Uncertainty and the IRP

IRP Technical Workgroup
April 22, 2015

Overview

- General review of uncertainty
- Decision Support approaches
- Metropolitan's Robust Decision Making Framework

Review of Uncertainty

Types of Uncertainty

There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know.

Known Knowns

- Official Demographic projections
- Project parameters
- Project yields
- Historical weather patterns
- Other?

Known Unknowns

- Project losses
- Changes in project parameters
- Regulatory Changes
- Shifts in demographics
- Economic boom and bust
- Climate Change

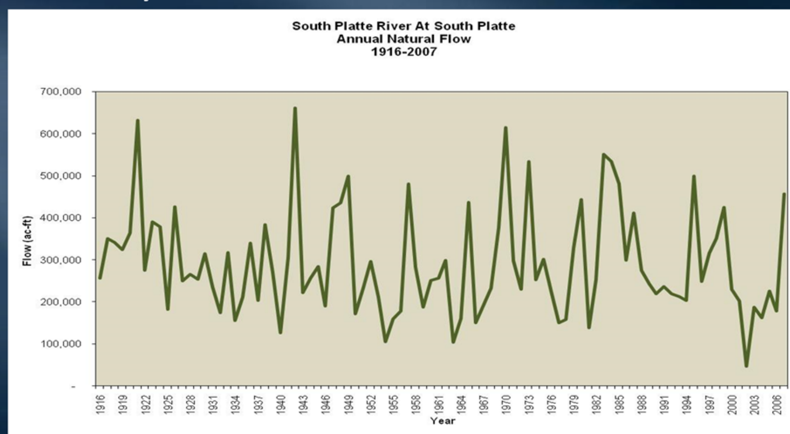
Unknown Unknowns

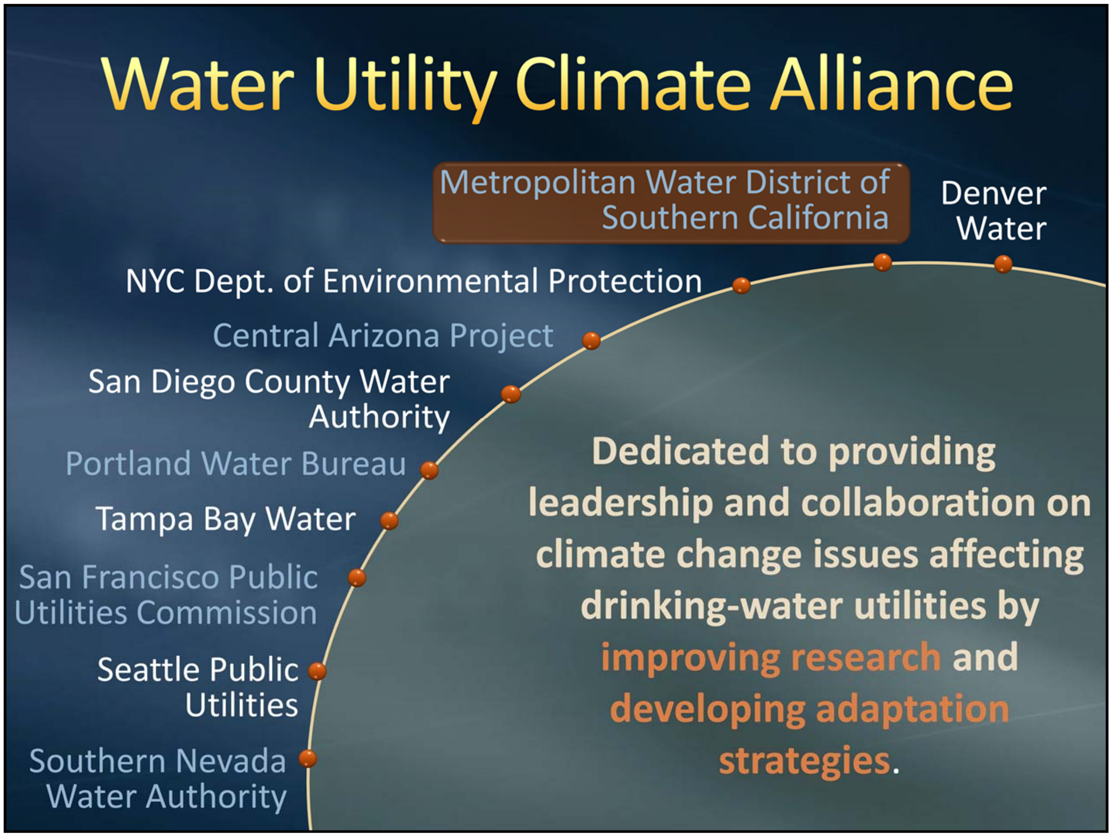
- I don’t know and neither do you, because that’s the basic idea of unknown unknowns

Decision Support Approaches

Traditional Water Supply Planning

- Based on observed weather and hydrology
- Assumes historic variability, history repeats, stationary climate





Further details:

- Delivers water to 42 million Americans
  - CAP 3-4 Million
  - Tampa 2.4 million
- Collaboration with nationwide large regional/municipal water districts

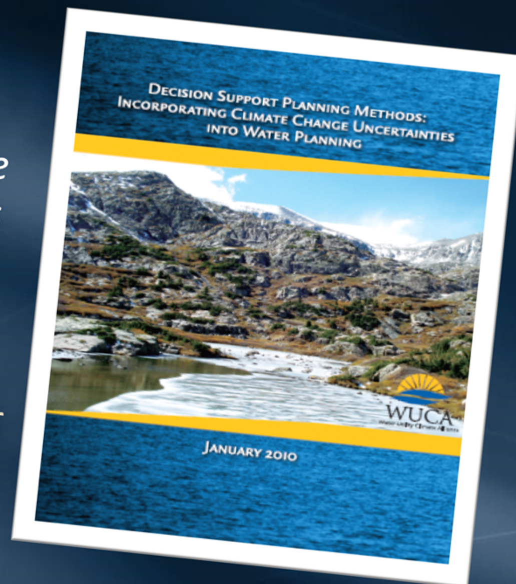
WUCA Decision Support Objectives

1. Aid in the transition from stationary to uncertainty based planning methods.
2. Bridge the gap between projections and the need to make decisions.
3. Identify, understand, and evaluate decision support methods to incorporate climate uncertainties into planning.
4. Raise awareness of decision support needs and promote research to improve methods.

