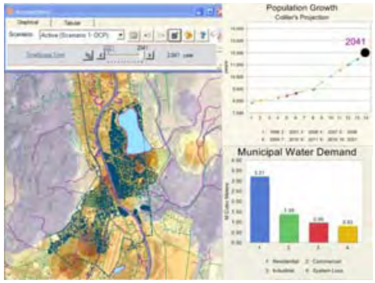






Pathways toward….

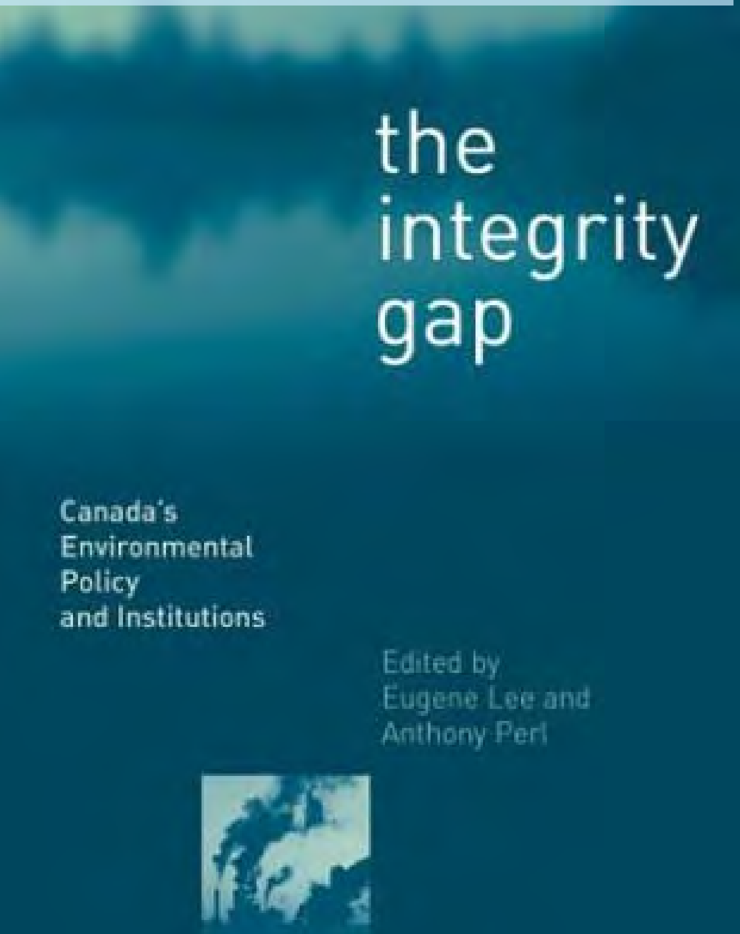
Mainstreaming Groundwater Protection Planning and Comprehensive Planning

Presenters:

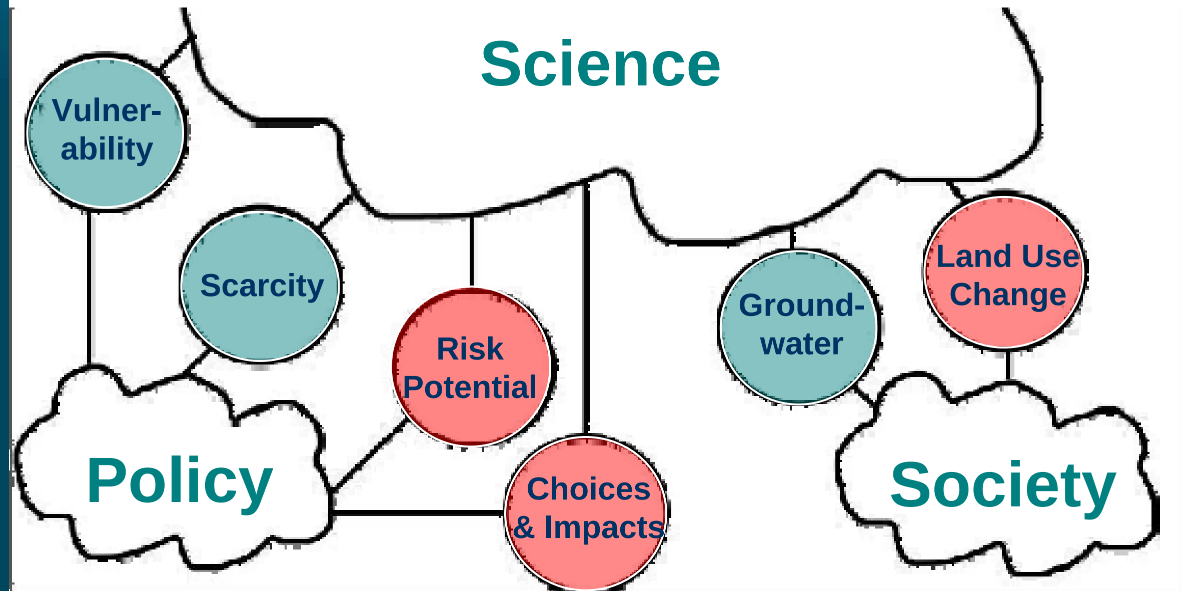
Murray Journeay, Sonia Talwar, Shannon Denny, Craig Forster, Boyan Brodaric,

Pathways... bridging the gap

"Governments all say they want sustainability, but are slow to implement strategies."



- **Integrated Modeling & Visualization** can support an ongoing dialogue about policy options and their coherence across jurisdictional boundaries.



Science & Policy Interactions

Motivating Question

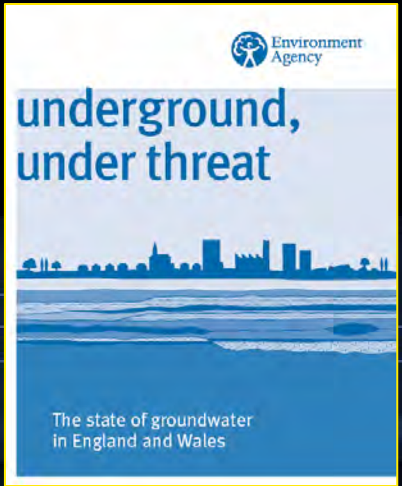
- **IF**

we can characterize the groundwater resource and know where and why there are vulnerabilities *(quality/quantity)*

THEN

where is it safe, or not safe, for people and property to be, and how can we mitigate impacts of these activities?

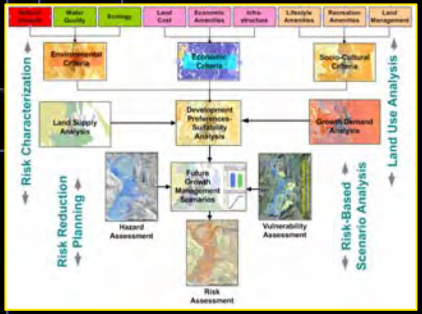
Summary of Main Points



- Draft version of a framework and methodology for mainstreaming conventional groundwater resource assessment and comprehensive planning

- Consistent with recommendations established by NAS, EPA ,EU and emerging trends in risk-based assessment (Environmental Protection, Climate Change & Disaster Reduction)

Summary of Main Points

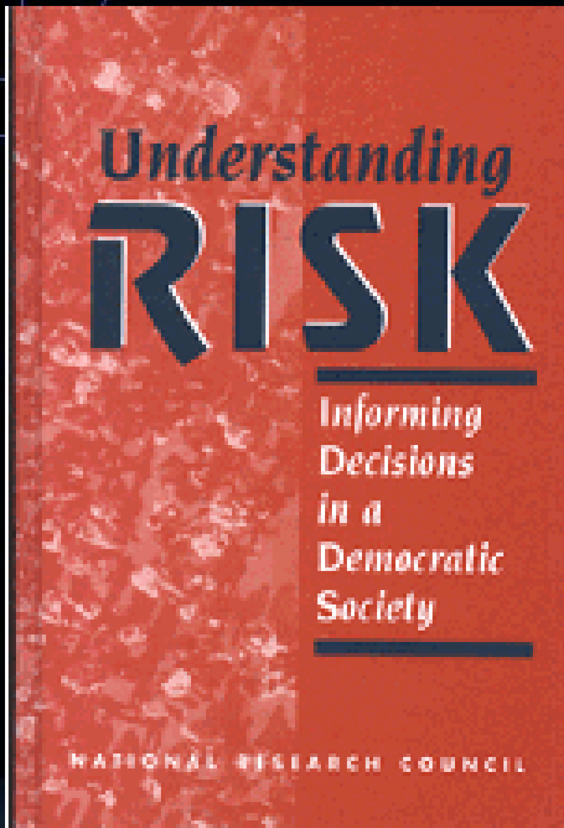


- Extends well established techniques for vulnerability and risk assessment by evaluating potential hazard impacts for existing and future settlement patterns
- Underpinning methodologies include Multi-Criteria-Decision Analysis, Cost-Benefit Analysis and Scenario-based integrated assessment modeling for evaluating groundwater protection.
- Piloting the use of a 'Groundwater Risk Index' to evaluate both impacts and mitigation- adaptation strategies.

Implications of our approach

- Complements and extends existing methodologies already in place (*e.g. BC well-head protection toolkit, aquifer vulnerability assessment, others*)
- Potential bridge to ongoing comprehensive land use planning initiatives at Provincial scale *(Regional Growth Strategy/Official Community Plans).*
- Continued collaboration with provincial, regional and academic partners, both in terms of ongoing methodology development and evaluation/refinement.

Multi-Criteria Decision Analysis



Analytic-Deliberative Framework

informing decisions in a democratic society…..

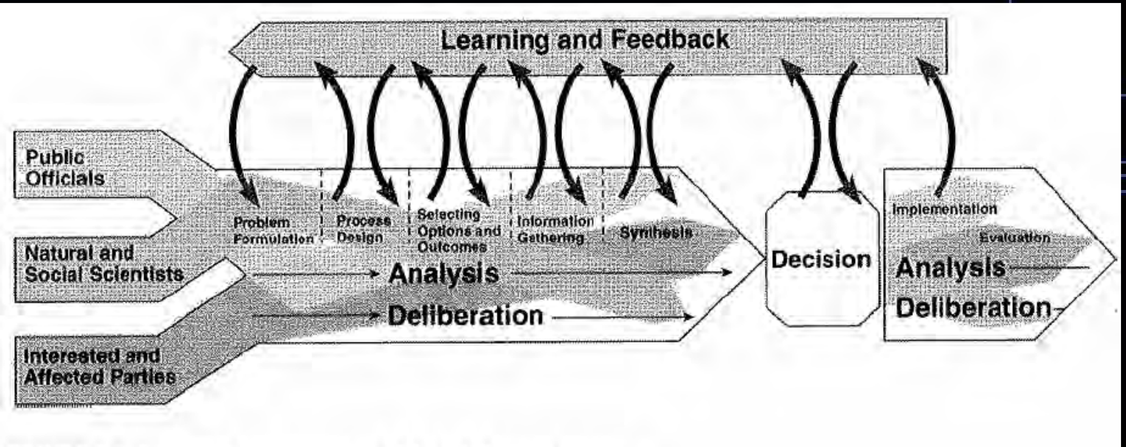


FIGURE 1-2. A schematic representation of the risk decision process.

National Research Council
National Academy of Sciences

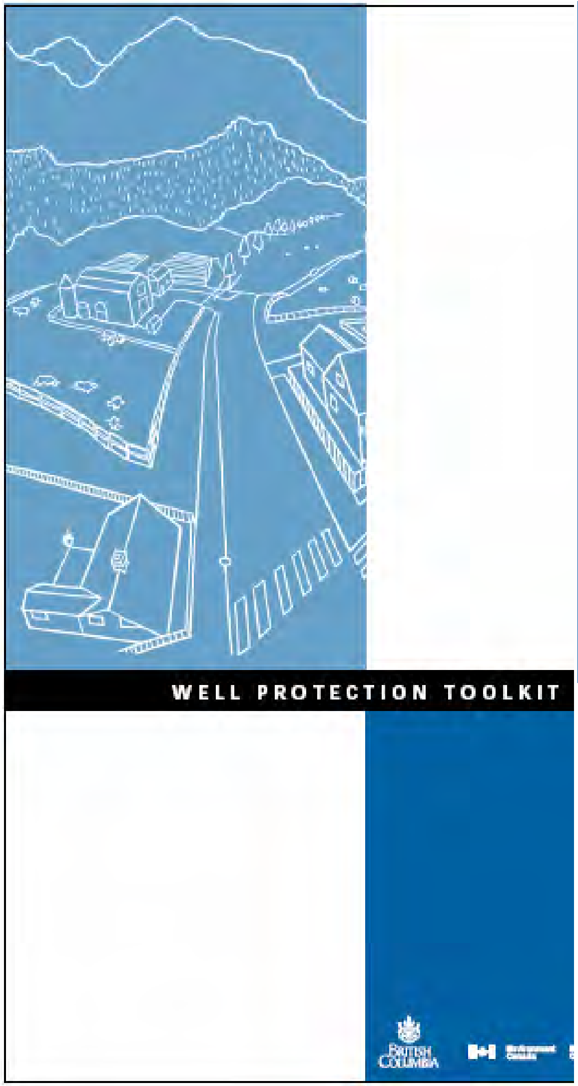
Stern & Fineberg, 1996

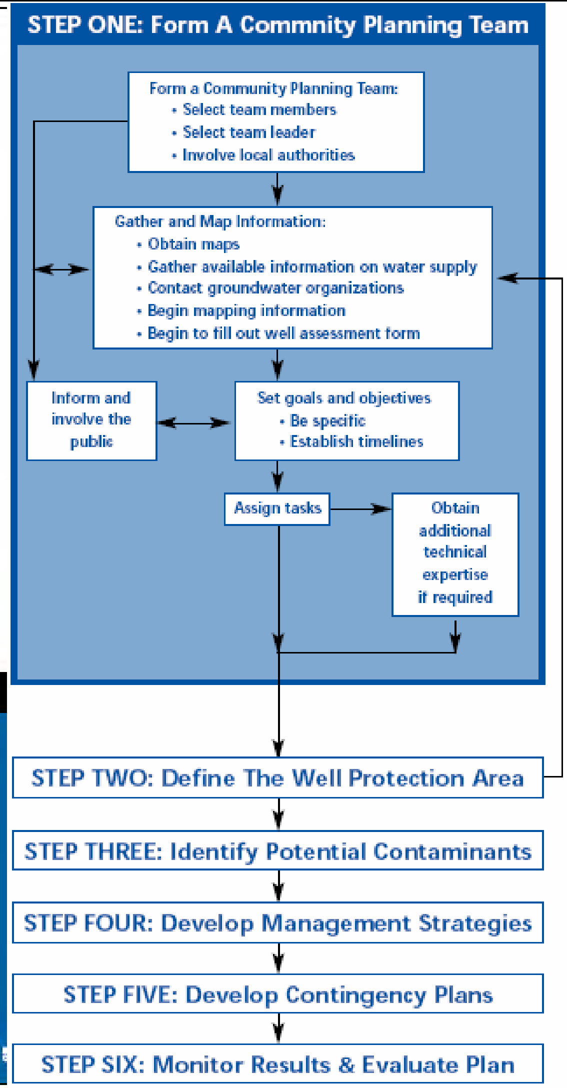
On a range of complex societal decisions:

