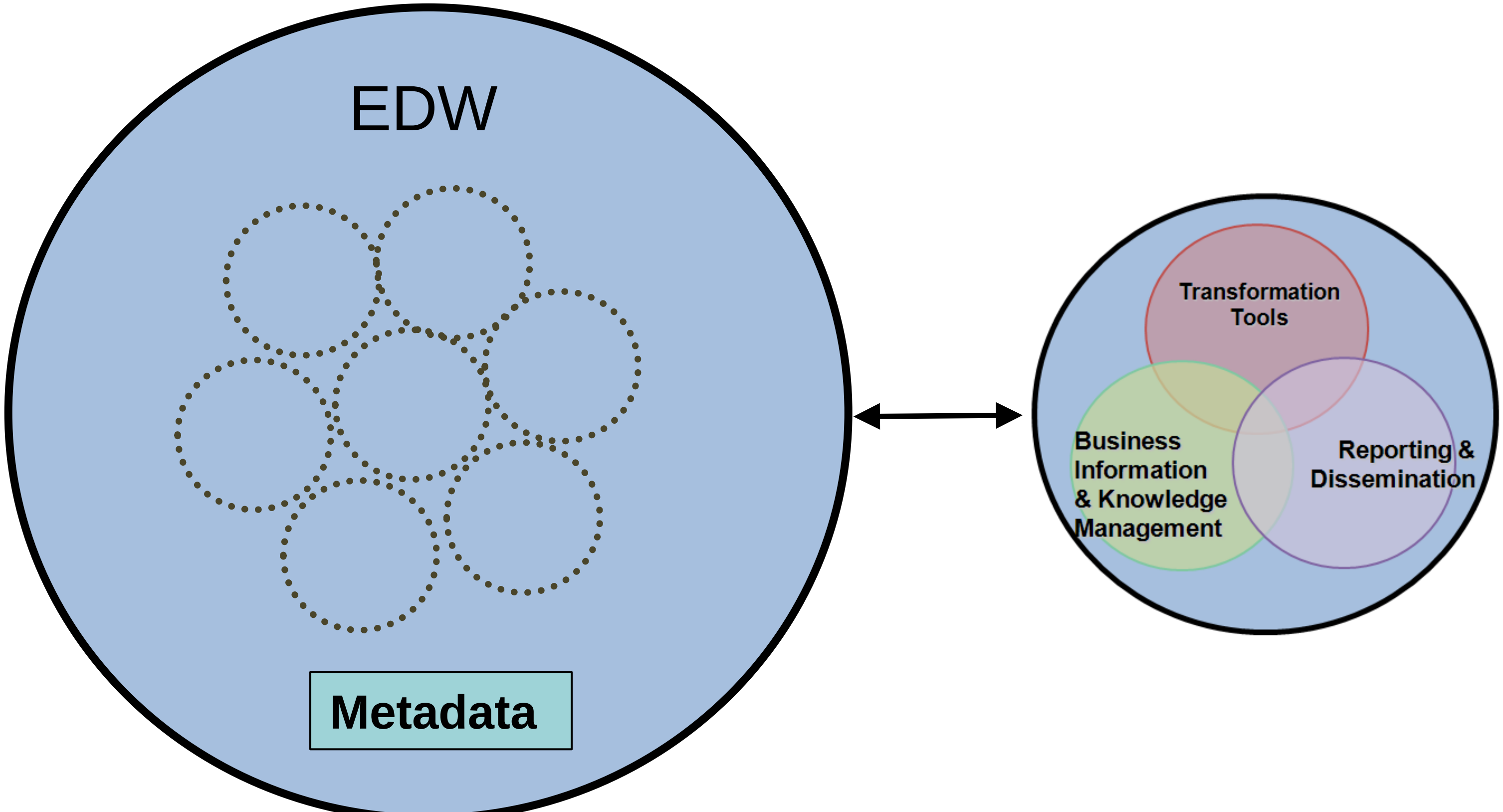

Corporate
I.R.M.P.
Forestry
& E.R.
Governance
Standards
Processes
Open
Security
EDW
Spatial and
Non-Spatial
Approvals
Operations
Compliance
Science & Planning
Integration
Strategy
Policy
HUB
Transformation
Tools
Business
Information
& Knowledge
Management
Reporting
& Dissemination