WUCA
Water Utility Climate Alliance

Decision Support White Paper

- *Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning*
- Prepared by Malcolm Pirnie and Denver Water
- Released January 2010

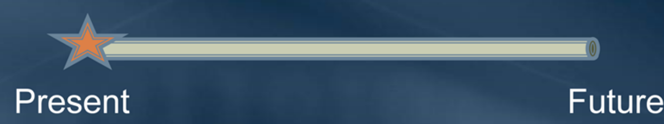


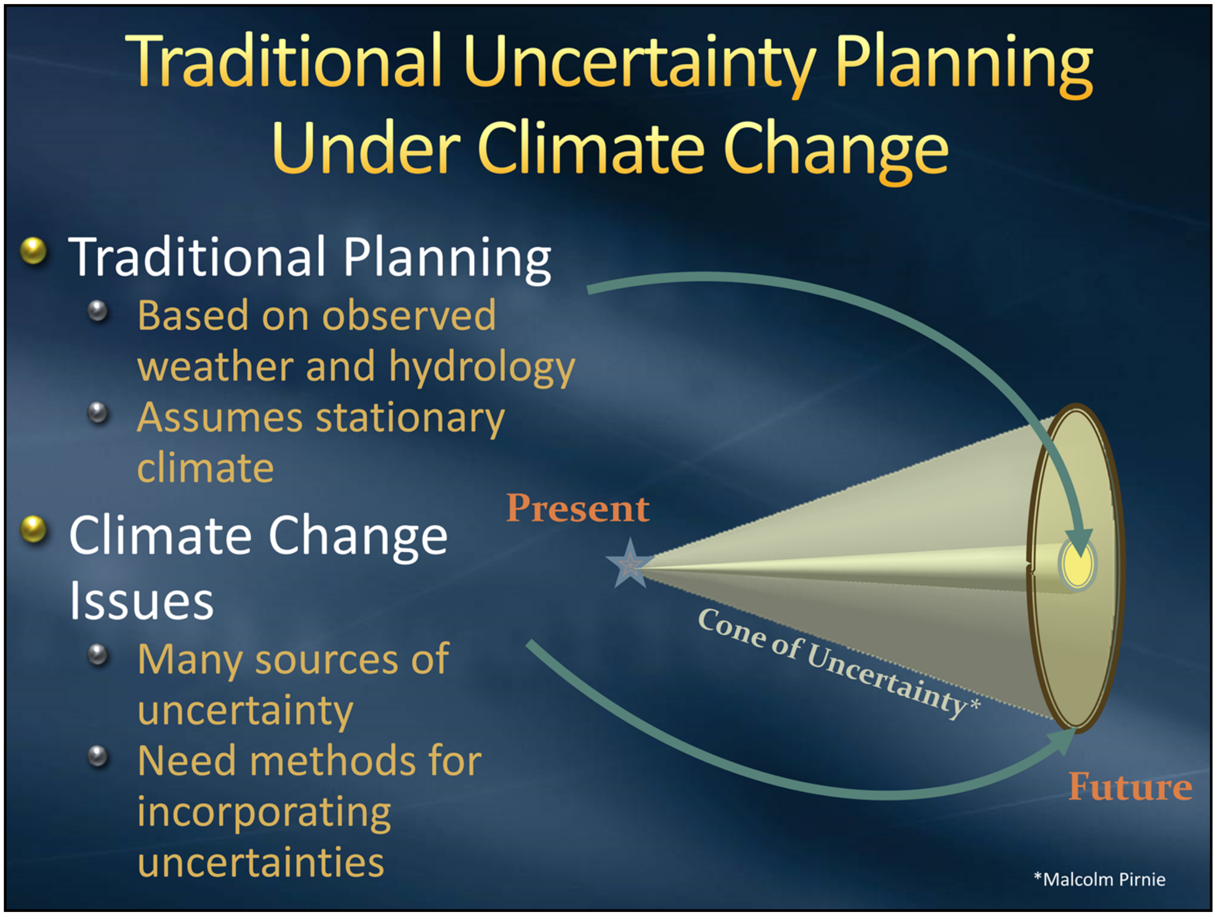
Five Planning Methods Evaluated

- Classic decision analysis - familiar but requires estimates of probabilities
- Scenario planning - relatively simply but only a few scenarios can be considered
- Robust Decision Making - considers many uncertainties but is highly computational and requires outside expertise
- Real Options – Perth, Australia is using this, but not yet written up
- Financial, Insurance, Portfolio planning