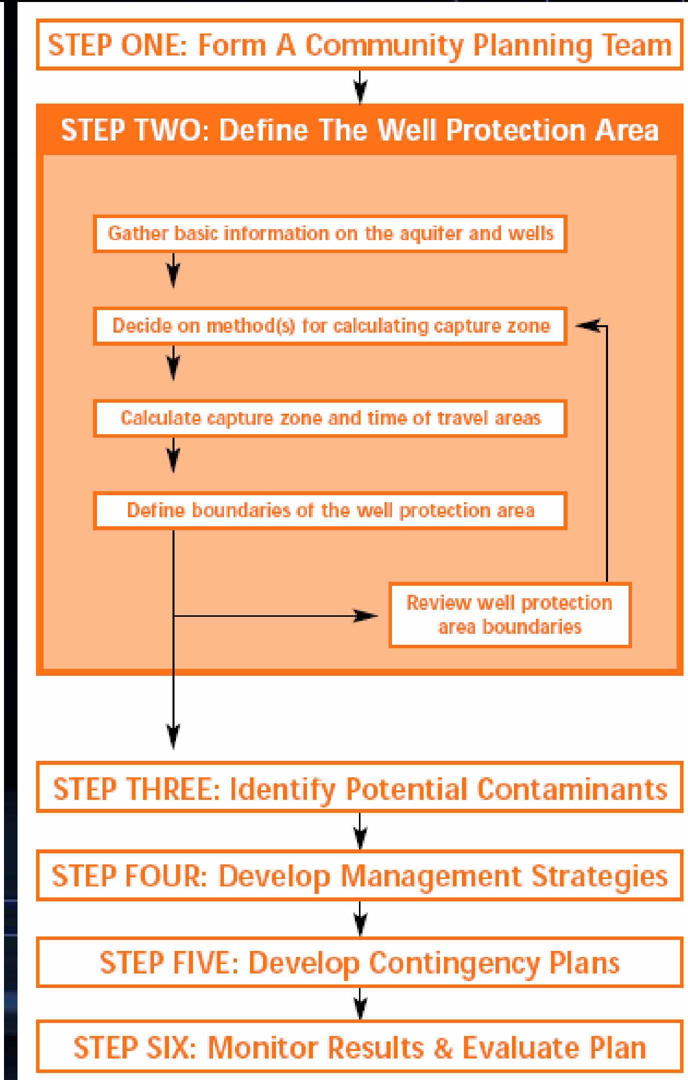
- *Environmental Protection (EPA;USACE;EU)*
- *Climate Change (UNEDP; EU; UN-APF)*
- *Natural Hazards (FEMA;NDMS;ISDR-HFA)*

BC Well Protection Toolkit; Tier 1-

(deliberative; guidelines for quantitative input)

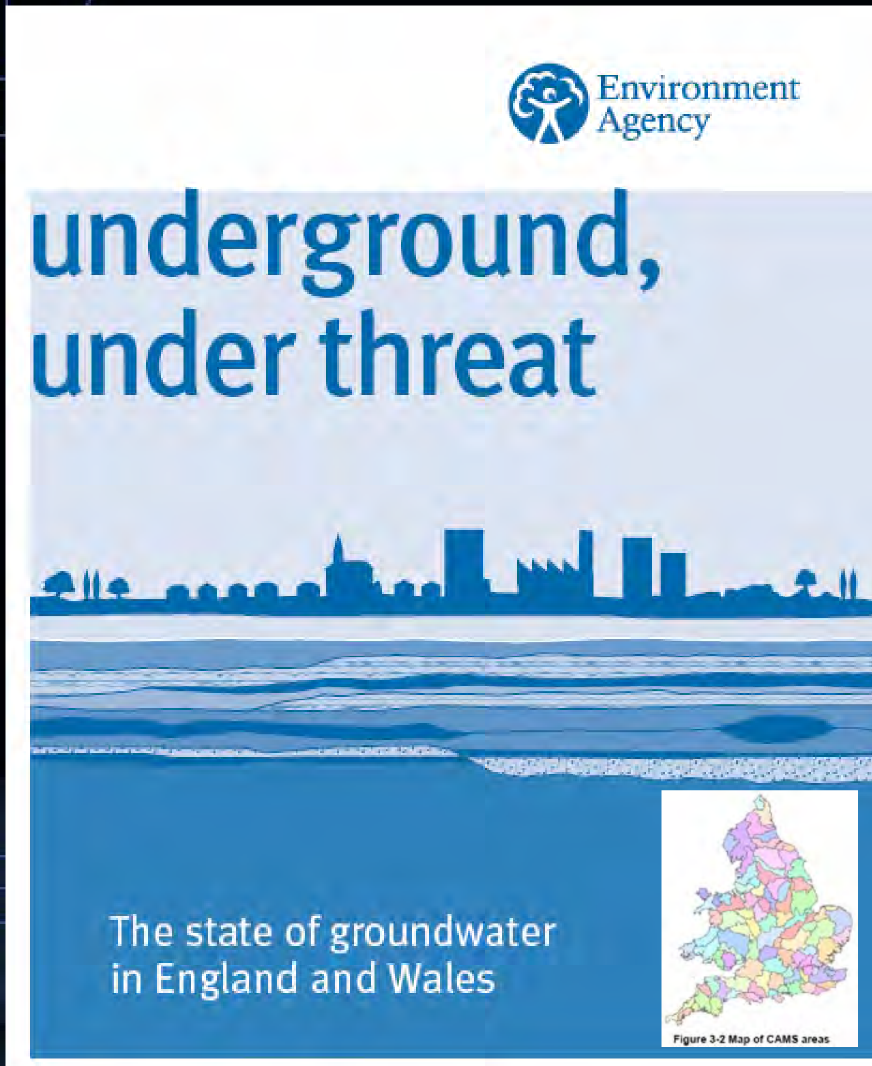


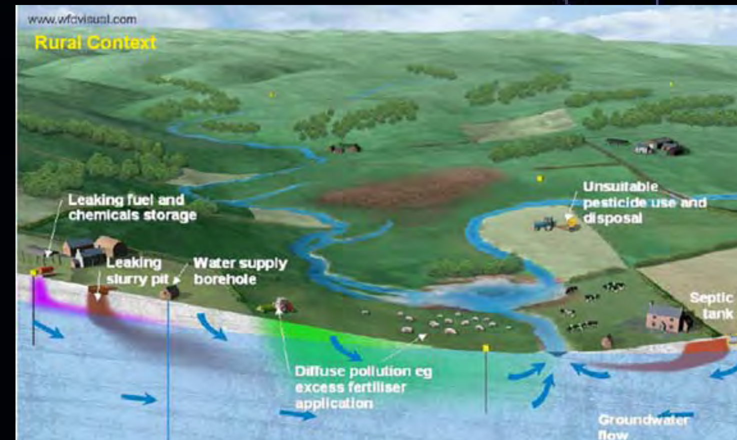


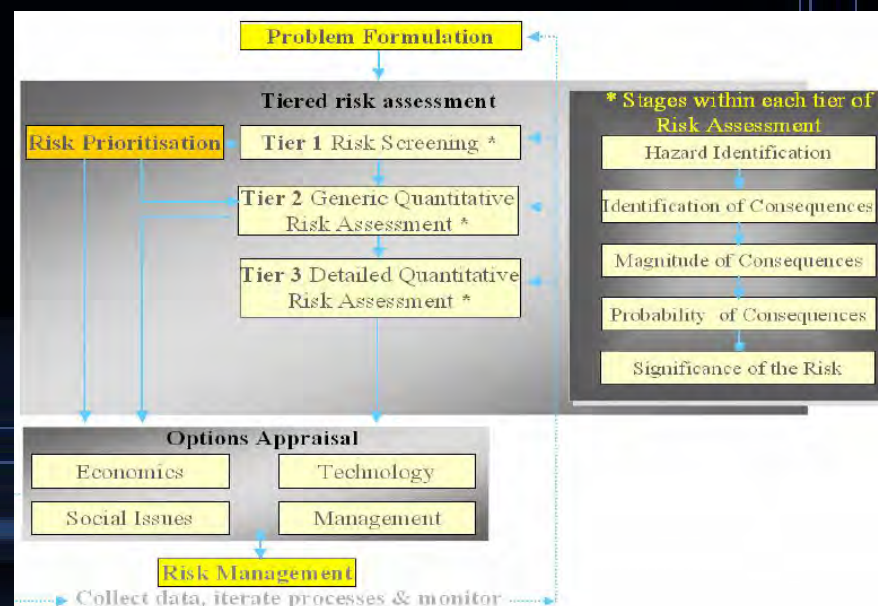


EU; Groundwater Protection Planning

Tiers 2/3 - *(deliberative; quantitative; analytic)*







EPA Source Water Assessment Program;

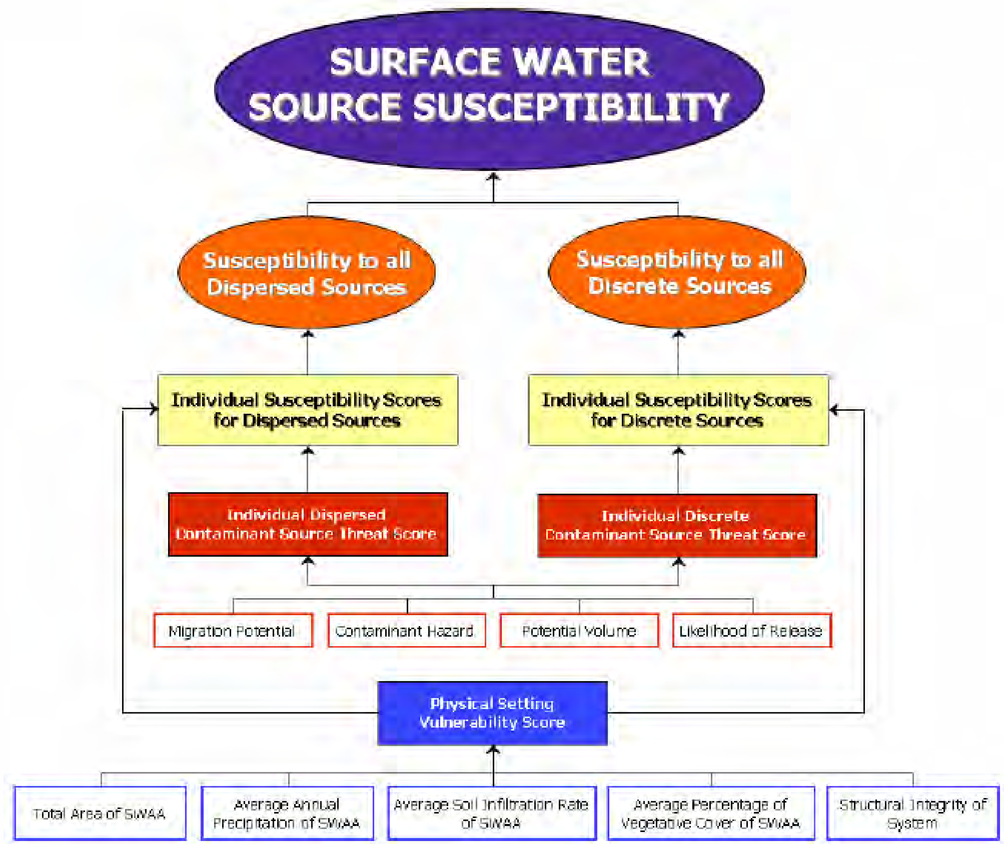
(deliberative; semi-quantitative)

United States Environmental Protection Agency | Office of Water 4606 | EPA 816-R-97-009 August, 1997