Vision of (ES)^2

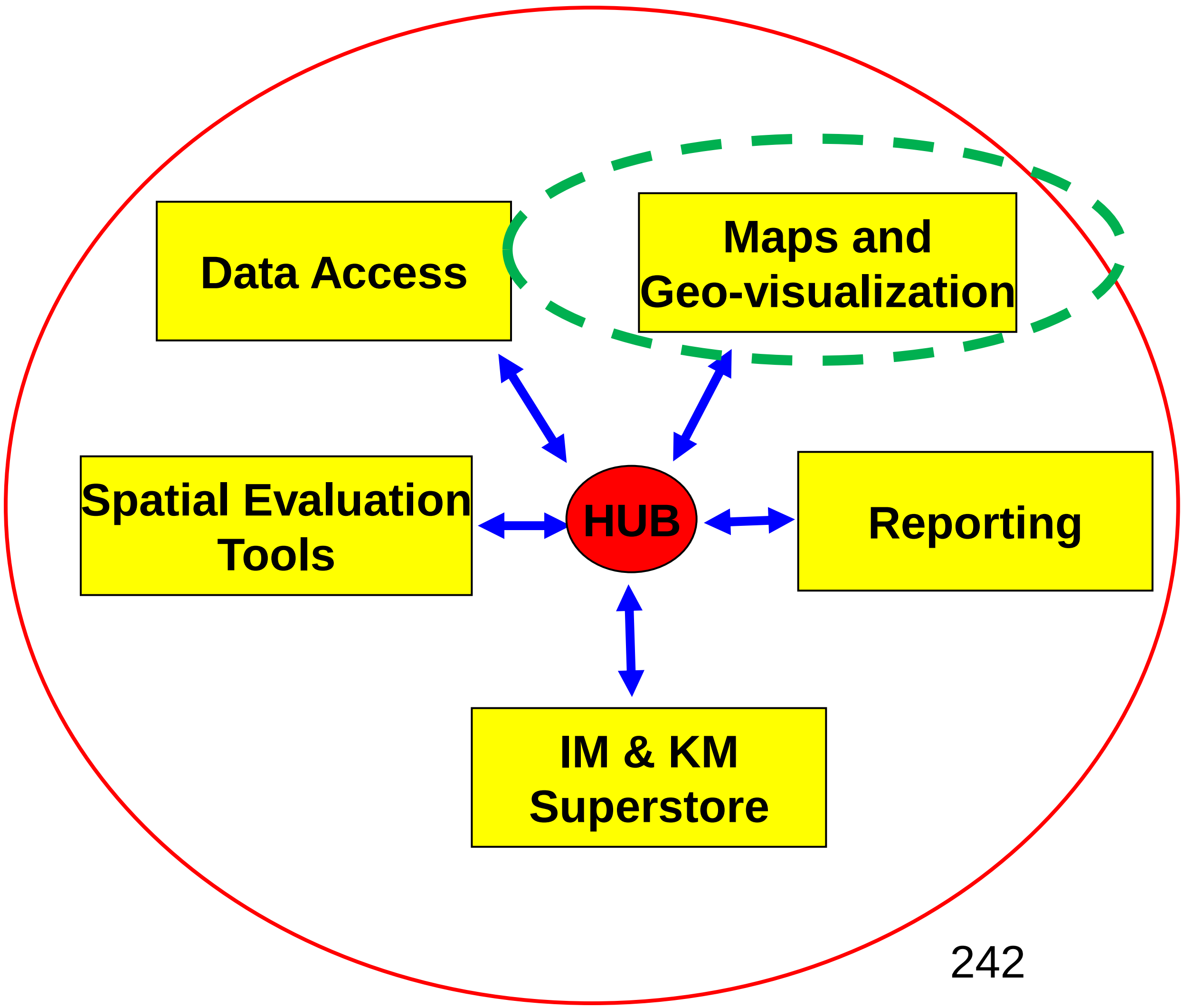


Data Access: Access to all the available data layers from various authoritative sources, including ESRD, GDA, NRE Pod, and partners