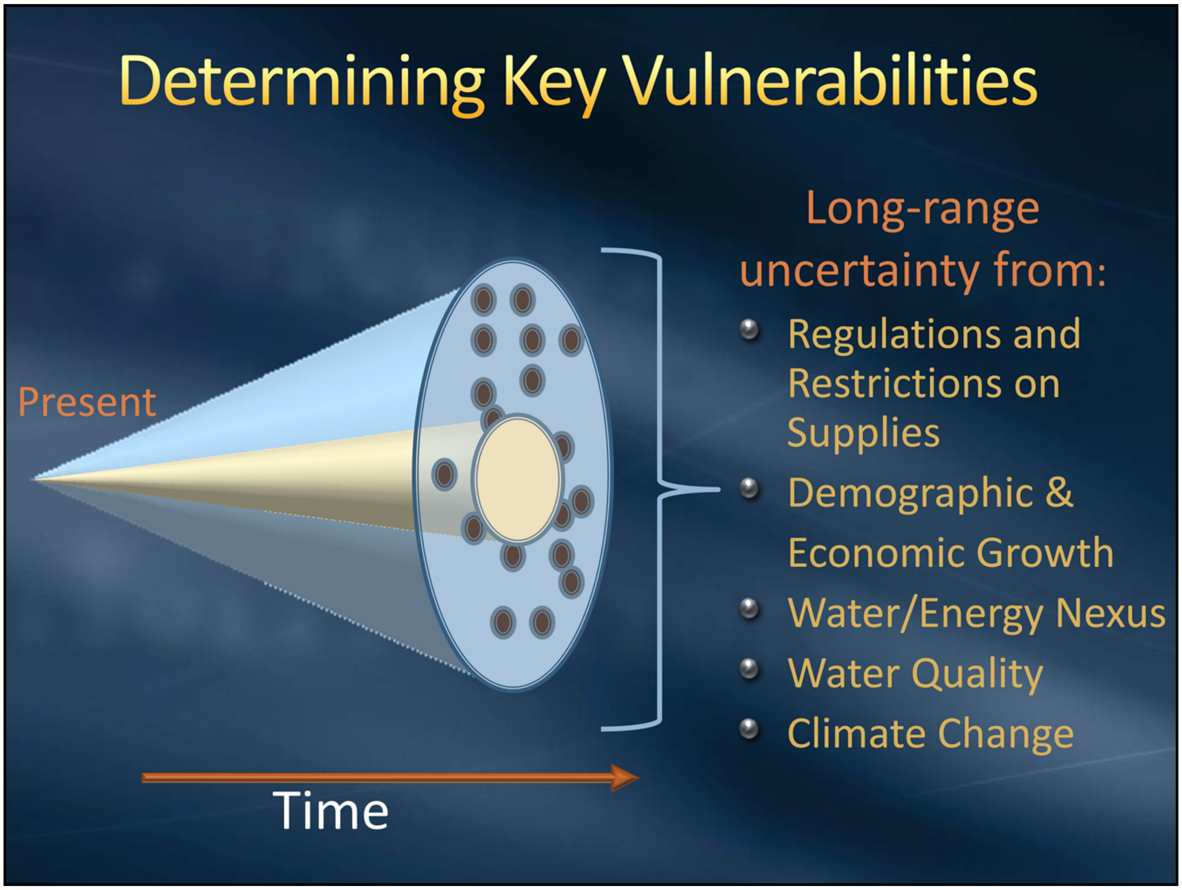
Cylinder of Certainty

- Traditional long-term planning
- Uses recorded weather and hydrology times series
- Assumes static natural systems (climate, watershed)





In the short term (5 to 10 year? we are stuck with lots of uncertainty
Not used to dealing with that much uncertainty
Need new methods.
Need to look elsewhere for methods



RAND corporation.
Committee had presentation.
Used for Inland Empire
MWD and Denver exploring.

Seven Steps to Adaptation to Climatic Uncertainty

1. Deny Uncertainty
2. Debate Uncertainty
3. Investigate Uncertainty
4. Attempt to Reduce Uncertainty
5. Accept Uncertainty
6. Plan for Uncertainty
7. Adapt to Uncertainty

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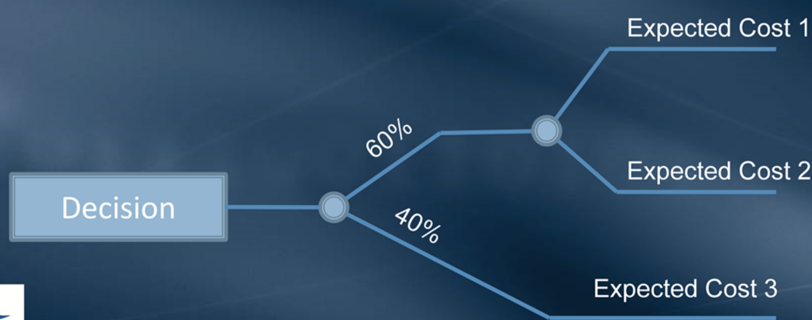
Decision Analysis

- Decision trees, probabilities and costs
- Minimize expected costs



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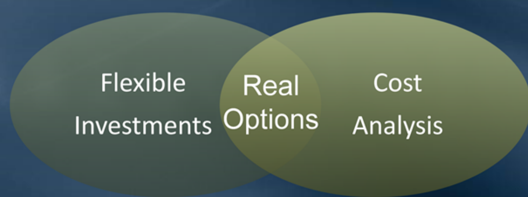
Real Options

- Combines decision analysis and financial theory
- Decision tree and financial hedging concepts



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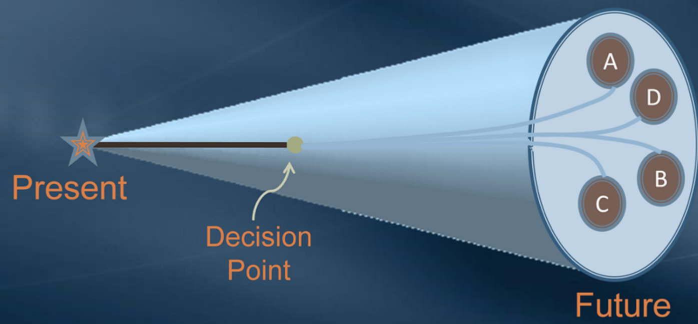
Scenario Planning

- Small number of equally likely scenarios [A, B, C, D]
- Common strategies (no regrets)
- Decision points