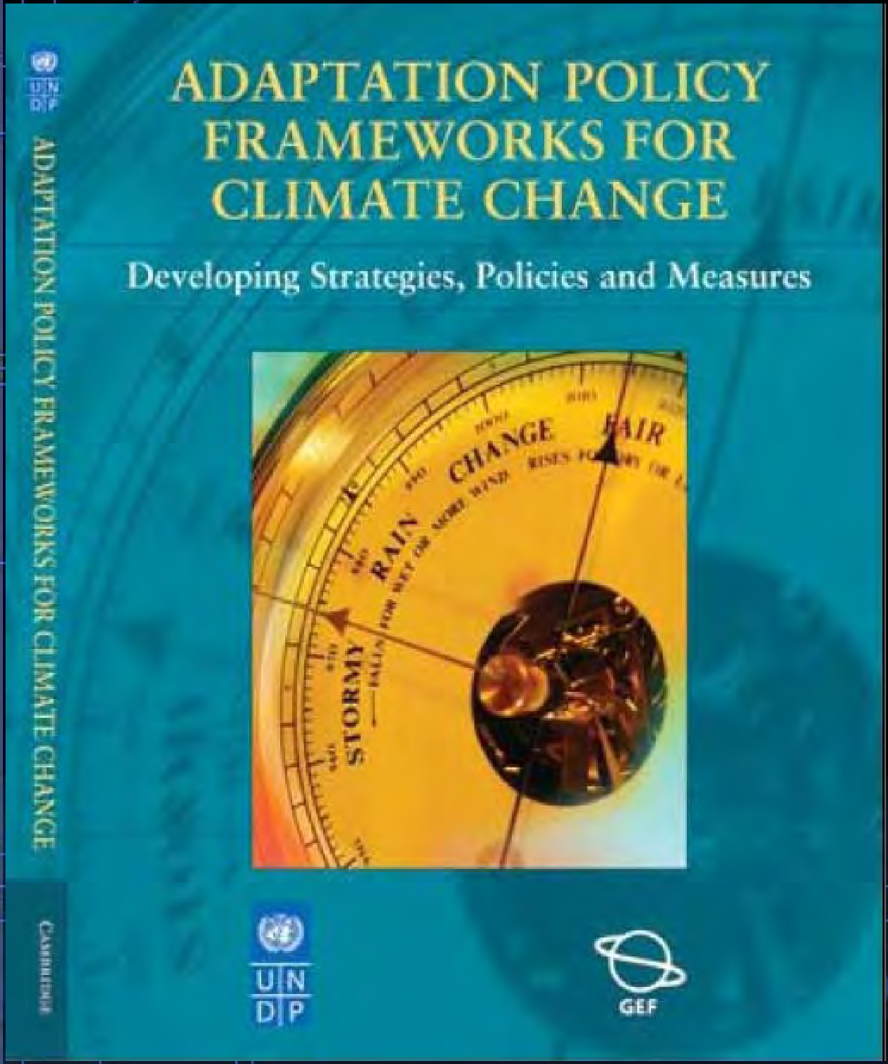
EPA

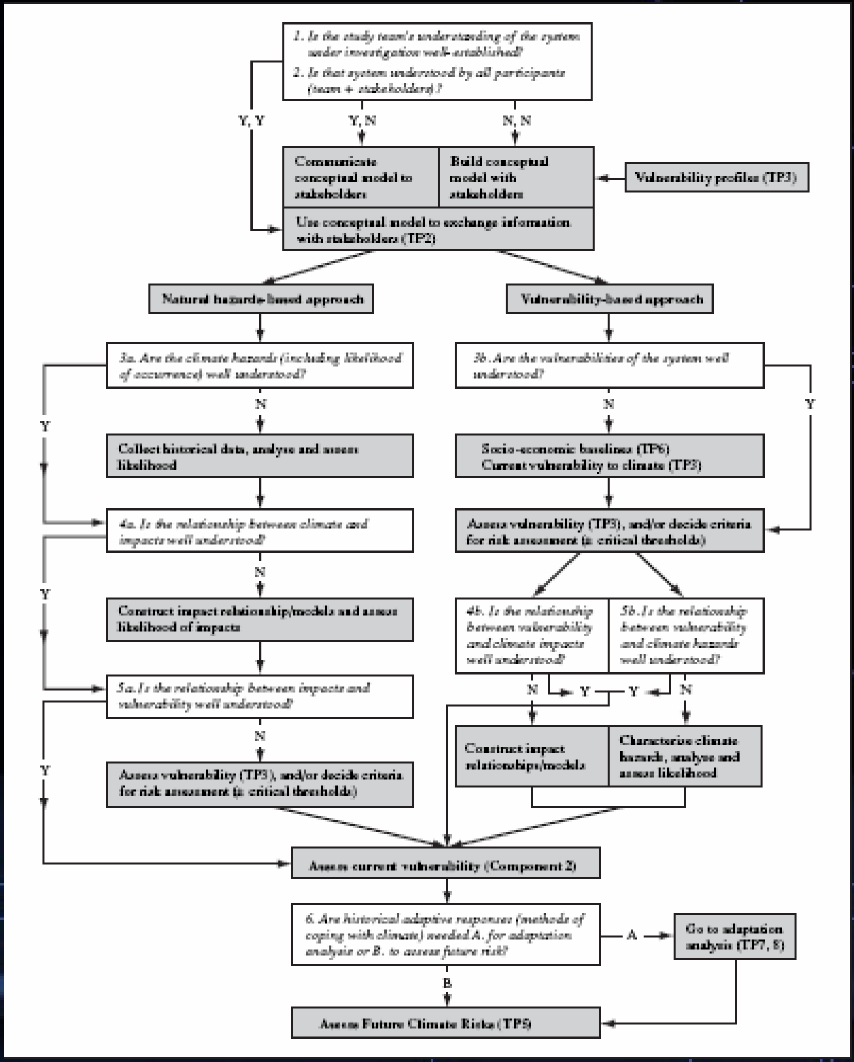
STATE SOURCE WATER ASSESSMENT AND PROTECTION PROGRAMS

Tiers 1- 3 SWAP-



APF - Integrated Assessment Framework for Policy Analysis

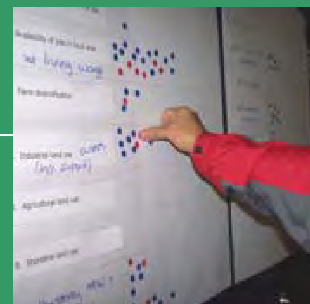




Analytic-Deliberative Framework for Groundwater Protection Planning

SGOG

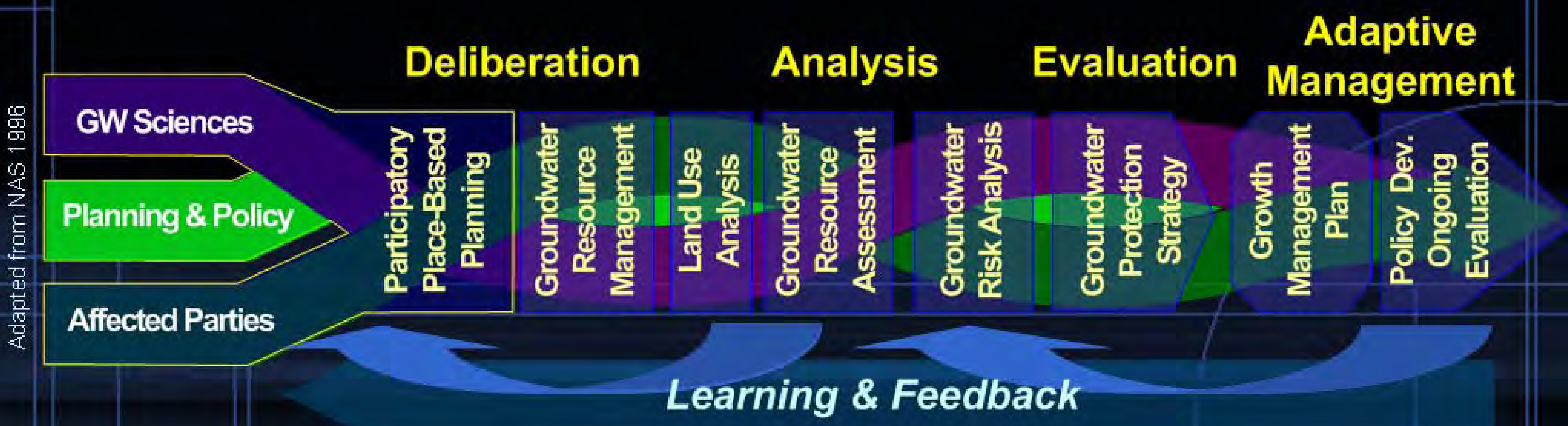
Priorities



Indicators

Targets

Concept Plan



Groundwater Protection Planning

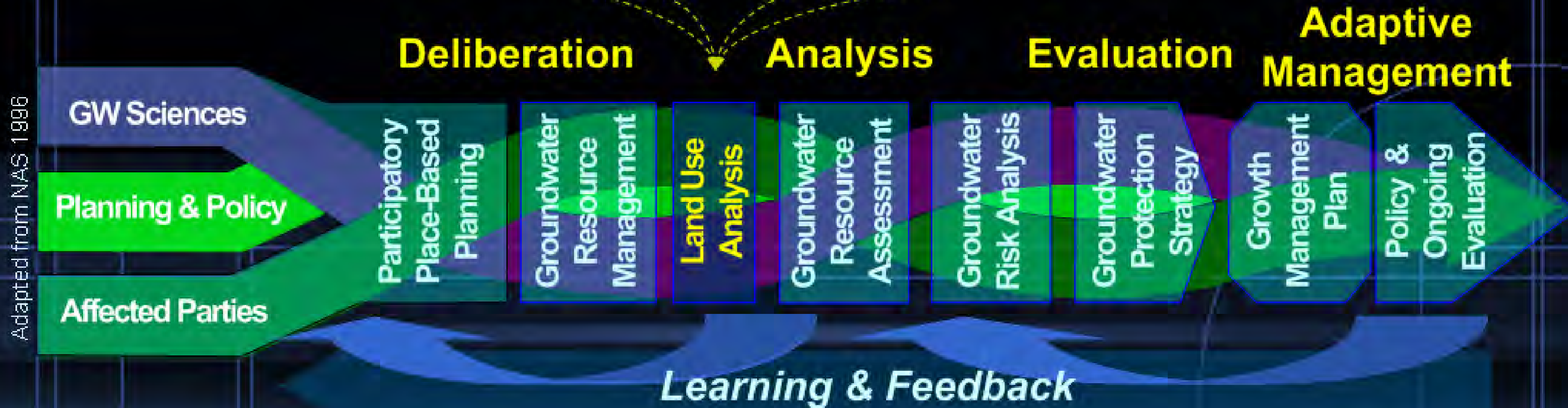
Land Use Analysis

Growth Potential
- *Population Growth*
- *Commercial Growth*
- *Economic Growth*

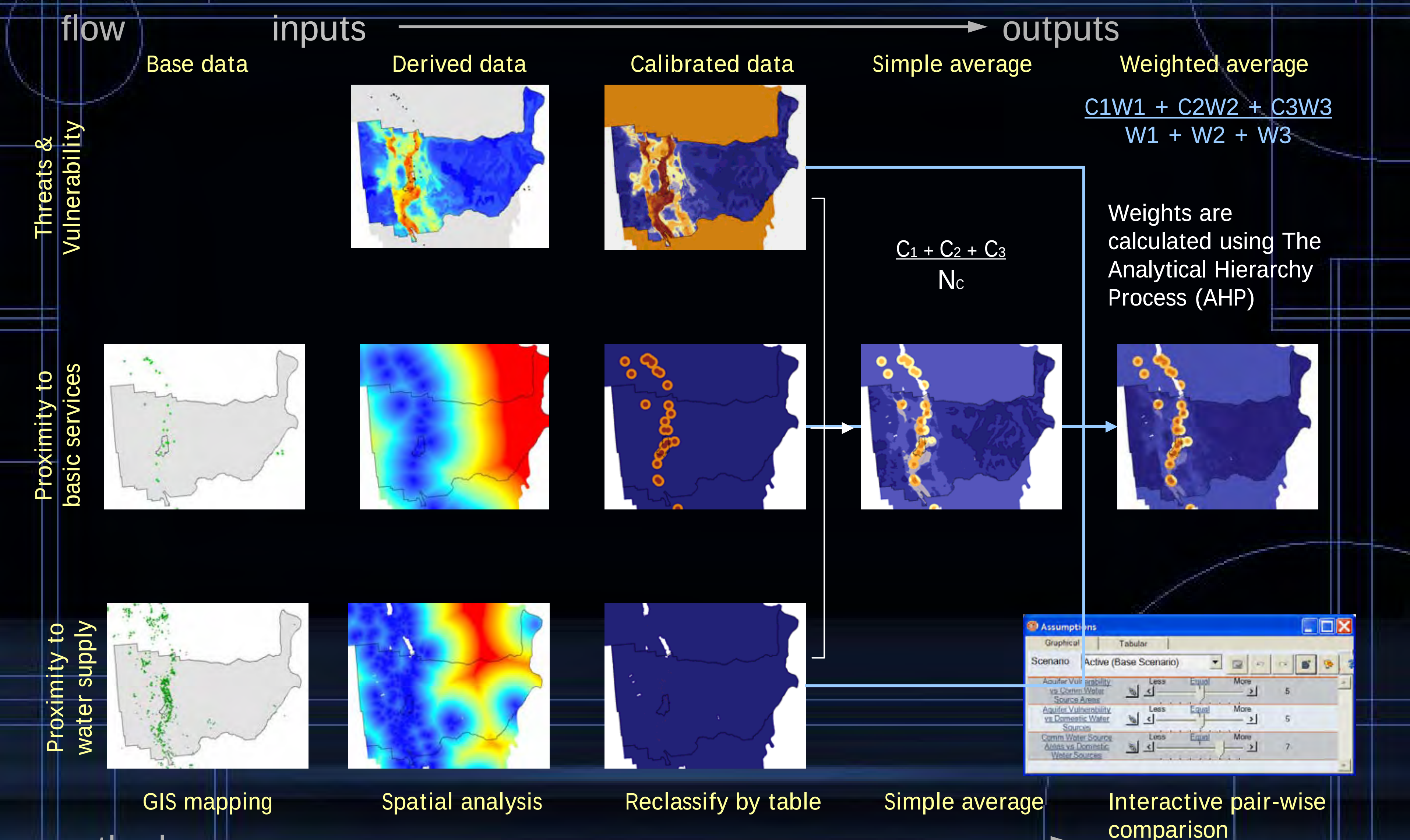
Build-out Capacity
- *Regulatory Constraints*
- *Policy Constraints*
- *Existing Development*
- *Development Potential*

