Development of a Curriculum for a Masters Degree Program in Water Resources Planning

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Prepared by a
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Introduction

The United States Army Corps of Engineers is interested in providing its employees with the opportunity to obtain a Masters degree in water resources planning as part of a program of incentives to encourage the hiring and retention of a top-quality workforce. The agency, which has a major water resources development and management mission through its Civil Works program, expects to lose a significant fraction of its experienced water resources planners over the next five years through retirements. There will thus be a need to hire large numbers of new water resources planners. A masters program in water resources planning that the agency could make available to potential new hires would be an attractive selling point in a competitive job market. It would also benefit the agency's planning capability through the opportunity for professional growth and enhancement of expertise that an advanced professional education offers.

At the request of the Corps of Engineers the Universities Council on Water Resources (UCOWR) polled its member organizations in the Fall of 2000 about the availability of water resources degree programs, and the interest of these institutions in participating in a masters program. Based on a significant positive response, the Corps requested that UCOWR form an academic advisory group to help think through what a water resources planning curriculum should contain, as well as how it might best be delivered. The academic advisory group consists of:

Dr. Duane Baumann, Geography, SIU
Dr. Darrell Fontane, Engineering/Planning, CSU
Dr. Steve Gloss, Ecology/Biology, Univ. of Wyoming
Dr. Ray Huffaker, Law/Economics, WSU
Dr. Ari Michelsen, Economics, TAM
Dr. Leonard Shabman, Economics, VTU

The group met in May, 2001 in the Washington, D.C. area. This discussion paper presents the committee's initial content and delivery options for a masters level curriculum. They are presented in this discussion paper to encourage further discussion and suggestions. Comments should be provided to Dr. Mark Dunning at mark.c.dunning@usace.army.mil (no longer available; see POC at bottom of document).

Content Requirements

The focus for the masters program is to better equip planners for being able to respond to 21st century water resources challenges. The committee concluded that in order to respond effectively, a masters program should be configured to produce generalist planners as opposed to being more narrowly specialized in one topic area. A water resources planning curriculum should be more analogous to an MBA type curriculum versus a MCE for example. The

program also needs to be interdisciplinary in focus. Key assumptions about the future water resources planning environment that should be integrated into course designs include:

- reduced emphasis on large-scale projects;
- more changes (rehabilitations/redesign) of existing projects to meet new needs;
- deauthorization/dismanteling of existing projects;
- more planning to manage/optimize system performance;
- watersheds as a planning focal point;
- more issue/program focus versus individual project focus;
- more interagency/collaboration and planning; greater reliance on institutional approaches to dealing with water resources issues;
- more technical review and management of private sector work;
- how policy is made and implemented, what is needed to defend your work in that broader context.

Program Description

A 30 semester hour program providing professional education in the theory and practice of water resources planning. The program is multi-disciplinary in orientation, and is intended for those having a bachelors degree in any engineering or science discipline.

Courses

The curriculum consists of eight "cornerstone" core courses providing grounding in key components of water resources planning (24 semester hours), plus an independent study or elective course (3 semester hours), and a final practicum "capstone" course of 3 semester hours (see Figure 1). Completion of the Corps of Engineers training program in water resources planning consisting of seven short courses could be substituted for the elective course. Similarly, the capstone course might be developed in conjunction with the development of a Corps expert planner training initiative to satisfy both requirements. Topic outlines for the courses are provided in Appendix A.

Delivery Options

In considering delivery options the committee was asked to consider some specific requirements:

- The Corps is a geographically diverse organization, operating out of 37 field offices (districts) and eight regional offices (divisions) around the country.
- It is expected that employees pursuing a masters degree would also be working full time with as little time away from the office as possible.

The committee identified a number of potential options for delivering the masters program:

- Distance learning: utilize televised courses, taped courses, e-mail and internet based courses.
- Weekend intensive courses: students travel to central site for weekend-long course. They leave for a month to pursue reading and assignment, and return for anther weekend to complete the course.
- Intensive short-courses: instruction provided over a week or two-week period.
- Resident program: students are resident at university for a semester or during the summer for intensive course work.
- Blended delivery: combinations of distance learning and one or more of the other options.

Next Steps

Three key activities are taking place this summer: refinement of the curriculum; more detailed exploration of delivery options; and the conduct of a "market survey" among Corps of Engineers planners to determine potential interest and preferences for delivery options. As the content and delivery mechanisms begin to gel attention will turn to detailed planning for initiating the program.

Comments/Suggestions

Please provide comments or suggestions regarding Master's curriculum content or delivery options to Dr. Paul Bourget; e-mail: paul.g.bourget@usace.army.mil or phone: 703-428-6292.

Figure 1. Curriculum Outline: Masters Program in Water Resources Planning

Cornerstone – Core Courses (24 semester hours)

- Philosophy of Planning (3 semester hours)
- Institutional Considerations in Water Resources Planning (3 semester hours)
- Social Decision-Making (3 semester hours)
- Ecology for Water Resources Planning (3 semester hours)
- Engineering for Water Resources Planning (3 semester hours)
- Economics for Water Resources Planning (3 semester hours)
- Hydrology/Hydraulics/Climatology (3 semester hours)
- Quantitative Methods for Water Resources Planning (3 semester hours)

Independent Study (3 semester hours)

Capstone Course – Advanced Planning Practicum (3 semester hours)

Appendix A

Topic Outlines of Courses in Masters Program in Water Resources Planning

Cornerstone Courses

1. Philosophy of Water Resources Planning

Learning Objectives:

1. To become familiar with the past theories, methods, and techniques of assessment and evaluation in the planning and management of the Nation's water resources.