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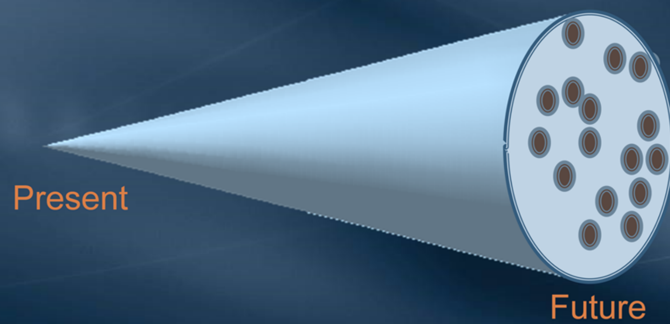
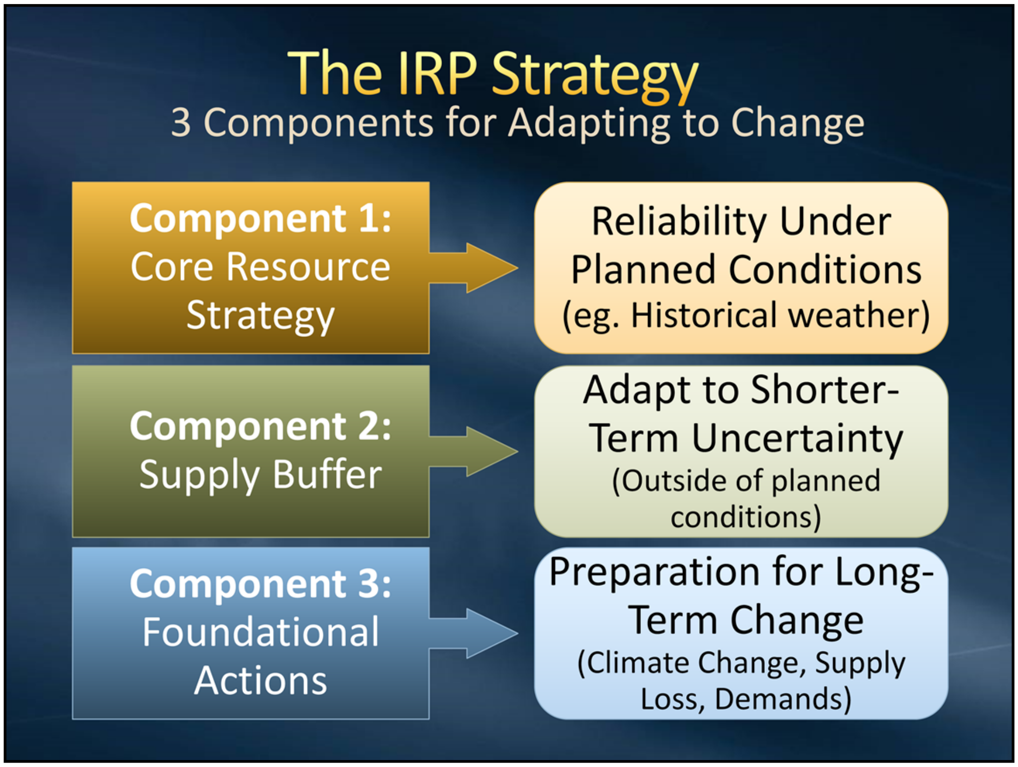
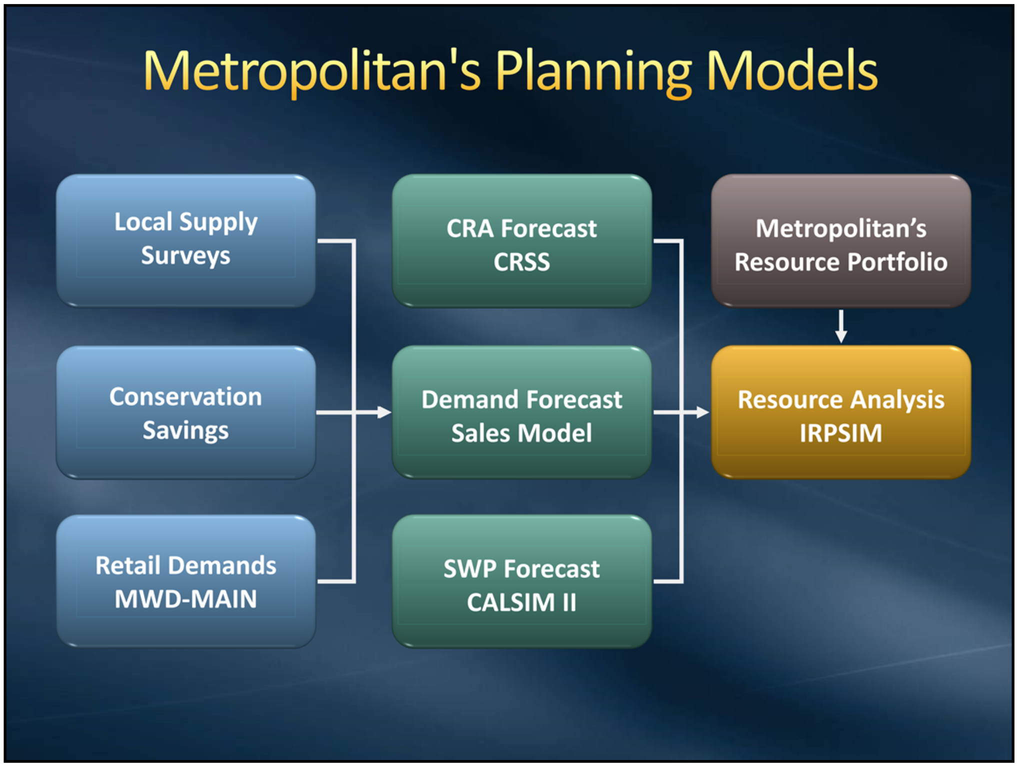
Robust Decision Making