Develop. Preferences
- *Environmental Criteria*
- *Economic Criteria*
- *Socio-Cultural Criteria*

Allocation Scenarios
- *Environmental Criteria*
- *Economic Criteria*
- *Socio-Cultural Criteria*

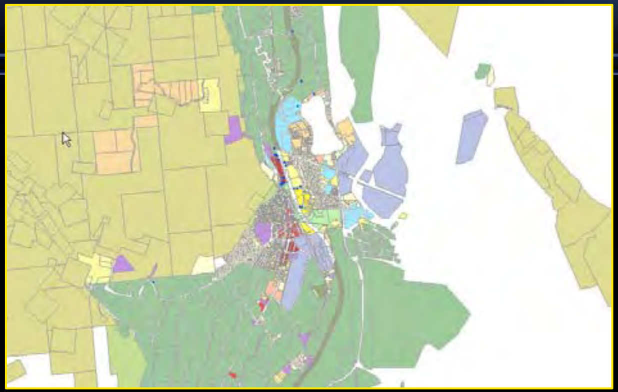


Multi-Criteria Decision Analysis

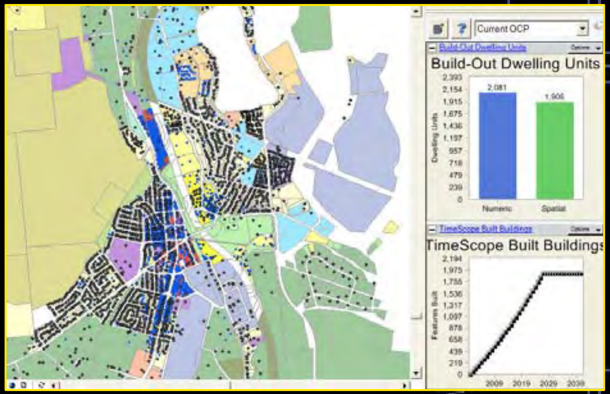


Land Use Analysis

Supply
(build-out capacity)



Future population numbers for a selected year are allocated to areas with highest **development preference** rankings.



Allocation Scenario

Development preference
(timing)

Each spatial unit is filled to its **capacity** and then the next highest one is filled, and so on, until demand is met.

Existing Conditions

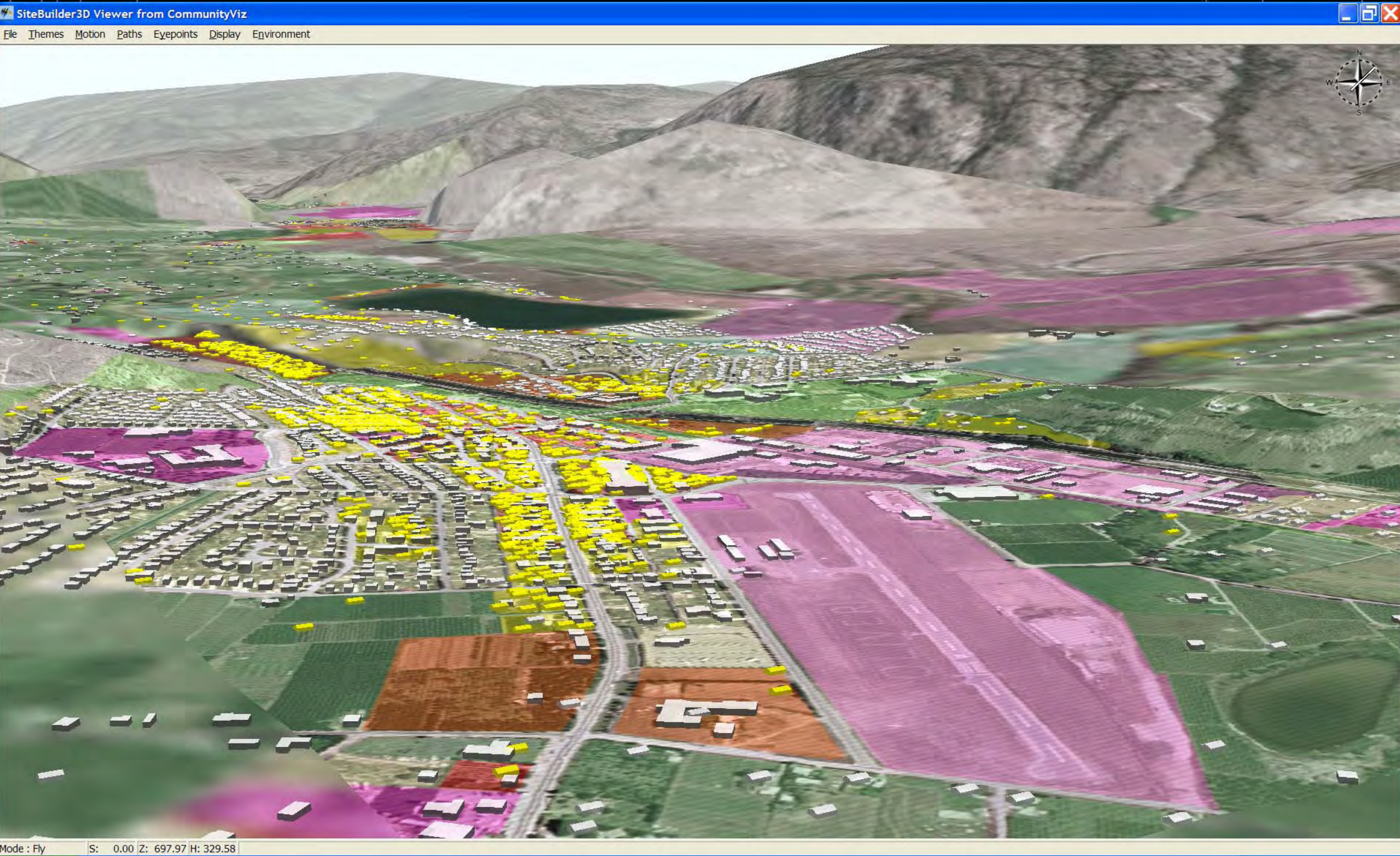
dwelling units = 2,753

OCP Buildout

Existing dwelling units = 2,753

Anticipated Demand = 5,186 – 7,627

OCP Buildout Capacity = 5,300



Land Use Allocation Model

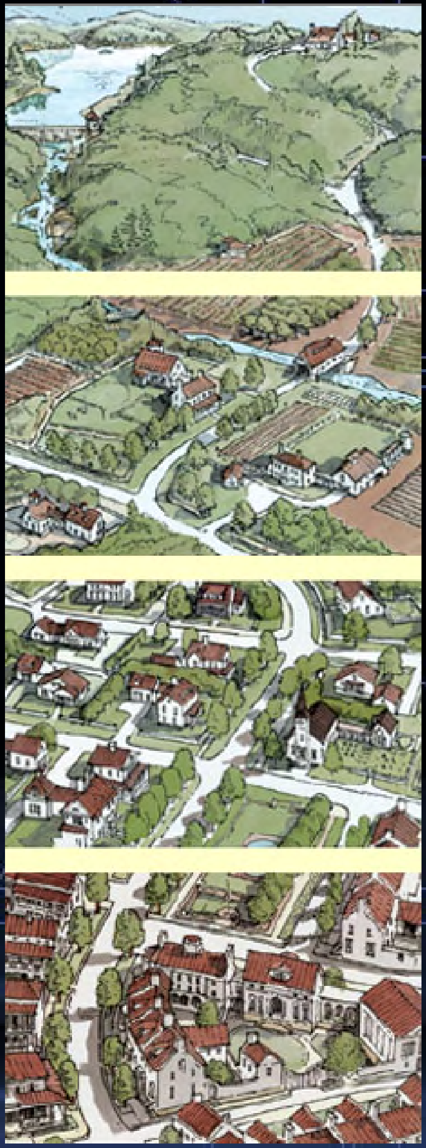
intended to assist Community and regional District planners in:

day-to-day operations

- DP review
- suitability analysis,
- regulatory & bylaw compliance,

longer-term strategic planning initiatives

- alternate growth strategy assessment
- greenways & ecosystem services plan
- Natural hazard mitigation
- water resource management
- OCP review & amendment process



NRCan Land Use Allocation Model

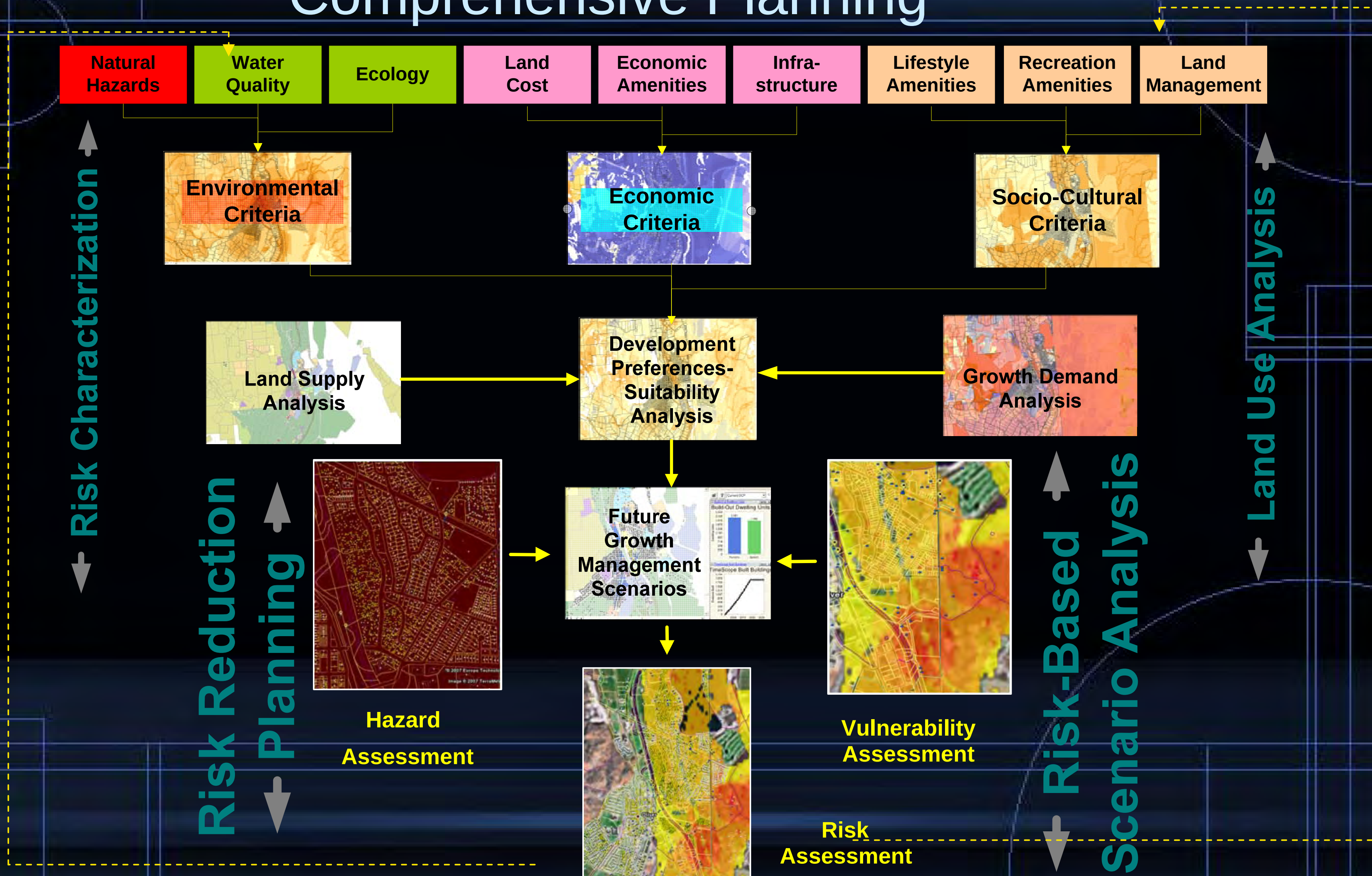
- Designed to support interactive exploration of land use scenarios and evaluation of growth management strategies/policies over time scopes of interest to a regional or local planning process

- Based on backcast modeling approach that emphasizes development of desirable future scenarios and policy options for achieving these outcomes

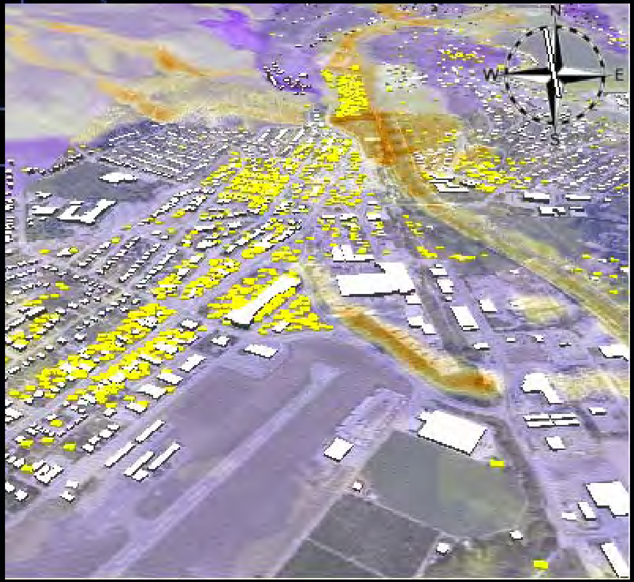
- Allocates growth (residential, commercial, etc.) to land area based on criteria that are developed, calibrated and weighted through a deliberative community planning process

- Model outputs include preference maps that reflect embedded knowledge and values of planning process, and allocation scenarios delineating incremental growth patterns over time.