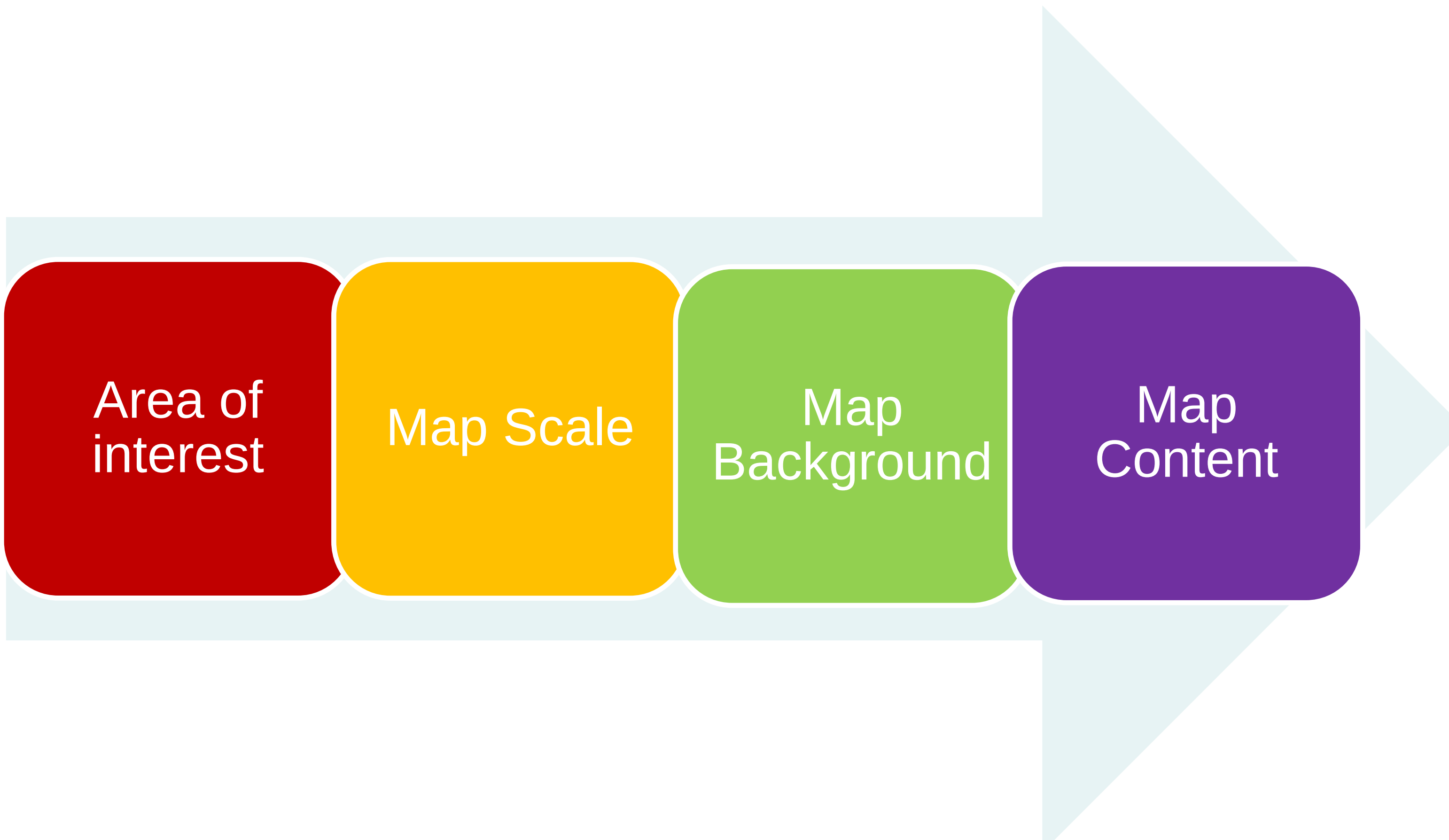
Data Centric: Access to Authoritative Data, Spatial and Non-Spatial



