Current Methods for Water Resources Planning

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Purpose

- Describe U.S. water resources planning requirements
- How is hydrologic frequency information and climate information used in decision making process
- How may current laws and regulations influence how we use climate information?
The four major US water resources agencies:

- USACE, U.S. Geological Survey, Bureau of Reclamation, National Oceanic and Atmospheric Administration

Mission:

- To evaluate practices of federal agencies to incorporate climate change considerations into activities related to Nation's water resources
- Provide foundation for future policies

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http://pubs.usgs.gov/circ/1331/
Outline

- Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G)
- Other Hydrologic Design Standards
  - Standard Project Flood
  - Probable Maximum Flood
- National Environmental Policy Act (NEPA)
- National Flood Insurance Program
- Risk and Uncertainty Analysis
- Proposed National Objectives, Principles and Standards for Water and Related Resources Implementation Studies (December 2009)
• Although from a U.S. Federal perspective, these laws and regulations represent issues faced by water managers everywhere:
  – Balance multiple competing objectives including economic costs;
  – Environmental constraints;
  – Standards-based approaches to risk.
Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies:

“The Federal objective of water and related land resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements.”

March 1983
Plan Selection

“A plan recommending Federal action is to be the alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (the NED plan)”

Exceptions may be made when there are overriding reasons for recommending another plan, based on other Federal, State, local and international concerns.
Proposed Principles and Standards

Revised Objectives

“The National Objective for water resources planning is to develop water resources projects based on sound science that maximize net national economic, environmental, and social benefits.”

Select and recommend the plan that ... provides the greatest net overall contribution to the National Water Resources Planning Objectives considering both monetary and non-monetary effects.

December 2009
Use of Hydrologic Frequency Information

• Estimated probability of future hydrologic events are used to calculate future benefits of alternative action plans.

• Expected benefits and costs provide economic justification for alternative management actions.
The standard project flood (SPF) is a flood “that may be expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably characteristic of the geographical region involved, excluding extremely rare combinations.”

SPF was often used as a design standard in mid-20th century when flow records were considered to be too short for adequate statistical analysis.
For a major project, the conservative practice in the United States is to base spillway design flood on the probable maximum precipitation (PMP).

PMP is based on maximum conceivable combination of unfavorable meteorological events.

Probable Maximum Flood (PMF) inflow hydrograph is developed by centering PMP over the watershed to produce a maximum flood response.
• NEPA Environmental Impact Statements
  – Insure that NEPA policies and goals are infused into programs and actions of the Federal Government
  – Provide discussion of significant environmental impacts
  – Shall inform decision makers and public of reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment.
NEPA

- NEPA process requires agencies to determine if their actions will have significant environmental effects.
- The NEPA process does not require a multiobjective tradeoff analysis of alternative plans like the Principles & Guidelines.
• Special Flood Hazard Area (SFHA):
  – Area of land that would be inundated by a flood having a 1% chance of occurring in any given year (also referred to as the base flood or the 100-year flood).

• Regulations
  – Purchase of flood insurance is mandatory if federal loans or grants were used to acquire or build structures or if mortgages are made by lending institutions regulated by the federal government.
  – Local communities must regulate floodplain development as a condition for participation in NFIP.
Why is it necessary to consider the National Flood Insurance Program when discussing Federal water resources planning?

Local communities must regulate floodplain development as a condition for participation.

Local communities would like to avoid flood insurance costs and regulation. Structural flood risk reduction projects are one means.
Decision Methods

• Multiobjective optimization (P&G) / optimize National Economic Development (NED)
  – Requires hydrologic frequency estimates to calculate benefits and costs of alternatives.

• Standards based
  – NFIP 1% chance flood – based on hydrologic frequency analysis.
  – Standard Project Flood (SPF) and Probable Maximum Flood (PMF) – a hydrometeorological approach for identifying a design flood
Risk and Uncertainty Analysis

• “Planners shall identify areas of risk and uncertainty in their analysis and describe them clearly.”
• Can use probability distribution if there is reasonably firm data, such as hydrologic risk.
• May characterize a set of outcomes with subjective probability estimates.
• Range of outcomes can be described by using sensitivity analysis.
Several have argued that Principles and Guidelines are flexible enough to accommodate planning for climate change, since sensitivity analysis can be used to test assumptions.

However, P&G says “formulation and evaluation of alternative plans should be based on the most likely conditions expected to exist in the future with and without the plan.”

Decision methodology tends to favor an optimization approach.
Proposed National Objectives, Principles and Standards for Water and Related Resources Implementation Studies

December 2009
Six step planning process:

1) Specification of the water and related land resources problems and opportunities (relevant to the planning setting) associated with the Federal objective and specific State and local concerns.

2) Inventory, forecast, and analysis of water and related land resource conditions within the planning area relevant to the identified problems and opportunities.

3) Formulation of alternative plans.

4) Evaluation of the effects of the alternative plans.

5) Comparison of alternative plans.

6) Selection of a recommended plan based upon the comparison of alternative plans.

March 1983
Proposed Revision

1) Identify the study objectives and ensure that Federal participation in the study is warranted;

2) Identify and assess the water and related resources problems, needs, and opportunities relevant to the planning setting associated with the study objectives;

3) Inventory, analyze, and determine the existing and most likely future water and related resources conditions within the study area relevant to the identified problems and opportunities;

4) Formulate alternatives, including identifying the No Action alternative, as well as nonstructural and structural alternatives, and combinations;
Proposed Revision (continued)

5) Evaluate the potential effects of all reasonable and viable alternatives;
   a) Evaluate the potential effects, positive and negative, on the significant resources relative to the most likely conditions without action, and
   b) Evaluate and display the potential effects of alternatives in a systematic manner.

6) Compare alternatives; and

7) Select and recommend the plan.
“Climate change represents persistent uncertainty that should be addressed in the planning process. The increased variability in temporal and spatial patterns of precipitation and water availability will challenge water systems serving all human needs. From specification of existing problems and opportunities to the formulation, evaluation and selection of plans, the accelerating changes in aquatic systems caused by a changing climate should inform our understanding of what our water resource needs are and how we can realistically respond to those needs.”
Proposed Risk and Uncertainty

• “Even with the best available engineering and science, risk and uncertainty will always remain.”

• “When uncertainties are about an alternative’s ability to function as desired and/or to produce the desired outputs or other potential undesired outputs, and thus potentially affect the justification, selection, and/or acceptability of the alternative, improved data, models, and analyses should be pursued.”
Use of Scenarios

• Because the future is uncertain, alternative without-plan future conditions may be identified as separate scenarios.

• The scenarios shall only be used as sensitivity tests to assess the robustness of competing alternatives, inform the plan selection, and more fully depict the potential performance of the selected plan.

• Probability or likelihood of each future condition and its affects (sic) shall be presented.

• Key uncertainties for both existing and future conditions shall also be disclosed.
Conclusion

• Two approaches influencing current U.S. water resources planning
  – Multiobjective optimization assuming “a most likely future condition” and characterizing future hydrologic events with a probability distribution.
  – Delineation of a flood hazard area based on flood frequency estimates (that currently assume stationarity).

• Are there approaches that would be more robust for dealing with hydrologic uncertainty?