Integration of Groundwater Protection Planning and Comprehensive Planning

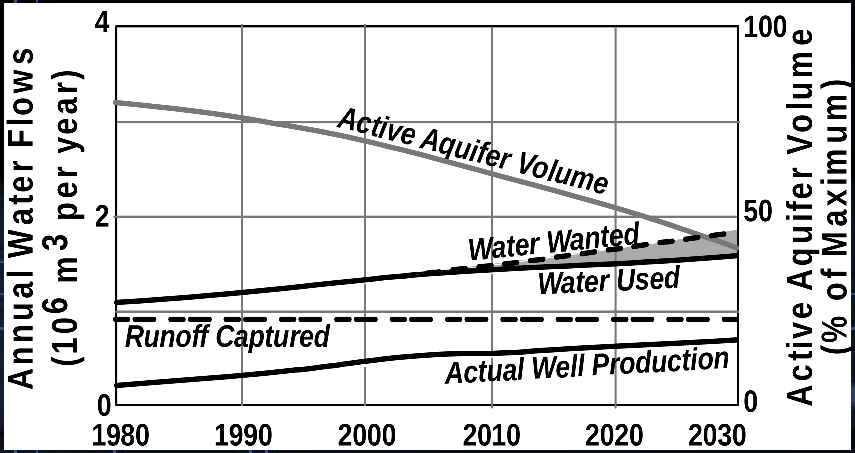


Elements of Groundwater Vulnerability



Water Quality

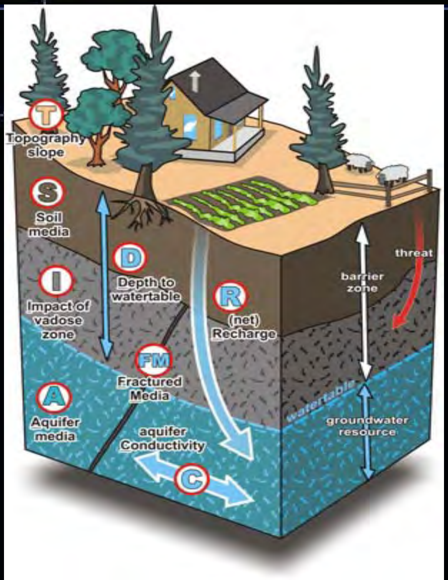
- Vulnerability: An assessment of the physical characteristics of groundwater aquifers (*susceptibility*) and the potential for surface contamination over time

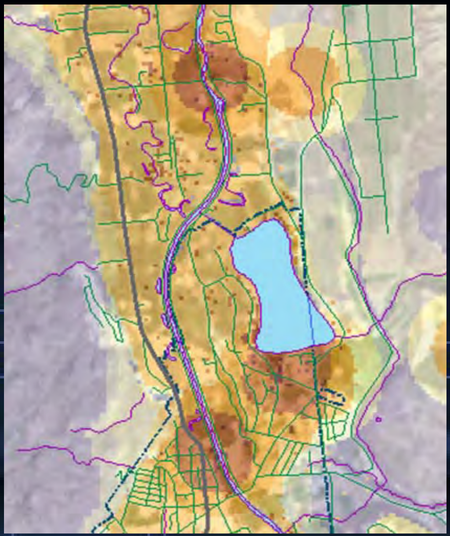


Water Quantity

- Sustainable Water Yield: the capacity of surface and groundwater supplies to balance environmental and human needs over longer-term strategic planning horizons (10-40 years).

Intrinsic Groundwater Susceptibility





Groundwater vulnerability maps provide science-based guidelines and an operational framework for:

- land-use planning and the development of Best Management Practices and/or policy recommendations for groundwater protection.
- informing communities and decision-makers about groundwater protection and stewardship

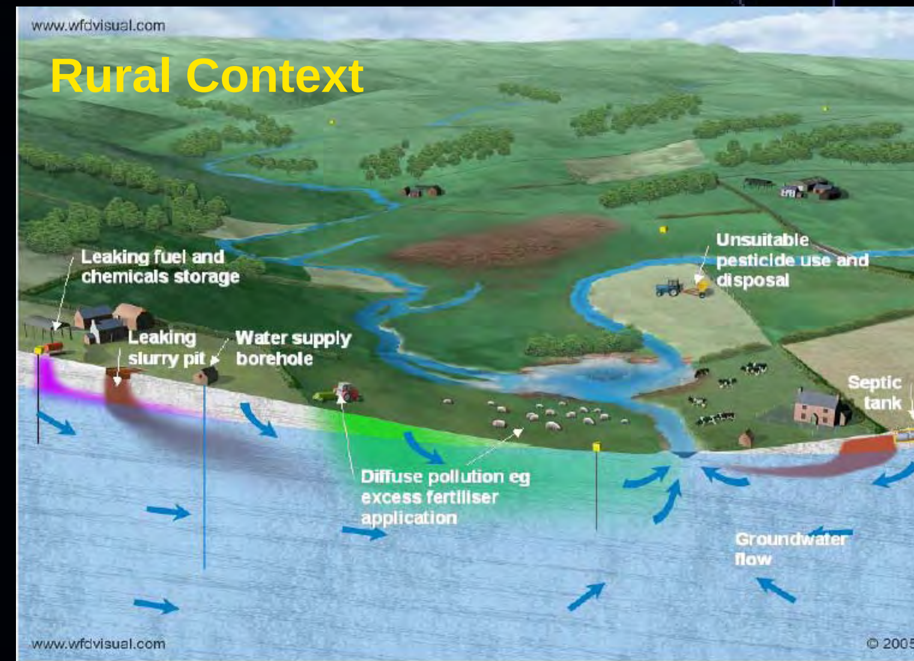
Groundwater Protection Planning

Groundwater Resource Assessment

Threat / Hazard Assessment:

$$(T) = \sum (E * M * L)$$

- ***(E)*** = *Spatial Extent (point/dispersed)*
- ***(M)*** = *Magnitude (toxicity, fate, amount)*
- ***(L)*** = *Likelihood of Occurrence*



Groundwater Protection Planning

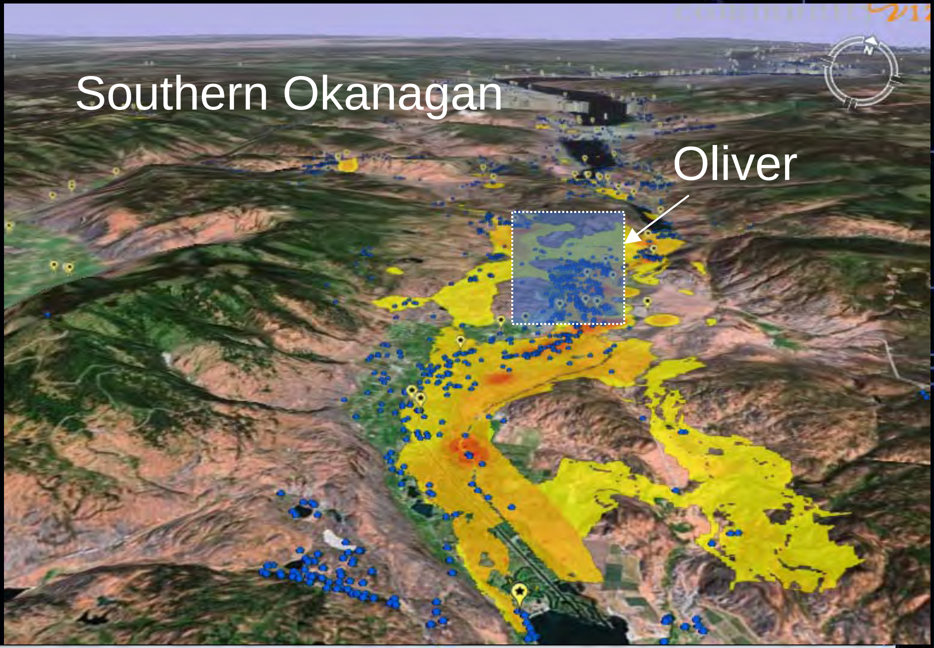
Groundwater Resource Assessment

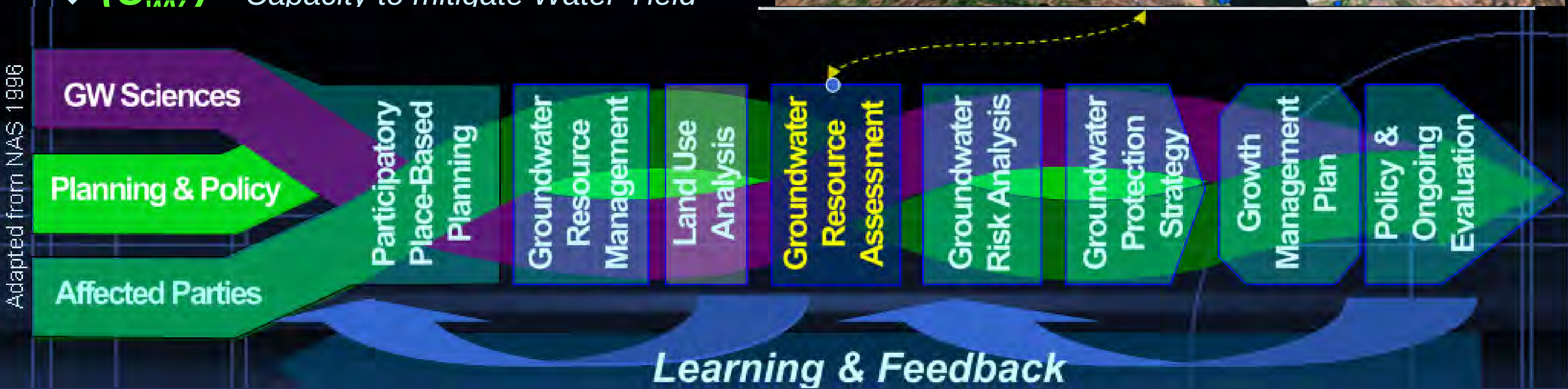
Vulnerability Assessment:

= Susceptibility/Capacity

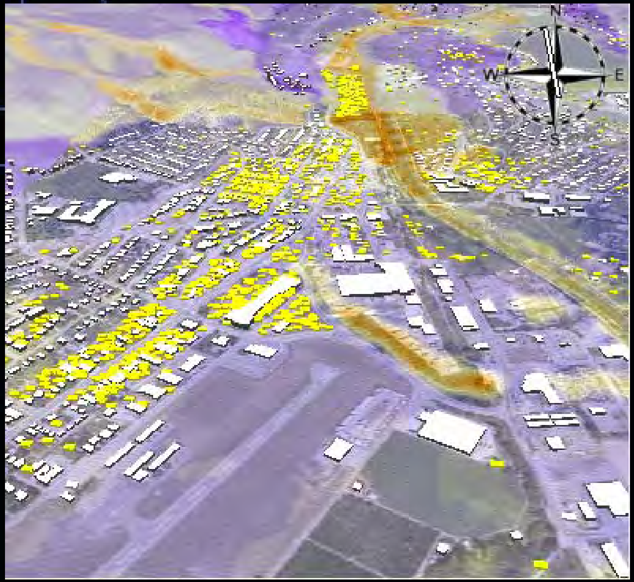
$$(V) = \sum (S_i * S_a / C_a) * (S_{wy} / C_{wy})$$

- (S_i) = *Intrinsic Groundwater Susceptibility*
- (S_a) = *Anthropogenic Susceptibility*
- (C_a) = *Anthropogenic Capacity*
- (S_{wy}) = *Susceptibility -Available Water Yield*
- (C_{wy}) = *Capacity to mitigate Water Yield*



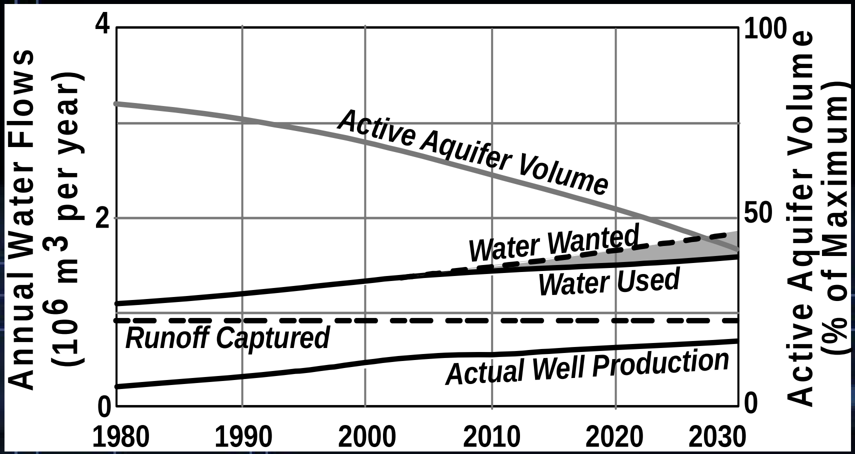


Elements of Groundwater Vulnerability



Water Quality

- **Vulnerability:** An assessment of the physical characteristics of groundwater aquifers (*susceptibility*) and the potential for surface contamination over time



Water Quantity

- **Sustainable Water Yield:** the capacity of surface and groundwater supplies to balance environmental and human needs over longer-term strategic planning horizons (10-40 years).