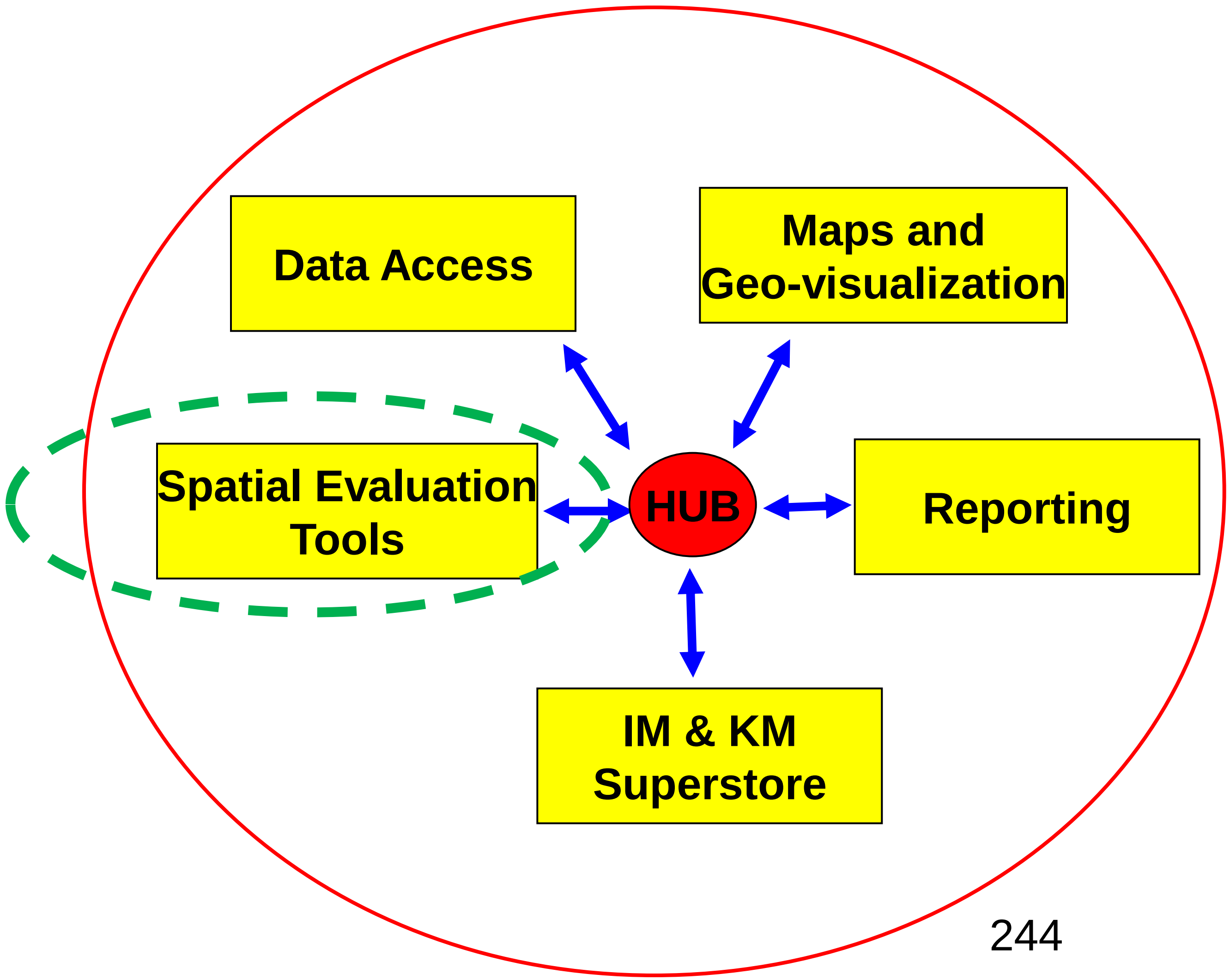
Vision of $(ES)^2$



Map and Geo-visualization: Automation of consistent cartographic, thematic maps at different scales



Vision of (ES)^2



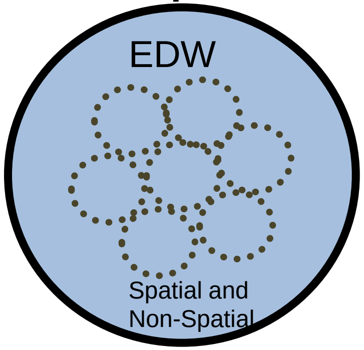
Spatial Evaluation: Access to (1) business spatial evaluation applications, (2) support for spatial analytical models, and (3) generic spatial tool sets