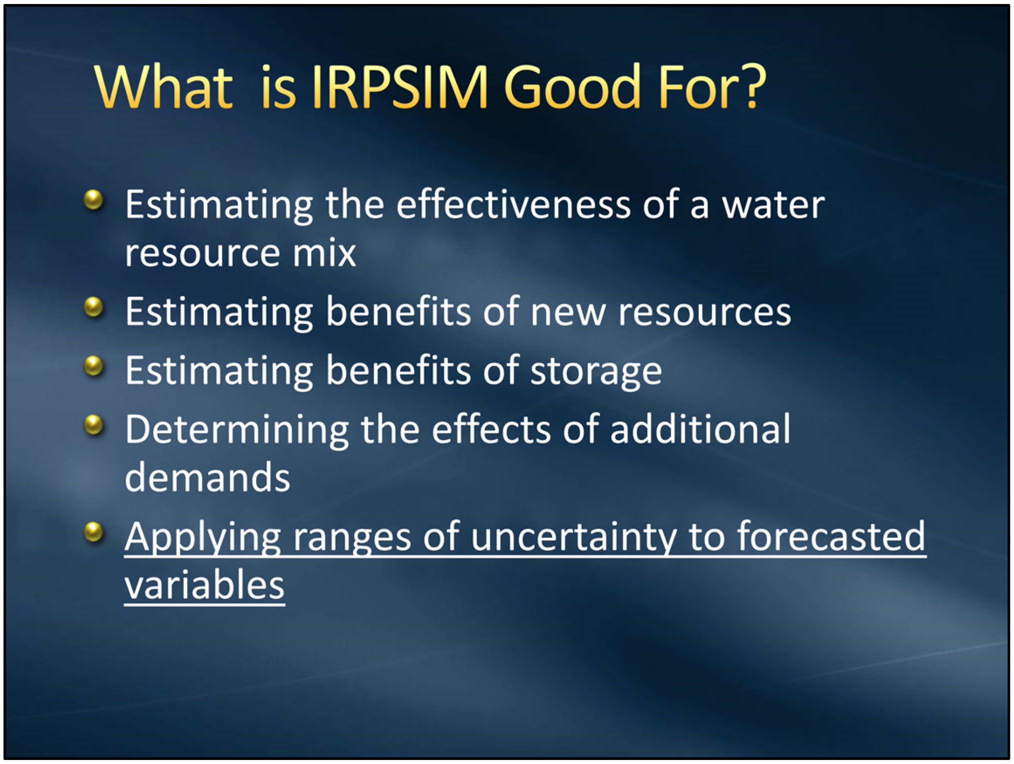
- Computer analysis of many equally likely scenarios
- Iteration and hedging
- Decision points



Overview of the IRP Robust Decision Making Process


The IRP Strategy
3 Components for Adapting to Change
Component 1:
Core Resource Strategy
Reliability Under Planned Conditions
(eg. Historical weather)
Component 2:
Supply Buffer
Adapt to Shorter-Term Uncertainty
(Outside of planned conditions)
Component 3:
Foundational Actions
Preparation for Long-Term Change
(Climate Change, Supply Loss, Demands)


Metropolitan's Planning Models
Local Supply Surveys
Conservation Savings
Retail Demands MWD-MAIN
CRA Forecast CRSS
Demand Forecast Sales Model
SWP Forecast CALSIM II
Metropolitan's Resource Portfolio
Resource Analysis IRPSIM


What is IRPSIM Good For?
Estimating the effectiveness of a water resource mix
Estimating benefits of new resources
Estimating benefits of storage
Determining the effects of additional demands
Applying ranges of uncertainty to forecasted variables

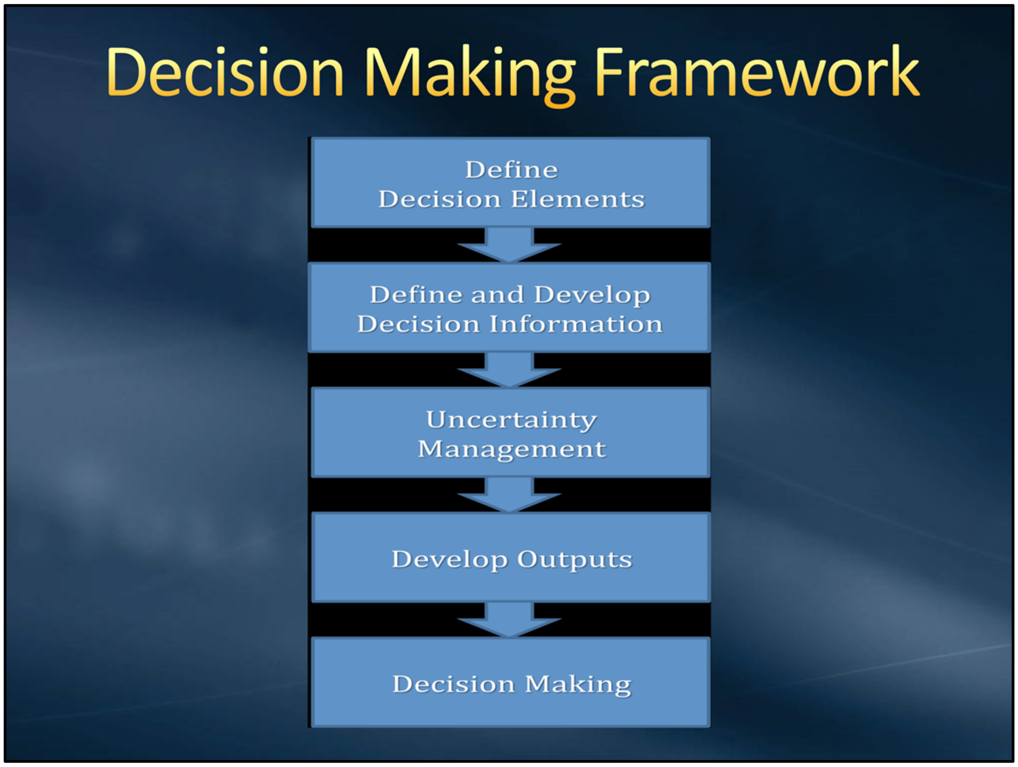
IRPSIM Summary

- Inputs
  - 30 Supply Sources and Programs
  - 10 Demand Categories
  - 20 Storage and Transfer Programs
  - 1000+ Supporting Variables
  - 24 Operational Stages
- Outputs
  - 50 Year Simulation
  - 83 Hydrologic Traces

50 Years x 83 Traces x 1000 Variables x 24 Stages

≈ 100 Million Calculations

Simulation Run Time… 8 seconds !