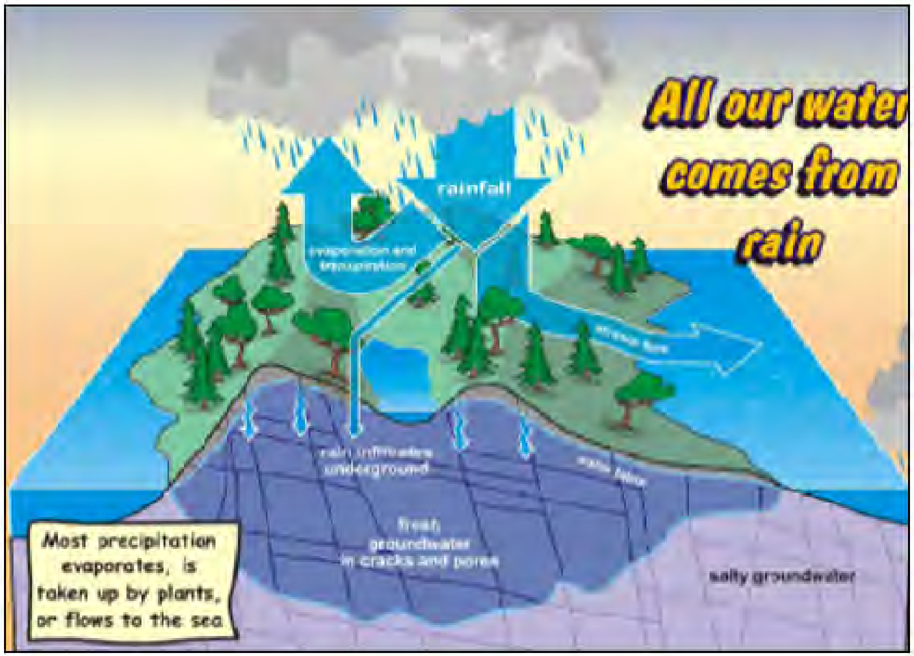
Sustainable Water Yield

Island Water Sustainability Model

Gabriola Island, British Columbia

Programmed by Craig Forster, Univ. of Utah, College of Architecture+Planning

Last Revised: July 18, 2006



INTRODUCTION

This model provides an opportunity for island residents and planners to learn more about the interaction between people and water systems on marine islands - particularly in the way that the island water systems might respond to different population growth and climate futures. Although this model is tuned to the specifics of Gabriola Island, the principal features of the system are similar to many marine islands around the world. Explore the model interface by clicking on each of the buttons below: "Background", "Inspect Model", and "Explore System".

Background

Inspect Model

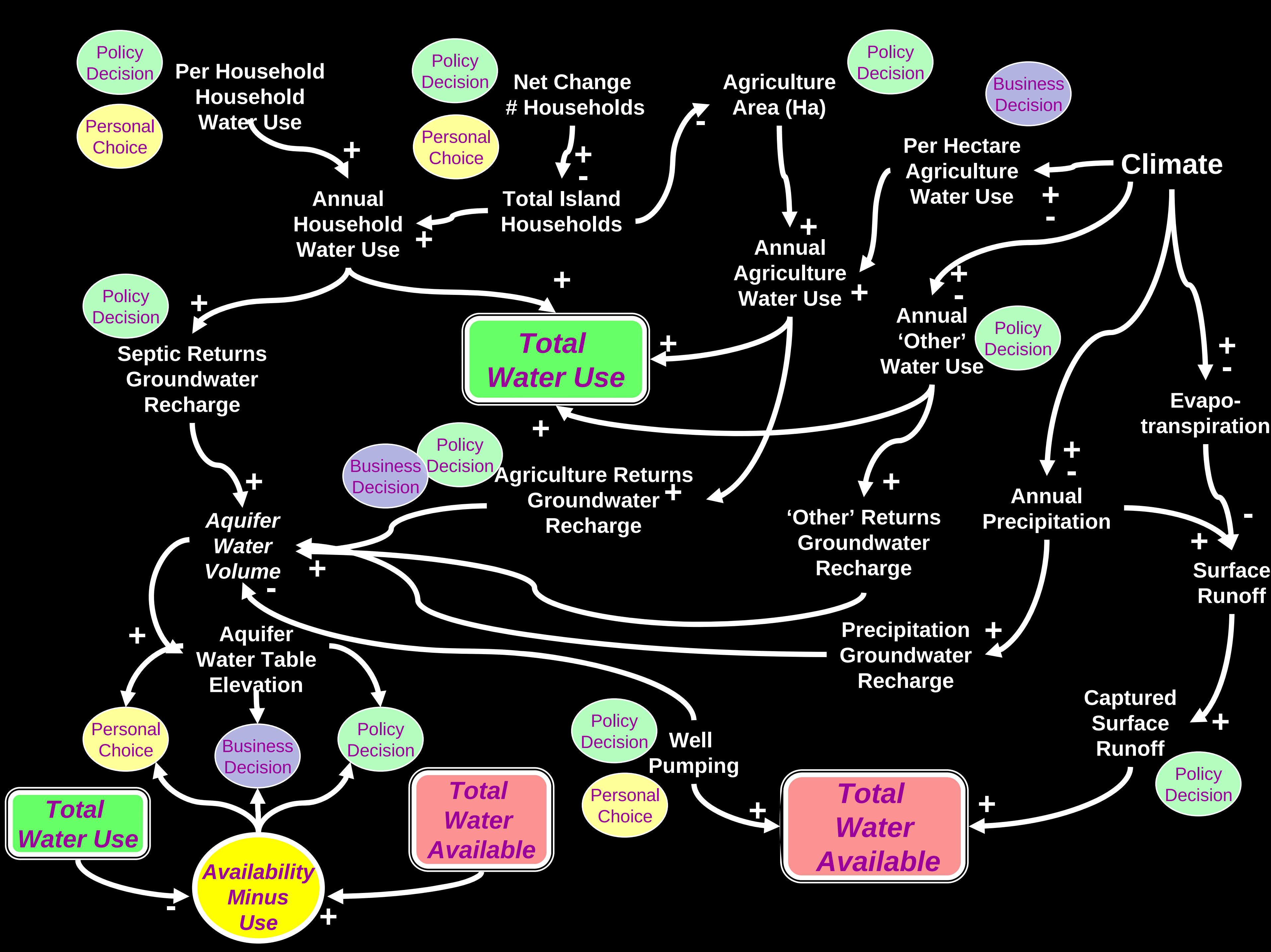
Explore System

If you GET LOST in the INTERFACE, try coming back here by clicking '1st Page' then start over. Also consider getting help from the interface map available by clicking on 'Map'.

Map

Quit

NOTE: Clicking this button always returns you to the previous screen



Policy Decision
Personal Choice
Per Household Household Water Use
Policy Decision
Personal Choice
Net Change # Households
Agriculture Area (Ha)
Policy Decision
Business Decision
Per Hectare Agriculture Water Use
Climate
Annual Household Water Use
Total Island Households
Annual Agriculture Water Use
Annual 'Other' Water Use
Policy Decision
Policy Decision
Septic Returns Groundwater Recharge
Total Water Use
Evapo-transpiration
Business Decision
Policy Decision
Agriculture Returns Groundwater Recharge
'Other' Returns Groundwater Recharge
Annual Precipitation
Aquifer Water Volume
Surface Runoff
Aquifer Water Table Elevation
Precipitation Groundwater Recharge
Captured Surface Runoff
Personal Choice
Business Decision
Policy Decision
Policy Decision
Well Pumping
Personal Choice
Policy Decision
Total Water Use
Total Water Available
Total Water Available
Availability Minus Use

Sustainable Water Yield

Looking to the Future
1990 through 2029

Reset Switch

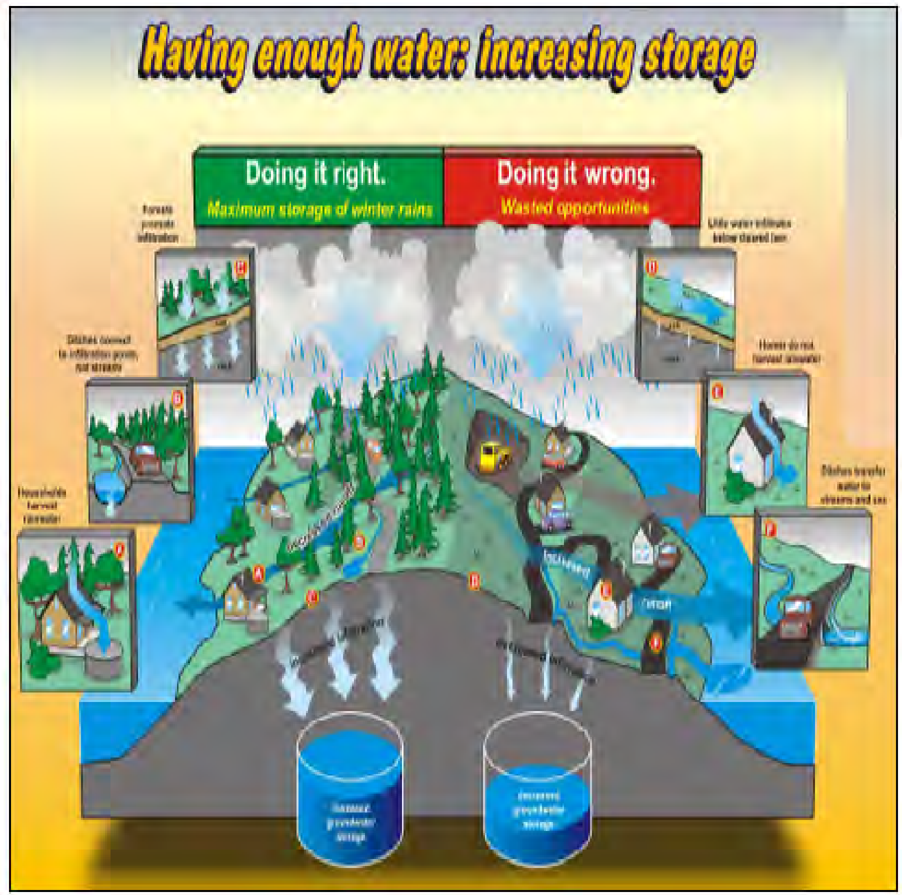
Start by clicking on 'Reset Switch' to reset the 'Natural System' switch to the 'down' or 'off' position.

1. How might future policies affect the system?

Future Policies

2. How might future climate change affect the system?

Future Climate



Explore System | **Graphs of Future**

1st Page | Map | Quit

Sustainable Water Yield

Looking to Future Water Demand Policies

Adjust future water demand policies here then go to 'Policies' to see change in water demand features OR go to 'Future' to see impacts on hydrologic system.

	Policy Action	Start Time for Policy
Agricultural water wanted can be reduced through conservation by reducing the irrigate rate per hectare of crop as a % of the 1990-2000 irrigation rate. This represents a change in crop or change in farming practices.	IRRIG Ag Crop Future Irrig Rate Reduc as % 1990 to 1999 0 – 50 12	IRRIG Ag Crop Irrig Rate Reduc Start Time 2005 – 2031 2022
Agricultural water wanted can be reduced after 2005 through loss of agricultural land at a specified annual % loss. Loss may be result of fallowing or due to conversion to urban land.	IRRIG Ag Land Future Loss Rate % 0 – 50 7	IRRIG Ag Land Loss Start Time 2005 – 2031 2011
Residential (including hospitality industry) water use can be reduced through conservation. Assuming no conservation from 1990 to 2000, conservation can be implemented any time after 2005 as a specified % decrease in water wanted.	Res Future Conserve Rate Reduc as % 0 – 50 0	Res Conserve Start Time 2005 – 2031 2024
Commercial/Industrial (non-hospitality) water use can be adjusted to consider different future conditions.	Comm Ind Want New mill cub m\mo 0.000 – 0.100 0.000	Comm Ind Want New Start Time 2005 – 2031 2031

Graphs of Future

1st Page | **Future** | **Policies** | **Map**

Sustainable Water Yield

Graphs of Future 1990 through 2029

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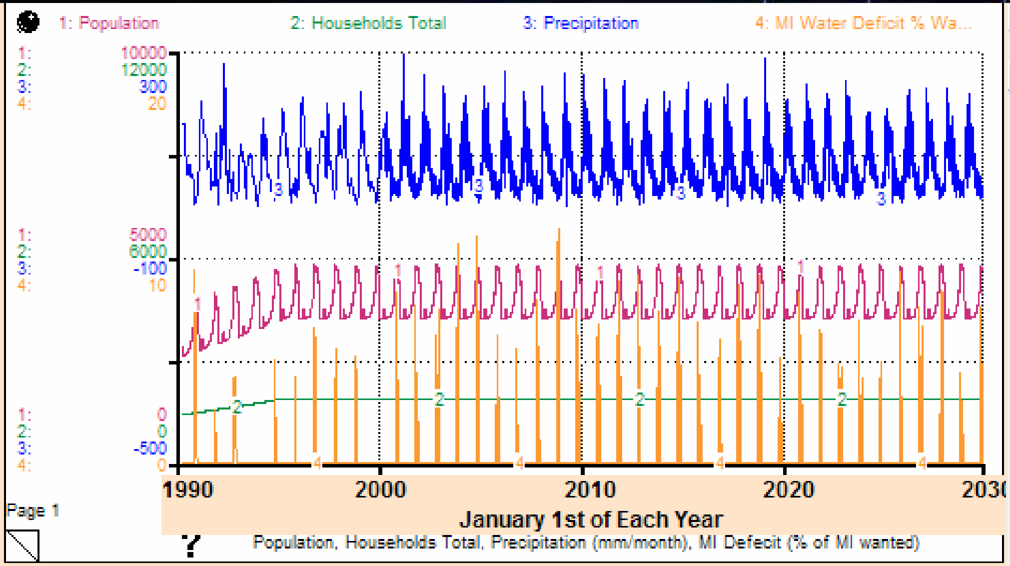
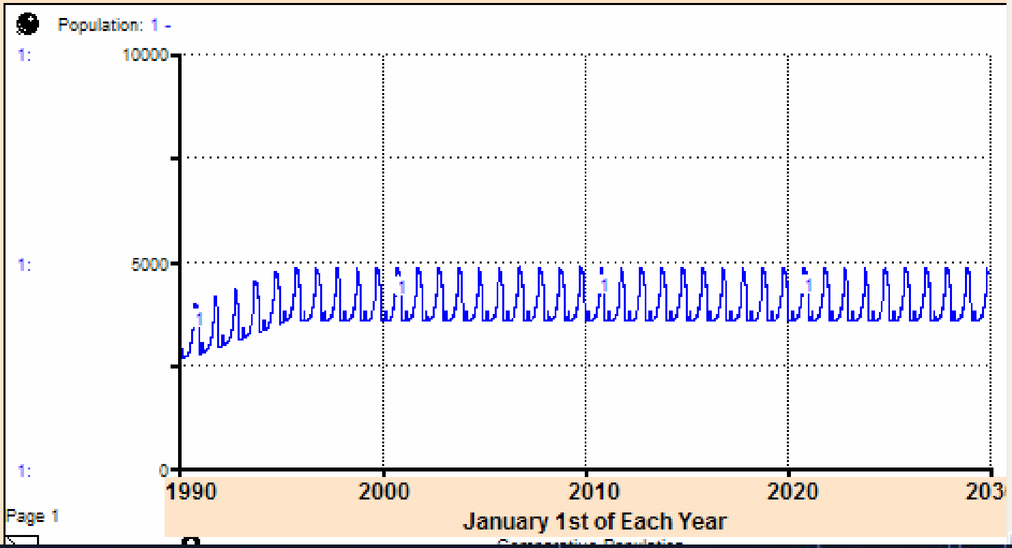


Want to see more graph details? Try this .....