1. Business Spatial Evaluation Applications, e.g., AWAIT, Mikisew, WESPAB , etc.

2. Support for environmental models, air, water, land, and biodiversity models

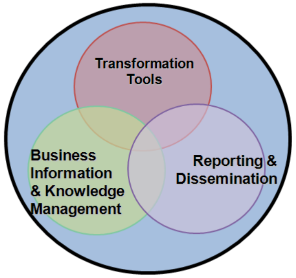
Geographic Extent

Model Selection



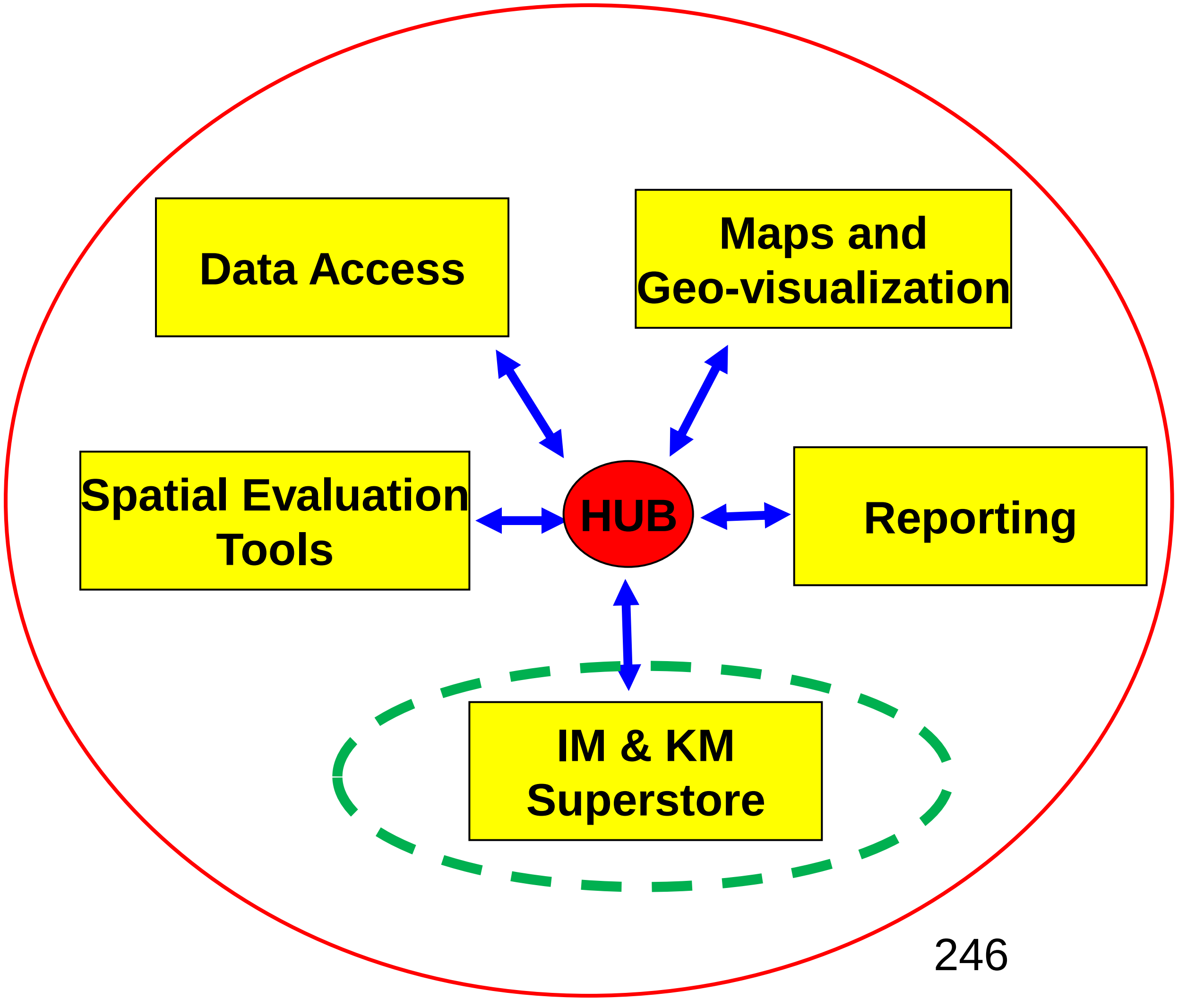
Data are formatted and packaged for a selected model as much as possible