Decision Making Framework
Define
Decision Elements
Define and Develop
Decision Information
Uncertainty
Management
Develop Outputs
Decision Making

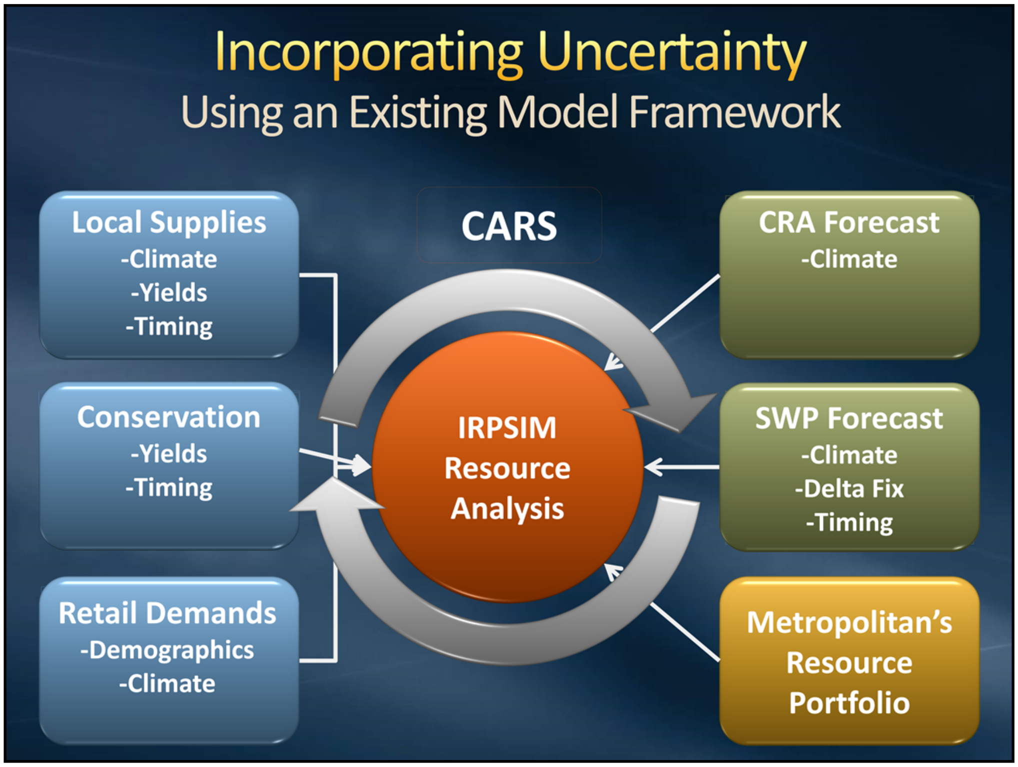


Diagram shows standard planning model framework
Uncertainty is introduced by replacing standard forecasts

Local Supplies – Climate sensitive local supply forecasts are impacted (i.e. LAA, surface production)

±20% variation in yield of forecasted development
Timing of forecasted development delayed up to 10 years

Conservation – Demographics influence quantity/density/rate of replacement of devices???

±20% variation in yield of forecasted development
Timing of forecasted development delayed up to 20 years

Retail Demand – Demographic patterns impact weather normal retail demands
Forecast of "climate bumps" that impact range of retail demands

CRA Forecast – RAND CORDS modeling estimated climate impacts on CRA supplies

SWP Forecast – SEC WEAP modeling forecasted climate impacts on delta exports
WEAP modeling adjusted to estimate no, partial, and full delta fix
Timing of Delta fix delayed up to 30 years

CARs – Computer Assisted Reasoning system

Defining Future Uncertainties

Factors and Ranges

Factor	Range of Uncertainty
Demographic Changes	4 Scenarios: Balanced Growth, Baseline Growth, Periurban Growth, High Growth
Climate Conditions	12 Climate Scenarios: 6 GCMs x 2 Emissions Scenarios used by IPCC
Bay-Delta Conditions	3 Scenarios: No Delta Fix, Partial Delta Fix, Full Delta Fix
Local Resource Yields	±20% Variation in Groundwater, Recycling, Groundwater Recovery, Conservation
Project Implementation Timing	Delays: 0-10 years Desalination & Recycling, 0-20 years Conservation, 0-30 years Delta Fix

Demands
Balanced Growth: IAS, lower projected growth, economic slowdown inland, increased density
Baseline Growth: **IRP, SCAG rtp12 SanDAG ???**
Periurban Growth: IAS, Growth rates similar to Baseline but concentrated inland
High Growth: IAS, Higher growth rates than baseline in all regions

Climate
GCMs: cnrm_cm3, gfdl_cm2, micro3_2_medres, mpi_echam5, ncar_ccsm3_0, ncar_pcm1
Emissions: A2, B1
Representative sample provides a sufficiently wide range to test IRP sensitivity to climate change
Result in supplies ranging from 93.7% to 104.7% of historical

Bay-Delta
No Fix: Current conditions with climate change
Partial Fix: 10% less than Full Fix
Full Fix: Current conditions with climate change, 2022 fix in proportion to 2011 reliability report -> 2005 reliability report