Decadal Graphs



RUN

Reset Graphical Input

Reset Sliders

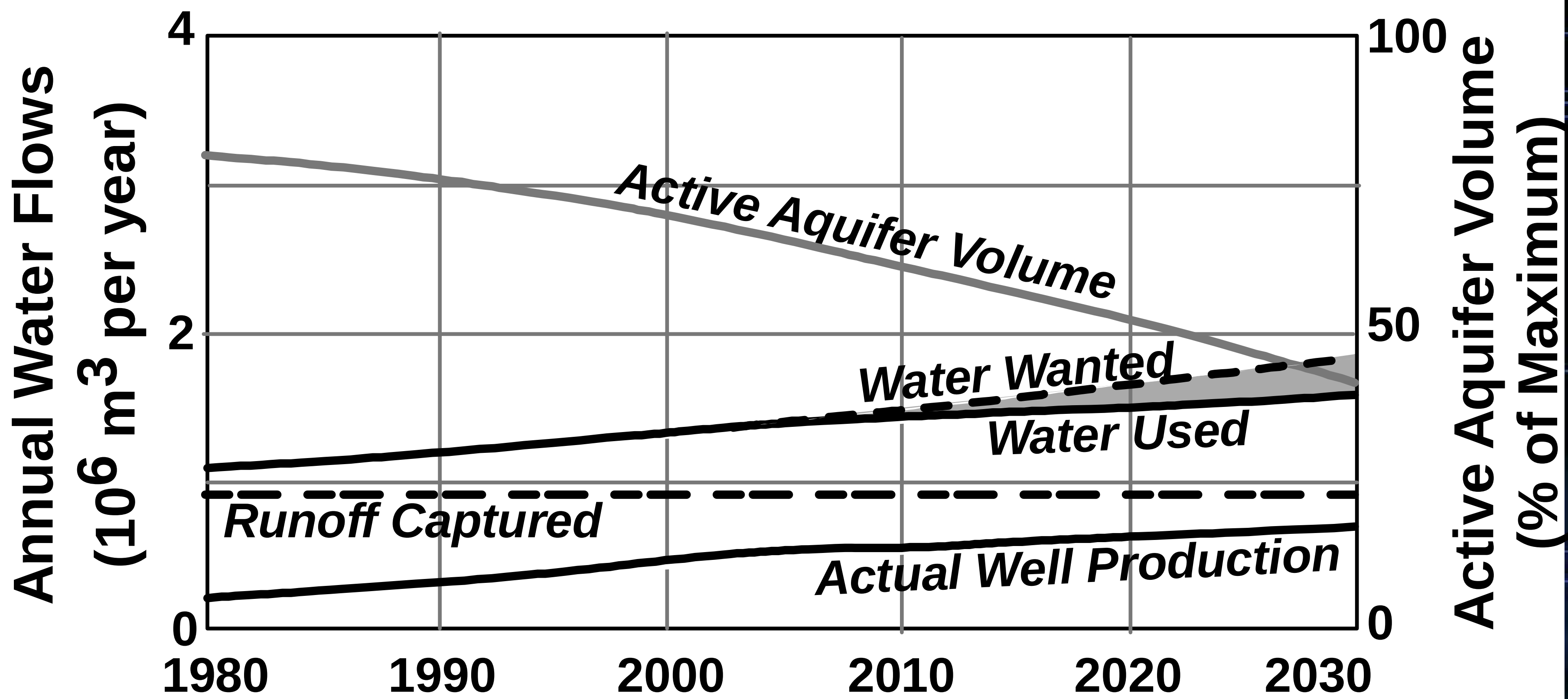
Reset Graphs

Future *Climate* *Policies*

1st Page *Map* *Quit*

Sustainable Water Yield

Vulnerability (Water Budget) $V_{wy} = (S_{wy}/C_{wy})$

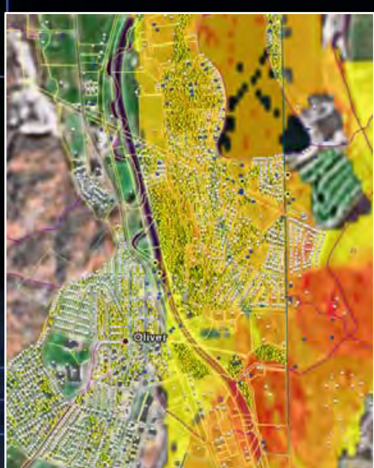


Groundwater Resource Risk Index

Risk (R) = Hazard-Threat (T) X Vulnerability (V))

Hazard-Threat (T) = $\left([E] \times [M] \times [L]\right)$

Vulnerability (V) = $\sum \left(Si*Sa/Ca\right) * (Swy/Cwy)$

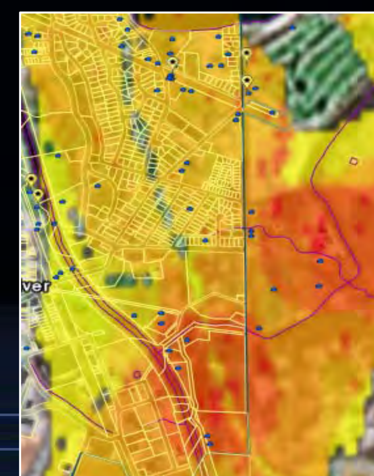


Risk Assessment

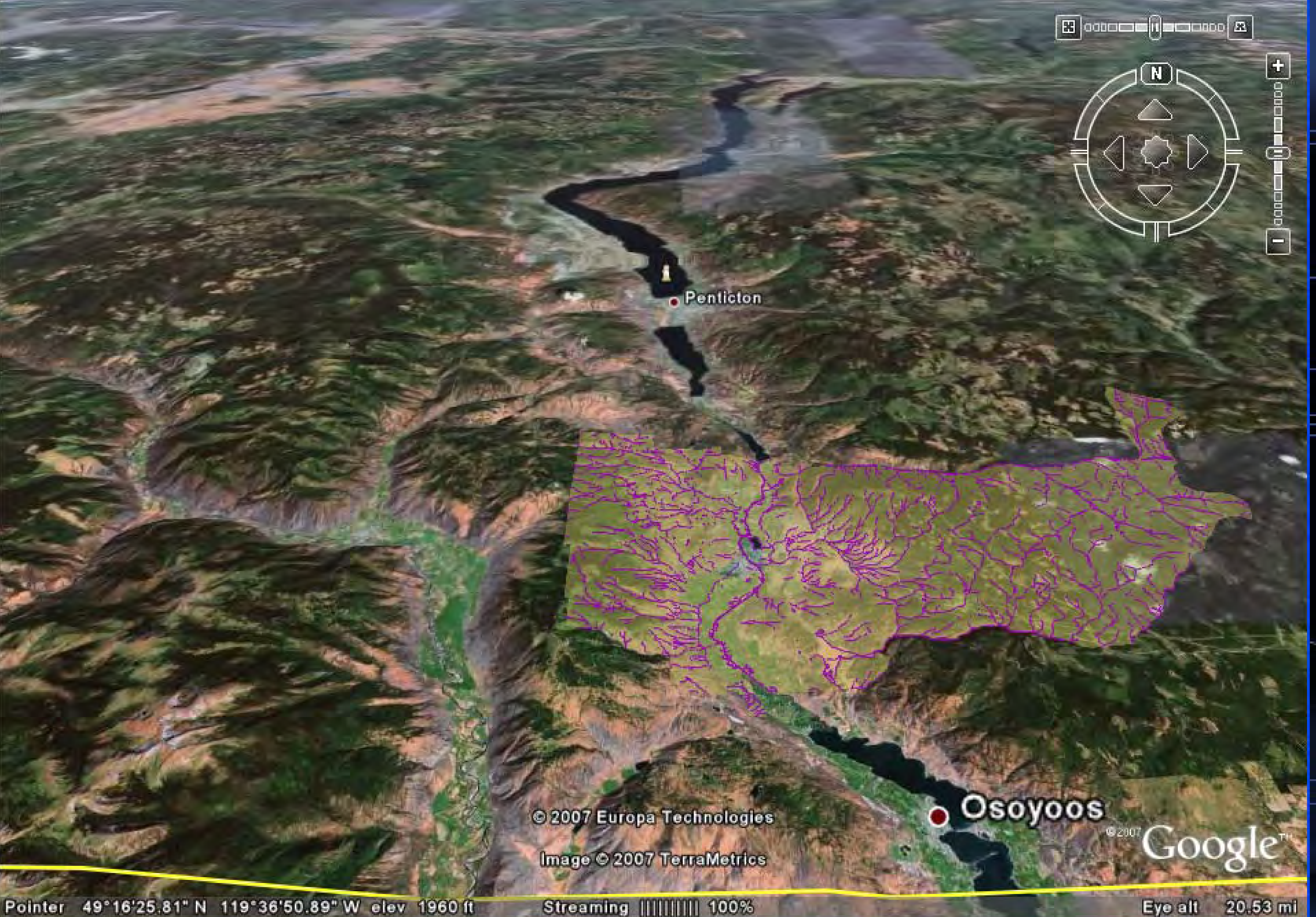
=

Hazard-Threat Assessment

X



Vulnerability Assessment

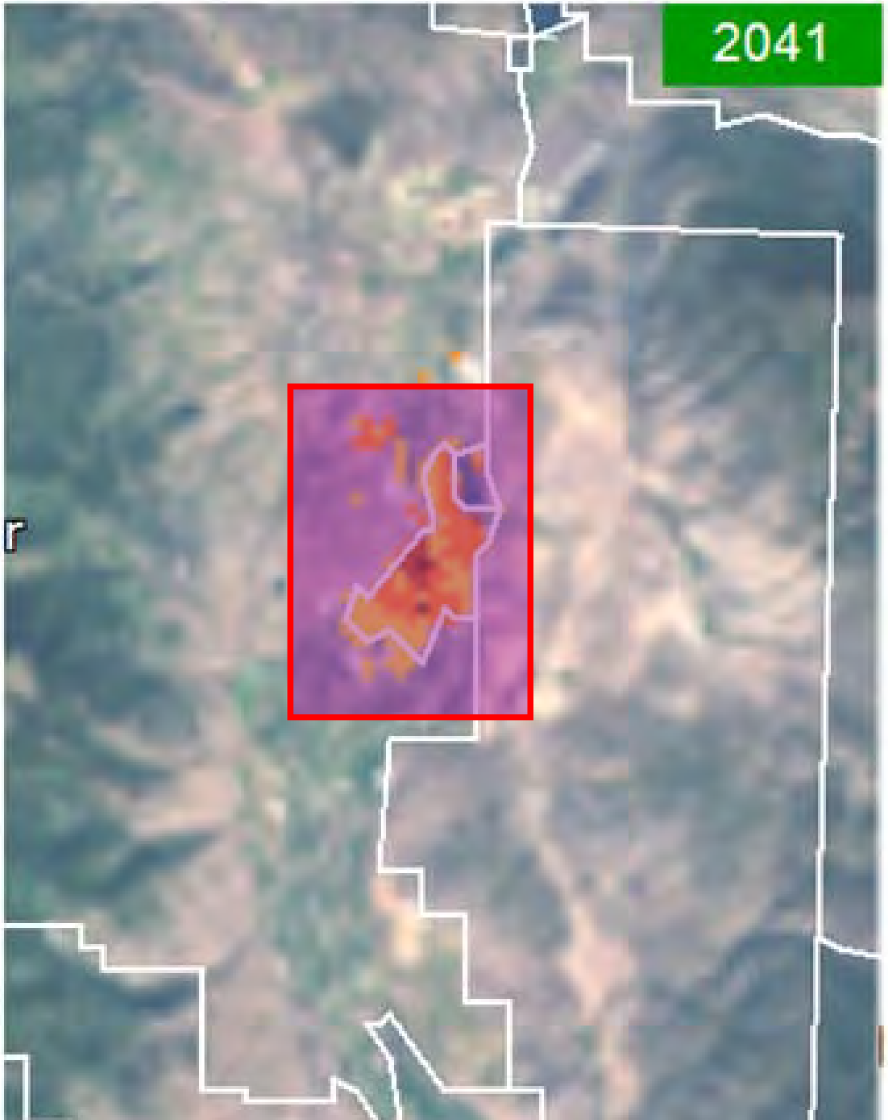

Penticton
Osoyoos
© 2007 Europa Technologies
Image © 2007 TerraMetrics
©2007 Google™
Pointer 49°16'25.81" N 119°36'50.89" W elev 1960 ft
Streaming |||||||||| 100%
Eye alt 20.53 mi