Environmental Modelling

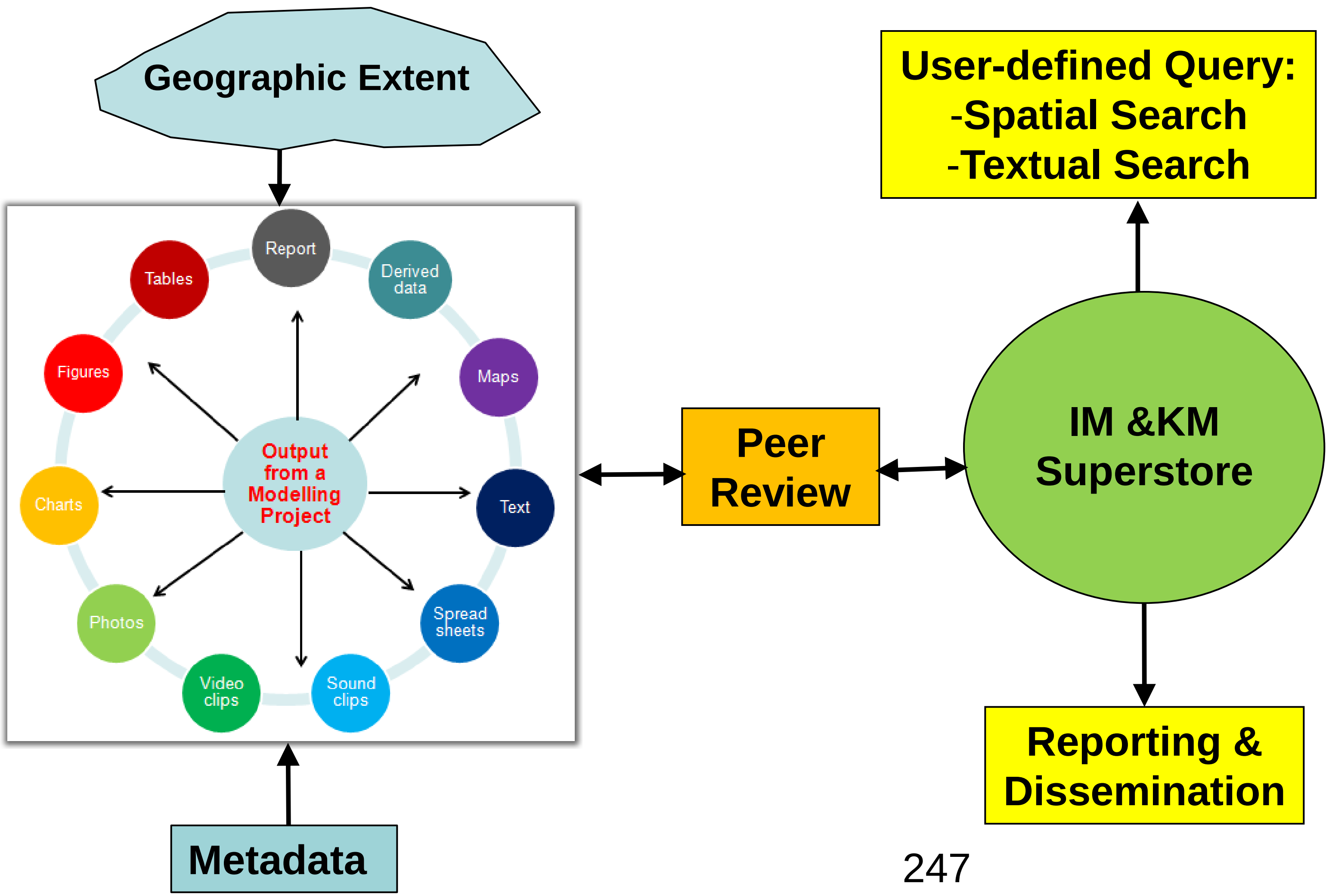


3. Generic Spatial Tool Sets, e.g., Zoom to Township, Place Name, etc.

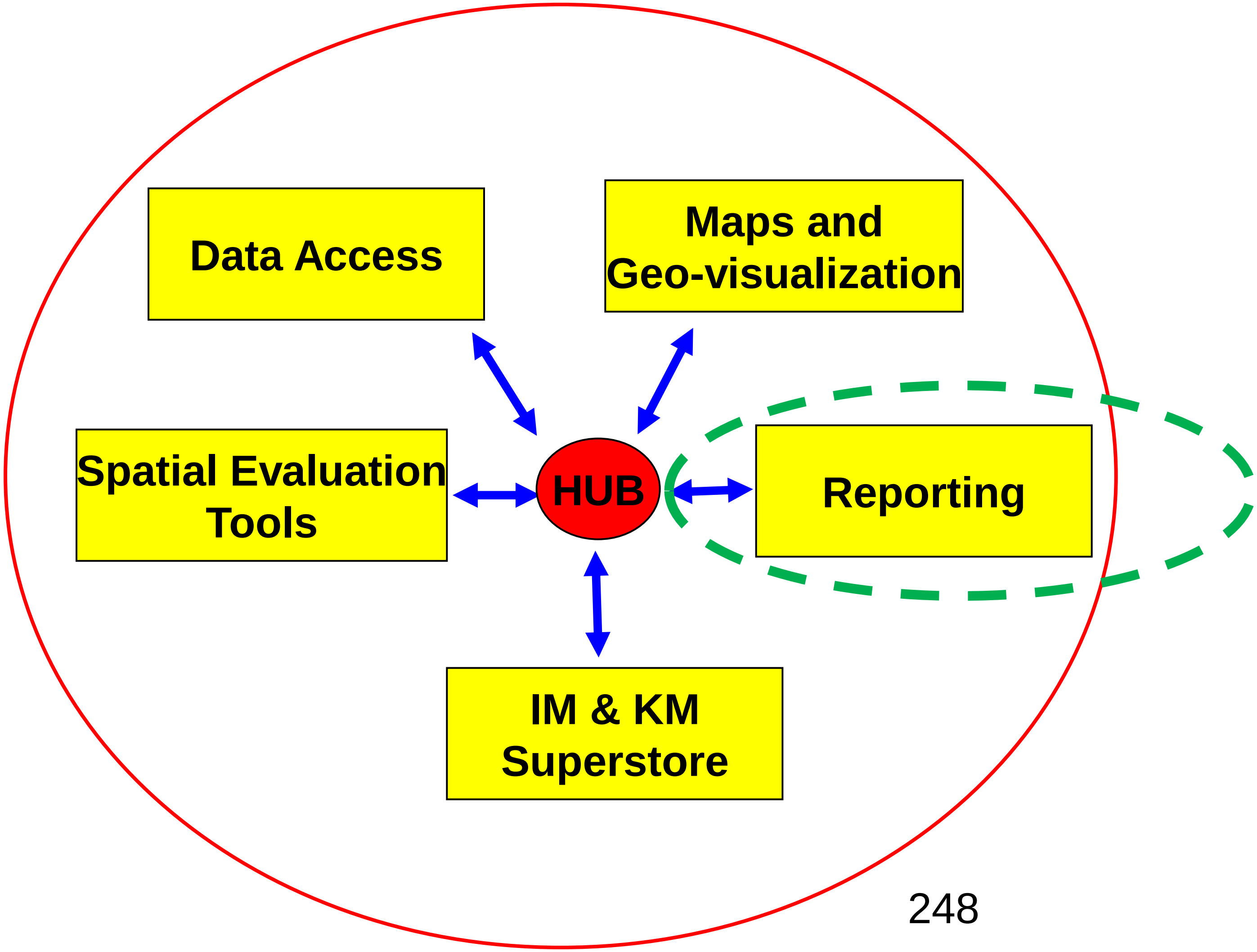
Vision of $(ES)^2$



IM & KM Superstore: Spatially/Textually-searchable catalog to manage/store/access project-based derived information and expert knowledge (derived databases, maps, text, reports, spreadsheets, graphics, pictures, audio files, video clips, etc.)



Vision of $(ES)^2$



Reporting: A spatially-searchable, open & transparent reporting system (a Story Teller) with an option for downloading relevant data and information

Benefits of $(ES)^2$

- Support business processes and management activities within CEMS, IRM, LUF.
- Support scientifically rigorous and defensible data, information and knowledge, i.e., putting the right data/information/knowledge, in the right format, in the right hands, at the right time.
- Support open data.
- Integrate various GIS functions.
- Align with the world-class Monitoring, Evaluation & Reporting vision.
- Support Alberta Monitoring Agency and Alberta Energy Regulator.
- Align with EDMS, including GeoDiscover Alberta.
- Achieve the goal of enterprise GIS (BPIT, 2011).