Local Resource Yields
80-120% of IRP forecast, each resource varied independently

Implementation Timing
Schedule of buildup shifted into the future, each resource varied independently

Analytical Steps

1. Configure IRPSIM modeling suite to reflect "Nominal Plan"
2. Evaluate "Nominal Plan" against large ensemble of scenarios
3. Identify and characterize key vulnerabilities
4. Develop more robust strategies
5. Evaluate new strategies against ensemble of scenarios
6. Present key performance tradeoffs (versus uncertainty and multiple metrics)

Evaluate “Nominal Plan” against large ensemble of scenarios

Experimental Design

Span plausible conditions

Not a statement of likelihood

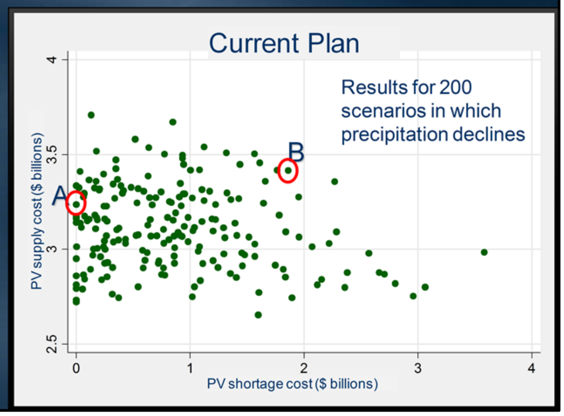
Performance of Plan

IRPSIM calculates a score for “Nominal Plan” for each scenario and metric

Example

Scenario uncertainty:
- Future climate
- Changes in groundwater
- Development of recycling
- Groundwater replenishment
- Reliability of imports
- Costs of imported supplies
- Costs of water use
- Costs of efficiency

Performance of “Current Plan” based on two cost metrics evaluated against 200 scenarios



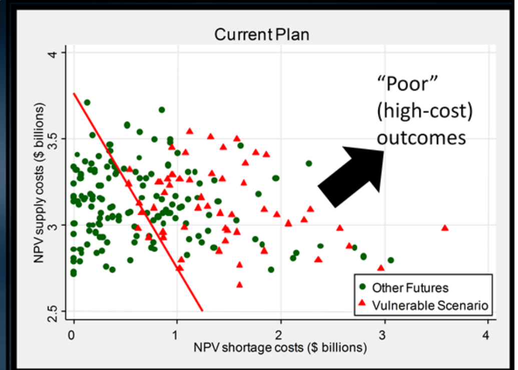
Identify and characterize key vulnerabilities

Performance thresholds for each metric define outcomes "good enough"