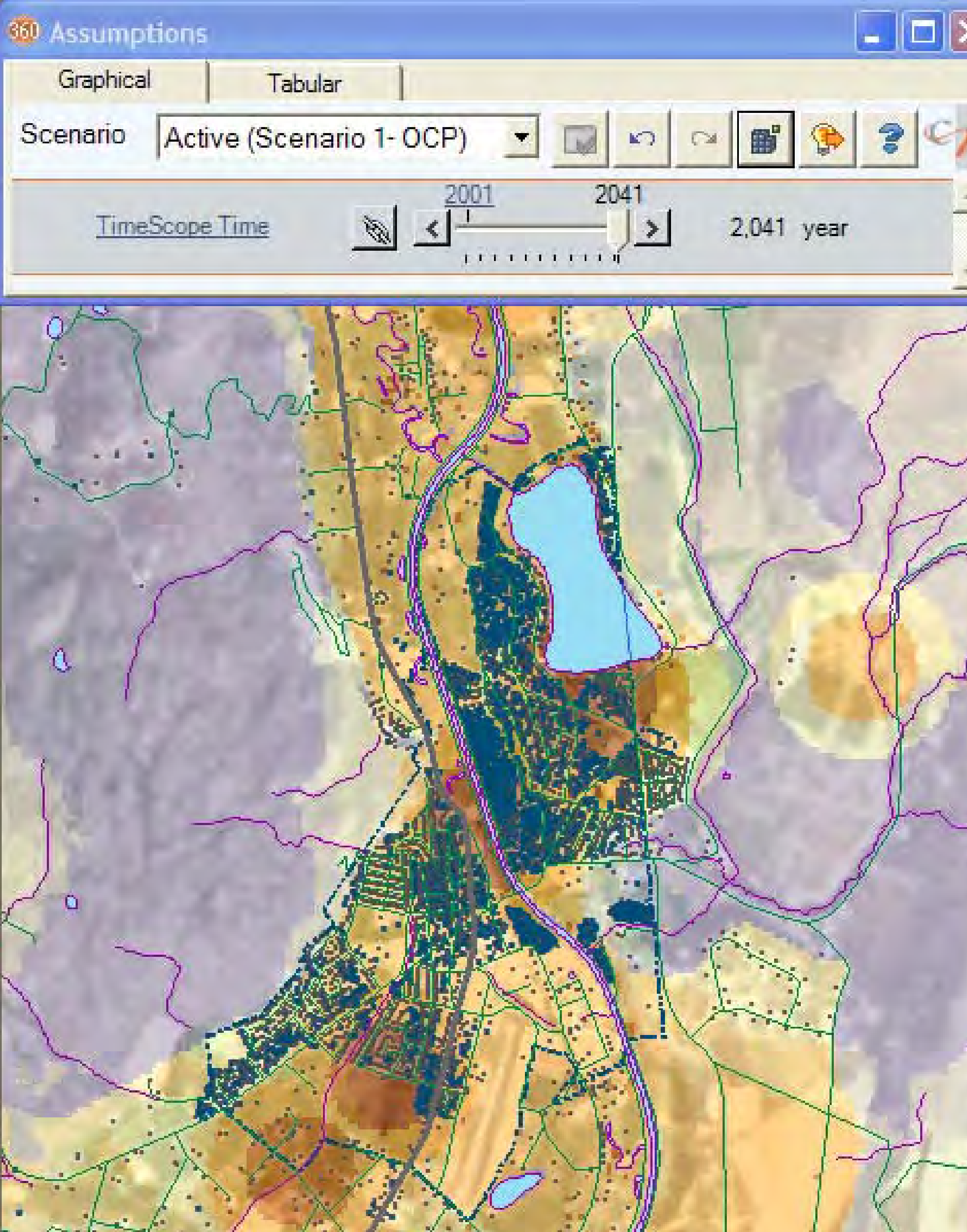

REGIONAL DISTRICT
RDOS
OKANAGAN-SIMILKAMEEN
Population Location
Continue current trend *
Protect ALR lands
Multi-nodal development
Job Location
Continue current trend *
Multi-nodal development
Development Density
Low density
Medium density *
High density
Very high density
Transportation Options
Reduce & Recycle
Water Conservation
Energy Conservation
Air Pollution
Population Growth
Economic Growth
Nodal Dense
Population Distribution
2041
Regional
MetroQuest
Context
Community
NRCan Land Use Model
Focus
SGOG
Priorities
Indicators
Targets
Concept Plan

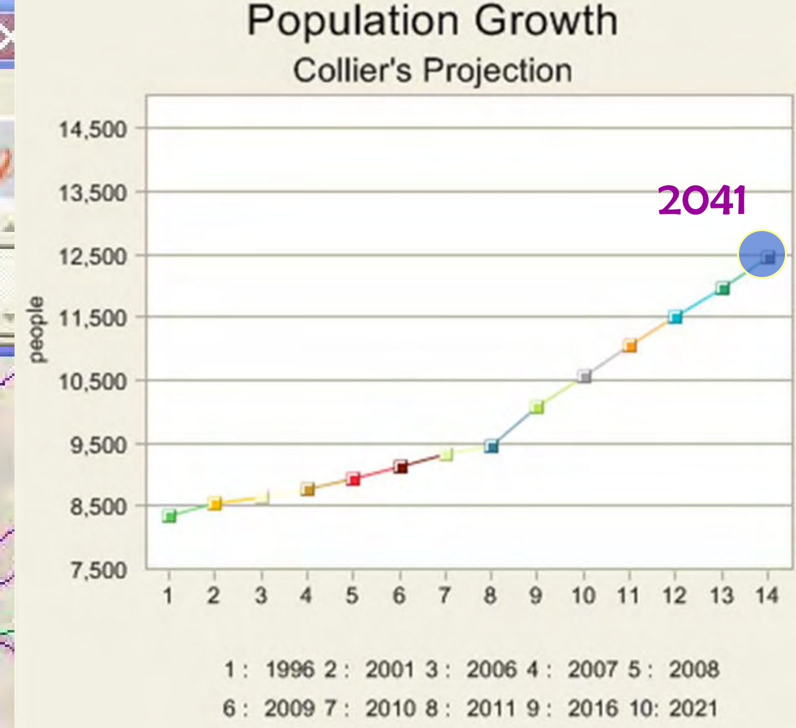
Oliver Grp Scen

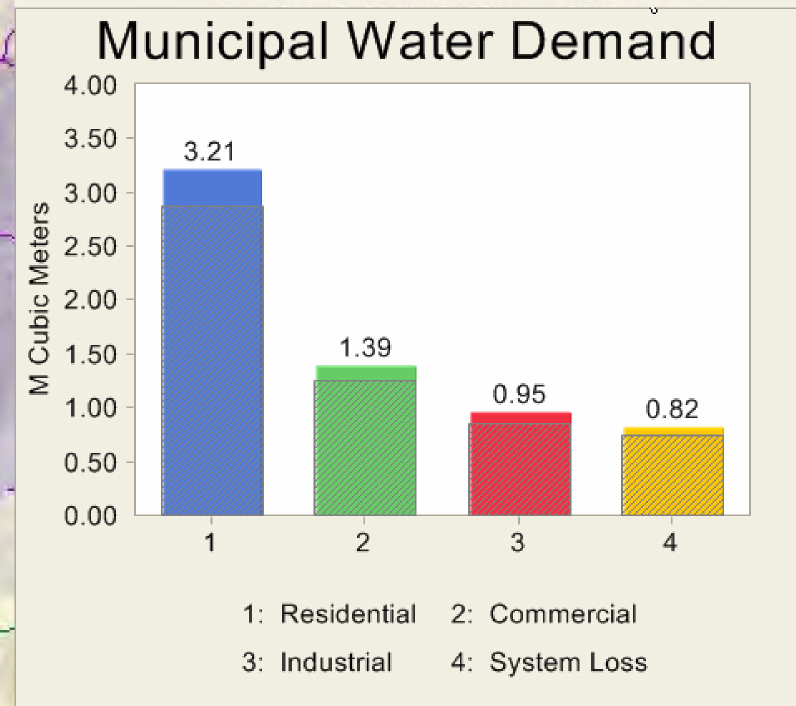
NRCan- Land Use Model

Population Distribution

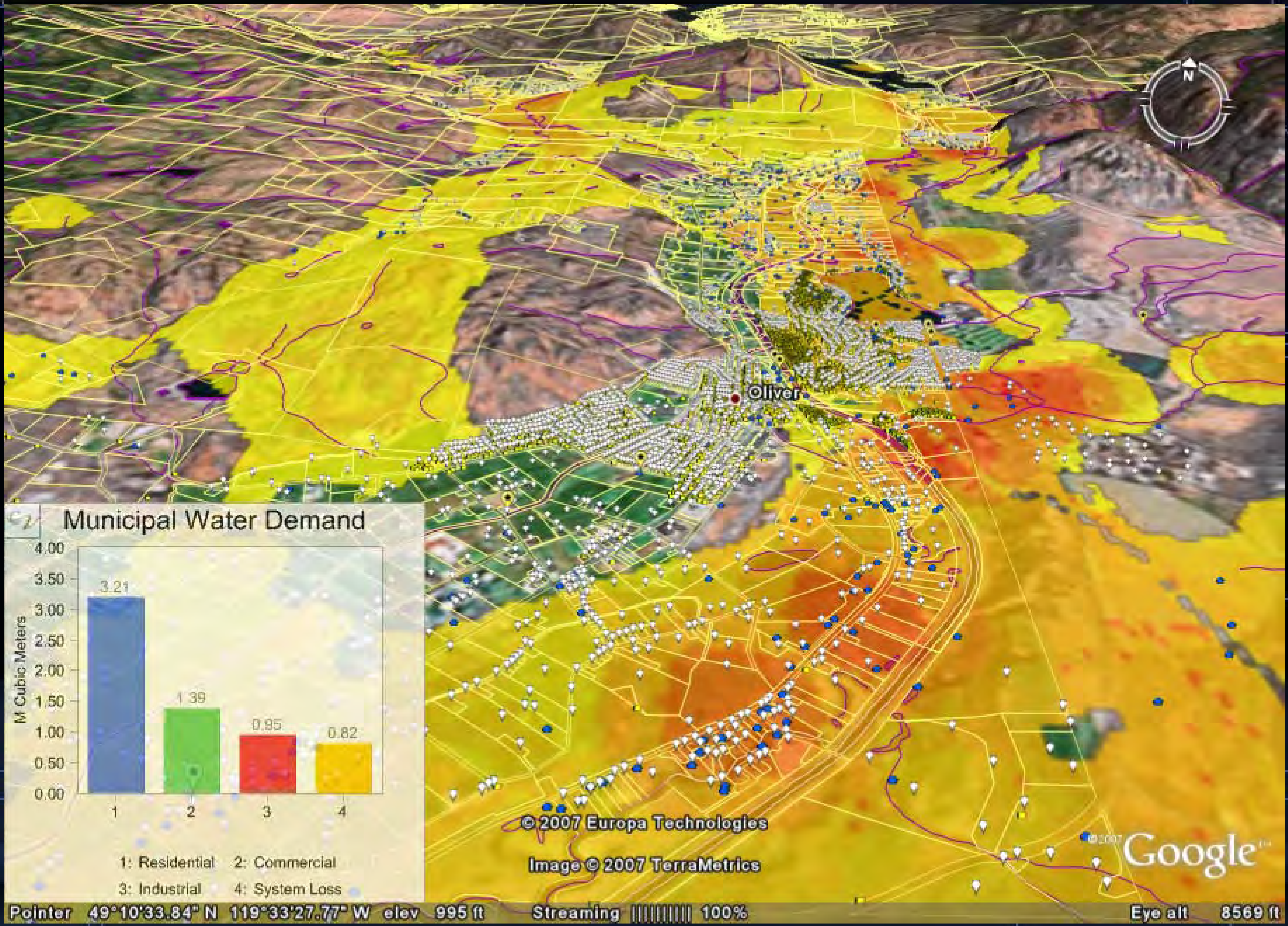



Assumptions
Graphical
Tabular
Scenario
Active (Scenario 1- OCP)
TimeScope Time
2001
2041
2,041 year


Population Growth
Collier's Projection
2041
people
14,500
13,500
12,500
11,500
10,500
9,500
8,500
7,500
1 2 3 4 5 6 7 8 9 10 11 12 13 14
1 : 1996 2 : 2001 3 : 2006 4 : 2007 5 : 2008
6 : 2009 7 : 2010 8 : 2011 9 : 2016 10: 2021


Municipal Water Demand
M Cubic Meters
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3.21
1.39
0.95
0.82
1 2 3 4
1: Residential 2: Commercial
3: Industrial 4: System Loss

Groundwater Resource Vulnerability



Implications of our approach

- Complements and extends existing methodologies already in place (e.g. BC well-head protection)
- Potential bridge to ongoing comprehensive land use planning initiatives at Provincial scale (Regional Growth Strategy/Official Community Plans).
- Continued collaboration with provincial, regional and academic partners, both in terms of ongoing methodology development and evaluation/refinement.