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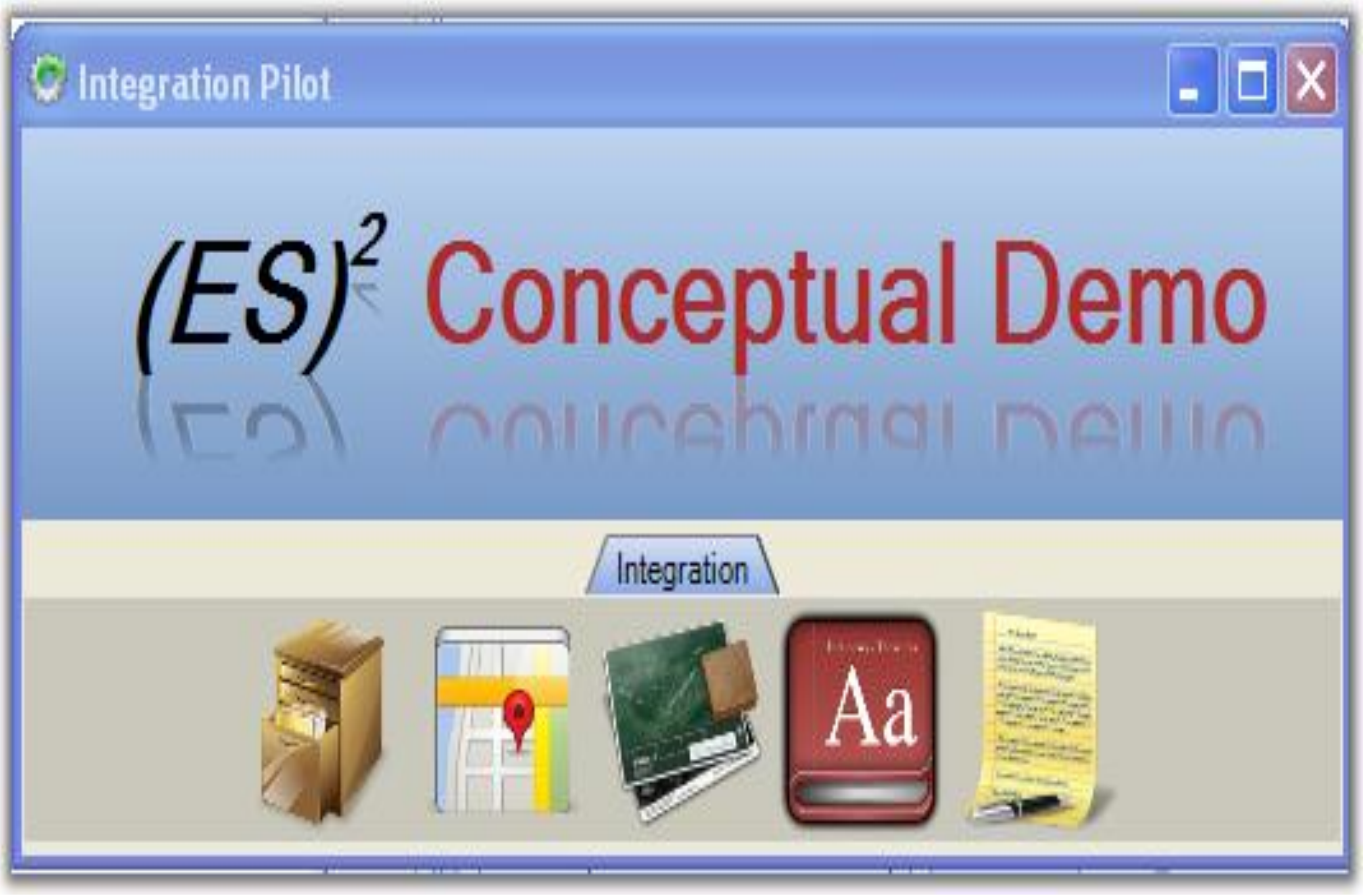
Conceptual Demo



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(ES)^2 Can Make a Difference!

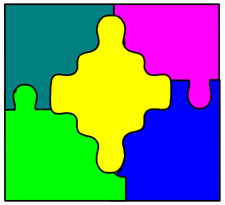
Without **(ES)^2** versus With **(ES)^2**

Stressful and frustrated modeler due to inaccessible data/tools and laborious, inconsistent, time-consuming, non-transparent**,** fragmented, and silo work.

Happy & productive modeler who are making meaningful contributions as a result of an efficient, effective, innovative, timely, informed, open, transparent, and credible enterprise spatial system.

Alberta

Summary



- We have a vision to create a world-class Enterprise Environmental Spatial System (ES)^2 for Alberta.

- We are excited and passionate to do the right thing, and we will strive to do it right through a journey of learning (and making mistakes!)

- We need your support and engagement. By working together, we can make a difference!

Thank You!

Q&A, Comments and Discussions

"A journey of a thousand miles begins with a single step. Just do it!"