Statistical tools characterize the scenarios that lead to "poor" outcomes

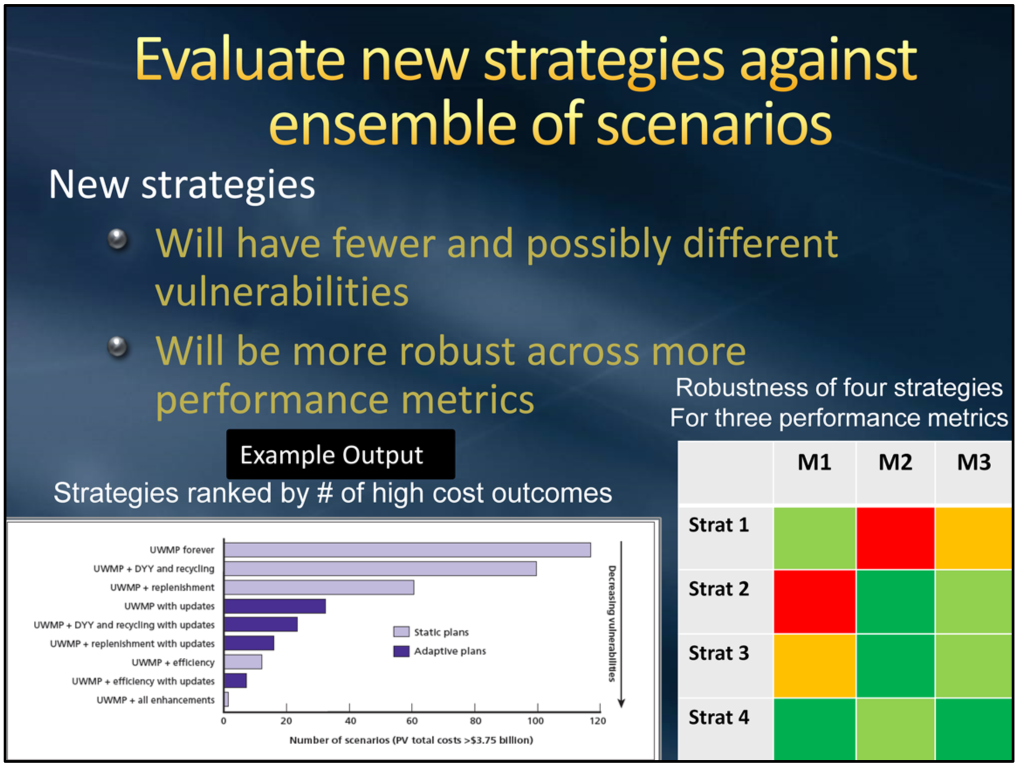
Summarize robustness across metrics

- Counts of "poor" outcomes for each metric



Three concurrent conditions lead to about half of poor outcomes

1. Warming and drying climate
2. Declines in groundwater percolation
3. Strong climate impacts on imports

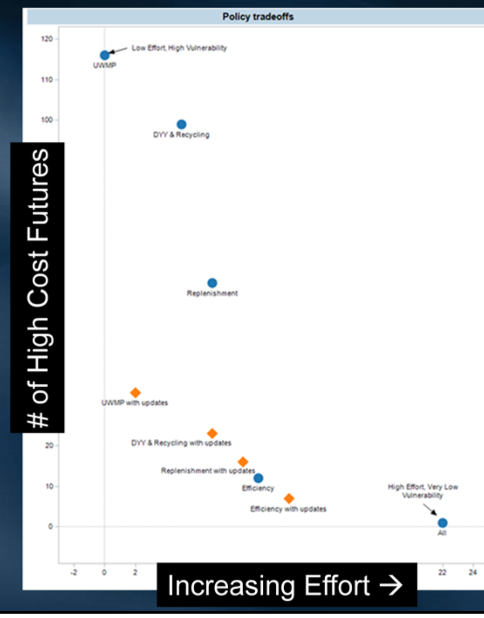

Evaluate new strategies against ensemble of scenarios
New strategies
Will have fewer and possibly different vulnerabilities
Will be more robust across more performance metrics
Example Output
Strategies ranked by # of high cost outcomes
UWMP forever
UWMP + DYY and recycling
UWMP + replenishment
UWMP with updates
UWMP + DYY and recycling with updates
UWMP + replenishment with updates
UWMP + efficiency
UWMP + efficiency with updates
UWMP + all enhancements
Static plans
Adaptive plans
Decreasing vulnerabilities
0
20
40
60
80
100
120
Number of scenarios (PV total costs >$3.75 billion)
Robustness of four strategies
For three performance metrics
M1
M2
M3
Strat 1
Strat 2
Strat 3
Strat 4

Present key performance tradeoffs

No strategy is perfect

- No strategy will eliminate ALL vulnerabilities
- No strategy will perform equally well across ALL metrics

Final tradeoffs permit Metropolitan to weigh risks and performance across metrics

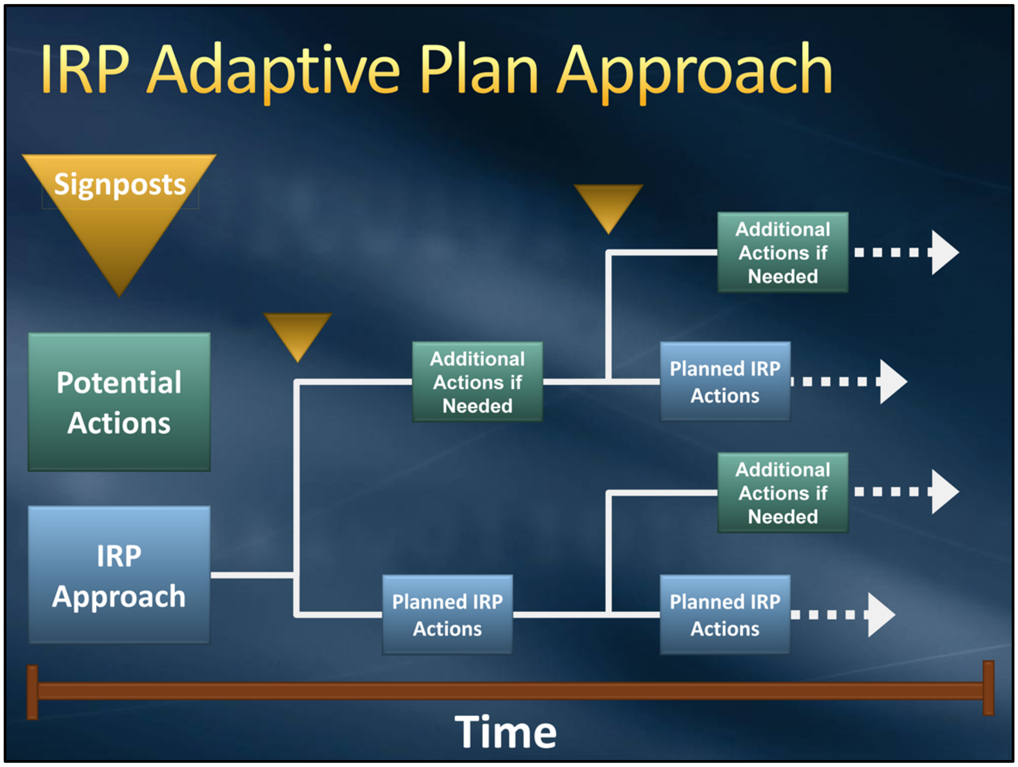


Analytical Approach

- Analyzed +6,900 combinations of uncertainty
- Used “scenario discovery” to identify where IRP goals were not met
  - Net Balance
  - Total Storage
- Used statistical methods to determined common areas of vulnerability

Summary of RDM Conclusions

- The IRP approach is vulnerable when two or more uncertainties turn out unfavorably
- Key uncertainties to monitor
  - Future Delta conditions
  - Demographic trends
  - Groundwater yields
  - Climate Conditions


IRP Adaptive Plan Approach
Signposts
Potential Actions
IRP Approach
Additional Actions if Needed
Planned IRP Actions
Additional Actions if Needed
Planned IRP Actions
Additional Actions if Needed
Planned IRP Actions
Time

Signposts for Monitoring

Demographics

- Growth Rates
- Growth Areas
- Housing Growth
- Density Trends
- Employment

Bay-Delta

- Environmental
- Ecosystem Restoration
- New Facilities
- Operations

Local Supplies

- Adjudications
- Water Quality
- Regulations
- Stormwater/Urban Runoff
- New Projects
- Reduced Yield

Climate Change

- Climate Trends
- Precipitation
- Temperature
- Global Modeling
- Downscaling

Summary of RDM for Metropolitan

- Developed by RAND Corporation
- Supports decision-making under deeply uncertain conditions
- Process involves data, modeling, and analytics
- Evaluates planning scenarios against a wide range of future conditions
- Identifies when and why scenarios to fail to meet planning goals
- Helps develop signposts and monitoring criteria for adaptive management


THE METROPOLITAN WATER DISTRICT OF
SOUTHERN CALIFORNIA