Incorporating Uncertainty into Integrated Regional Water Resources Planning

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INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

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Planning under Uncertainty

- Planning *with* certainty is a rare luxury
- Planning under uncertainty is the norm
Outline

• Planning under uncertainty
• 5-steps for uncertainty assessment
• Case-Study — Texas water planning
• Lessons learned
The Planning Process

Now

Decisions, Actions

Where we want to be

How we get there

Success

Future

Now
Planning under Uncertainty

Where we want to be

Decisions, Actions

How we get there

Success

Future?

Now
Alternatives?

- Ignore uncertainty
  - Deterministic
  - Reactive
  - Near-Term

- Account for uncertainty
  - Probabilistic
  - Scenarios
  - Adaptive
  - Long-Term

"Political and economic uncertainty make long term planning difficult. Let's stick to ordering lunch."
Planning under Uncertainty

• How do we maximize our chance of success given everything we do not know?
5-step Program

1. Identify Uncertainties
   • Known Unknowns/Unknown Unknowns

2. Characterize Uncertainties

3. Relate Uncertainty to Key Decisions

4. Assess Sensitivity to/Importance of Uncertainties

5. Manage Uncertainty
   • Reduce Uncertainty
   • Increase Reliability/Reduce Risk
   • Increase Resilience
   • Monitor, Measure, and Adapt
Case Study

Analyzing Uncertainty and Risk in the Management of Water Resources for the State of Texas

by
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Austin, Texas 78711-3231
Texas Water Planning Framework

- Regional water planning process for resilient water supply
  - Drought of record
  - Deterministic
- Stake-holder driven process
  - Regional water planning groups
- 50-year planning horizon
  - Updated every 5 years
Objective

- **Methodology** to inform decision-makers how to characterize and account for uncertainty in regional water resources planning
  - Build on the current (deterministic) water planning framework
Methodology

Uncertainty in Demand

Uncertainty in Supply

Uncertainty in Water Needs

Uncertainty Quantification

Select Water Management Strategies

Assess Reliability of Meeting Needs

Add/Modify Strategies to Improve Reliability

Planning under Uncertainty
Uncertainty Characterization

• Uncertainty in demand
  – Population projections
  – Water usage rates

• Uncertainty in supplies
  – Water supplies in future droughts
  – Climate-change impacts

• Create multiple demand and supply scenarios
Demand Scenarios

- 6 Pop. Proj. x 3 usage rate = 18 demand scenarios
Supply Scenarios

• LCRA/SAWS Climate Change Study used as basis for modeling uncertainty in climate
• 2 GCMs x 2 Future Emission Scenarios + 1 Baseline = 5 Supply Scenarios
# Supply Scenarios

<table>
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<tr>
<th>Climate scenario</th>
<th>No Climate-Change</th>
<th>CCSM-A2</th>
<th>CCSM-B1</th>
<th>GFDL-A2</th>
<th>GFDL-B1</th>
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Water Needs Scenarios

- Water Need = Water Demand – Water Supply
Water Needs Scenarios
Evaluating Projects

- **Baseline strategy = Conservation and Reuse (C&R)**
  - Meets (deterministic) projected water needs (10,000 AFY)
  - Only 22% reliable
Evaluating Projects

- 6 potential strategies to meet the deficit

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<thead>
<tr>
<th>Strategy ID</th>
<th>Strategy</th>
<th>Capital cost (S million)</th>
<th>Expected yield¹ (ac-ft/yr)</th>
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## Project Portfolios

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<th>Strategies considered</th>
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<th>Expected total yield (ac-ft/yr)</th>
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Cost-Reliability Trade-Off
Sensitivity to Uncertainty

Cumulative Probability

Water Surplus

No Uncertainty

Water Need

2050 Water Need

-150,000 -100,000 -50,000 0 50,000 100,000 150,000 200,000 250,000

Uncertainty in Climate, Population, and Usage Rate
Uncertainty in Climate and Population
Uncertainty in Climate Only
Uncertainty in Population Only
Sensitivity to Uncertainty

The diagram illustrates the relationship between reliability and cost, with various uncertainties considered:

- **Climate Uncertainty**
- **Population Uncertainty**
- **Climate + Population + Usage Rate Uncertainty**

Points labeled A to L represent different scenarios or conditions, indicating how reliability changes with cost under varying uncertainty factors.
Summary

• Framework to plan under uncertainty based on existing planning framework
• Identified and characterized key uncertainties in demands and supplies
• Developed project portfolios to improve reliability of water plan
• Evaluated trade-offs in cost and reliability to rank and select project portfolios
Other Planning Studies...

Water 2120: Securing Our Water Future

Albuquerque Bernalillo County
Water Utility Authority
Other Planning Studies...

Integrated Water Resources Plan

March 27, 2019

Modeling Scenarios: Finding Vulnerabilities

Scenario 1: Loss of Imported Water

Scenarios 2 & 3: Water Supply Allocation Plan, Multi-Year Drought

Scenarios 4 & 5: Water Quality Impairment

Scenario 6: Water Management
Lessons Learned

• Demonstrate importance of considering uncertainty
  – ‘Baseline’ solution not reliable
• Having a well-defined deterministic planning framework is key
• Start simple – easier to communicate ideas to stakeholders
  – Sequentially add ‘layers’ of uncertainty
  – Scenarios keep things ‘real’
  – Sensitivity analysis shows importance of different uncertainties
• Enables more robust decision making
It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

Mark Twain