2. To develop an appreciation and insight into the complexity and conflicts in multi-objective water resources planning.

3. To become familiar with the classics in water resources planning and management literature.

I. Perspectives on Resource Use
   A. Pre-Malthus (Greeks, Romans, Etc.)
   B. Pre-Industrial Society: Malthus
   C. Early Industrialism: Ricardo
   D. Present: Morse and Barnett (Society = Growth)

II. Population Growth
   A. Past Growth - to 1650 and to Present
   B. Sources of Data
      1. Historical
      2. Current
   C. Methods of Population Projections
   D. Case Studies in corps of Engineers

III. Environmental Policy and Thought in U.S.: A Historical Overview
   A. Laws, Regulations, and Policy
   B. Influential Leaders
   C. Growth of Federal Bureaucracies Involved in Water
      1. Forest Service
      2. Agriculture
      3. EPA
      4. TVA
      5. Corps of Engineers
      6. Bureau of Reclamation

7. Etc.

IV. Planning and Evaluation
- A. Objectives
- B. Past Approaches in Planning: Historical Overview
  1. Planning Process in Corps
  2. Single to Multi-objective Planning
  3. Major Factors in Planning
     - Environmental
     - Economics
     - Sound Guides
     - Spatial Linkage
- C. Principle and Guidelines: Objectives and Accounts

V. Methods for Assessment and Evaluation
- A. B-C Analysis
- B. EIS Analysis
- C. Social Impact Assessment
- D. Optimization of Economic Efficiency, Environmental Quality, and Social Objectives: Past Efforts

VI. Demand Forecasting
- A. Techniques of Forecasting: Guidelines and Principles
- B. Past Approaches: An Evaluation
- C. Case Studies
  1. IWR-Main
  2. Flood Damage
  3. Risk/Benefit
  4. Etc.

VII. Corps Mission
- A. History of Corps of Engineers
- B. Planning Process in Corps: Strengths and Weaknesses
- C. Public Involvement and Plan Formulation

VIII. Future of Water Resources Planning
- A. Future of Water Resources in U.S.: Problems and New Approaches
- B. Public vs. Private Sector: Responsibilities and Accountability
- C. Corps of Engineers Role

2. Institutional Considerations for Water Resources Planning (3 semester hours)

Learning Objectives: The first major learning objective is for students to understand the law making process. The course begins with the U.S. Constitution because it is the master plan directing how the legislative, executive and judicial branches of federal and state governments must interact in creating law. The course highlights the constitutional role of each branch of the federal government, and the role of federal agencies in particular. The second major learning objective is for students to understand the particular laws governing the activities of the Corp, including enabling statutes and environmental statutes.

Course Outline:

I. The Sources of Law

A. The United States Constitution

1. "About the Constitution of the United States." http://lcweb2.loc.gov/const/abt_const.html
2. "The Constitution of the United States." http://lcweb2.loc.gov/const/const.html

B. The Legislative Branch

1. Johnson, C.W. Parliamentarian of the U.S. House of Representatives. "How Our Laws Are Made." November 12, 1997 http://thomas.loc.gov/home/holam.txt

C. The Judicial Branch

1. Kubesek, N. and G. Silverman, Chapter 2: "The Litigation Process," in Environmental Law, 2nd ed., Prentice Hall, Upper Saddle River, New Jersey, 1997.

D. The Executive Branch

1. Kubesek, N. and G. Silverman, Chapter 3: "Administrative Law," Environmental Law, 2nd ed., Prentice Hall, Upper Saddle River, New Jersey, 1997.

2. Legal roles and duties of the Army Corps of Engineers (e.g., enabling statutes, duties under environmental laws)

II. Public Choice Theory: Economic Evaluation of Political Process

A. Gwartney and Wagner. "Public Choice and the Conduct of Representative Government in Public Choice and Constitutional Economics, eds. Gwartney and Wagner, JAI Press Inc., Greenwich, Connecticut, 1988.

III. Law

A. Water Law

1. Gould, G. "Water Rights Transfers and Third-Party Effects." Land and Water Law Review 23(1):1-41.

2. Huffaker, R.G., A. Michelsen, J. Hamilton, and M. Frasier. "The Uneasy Hierarchy of Federal and State Water Laws and Policies." *Water Resources Update* (January 2001):3-10.

3. Huffaker, R.G., N.K. Whittlesey and J. Hamilton. "The Role of Prior Appropriation in Allocating Water Resources into the 21st Century." *International Journal of Water Resources Development* (June 2000):265-275.

B. Environmental Law

1. Endangered Species Act

Rohlf, D. J. The Endangered Species Act: A Guide to Its Protections and Implementation. Stanford Environmental Law Society, Stanford Law School (1989).

Tarlock, A. D. "The Endangered Species Act and Western Water Rights." Land and Water Law Review (1985):1-30.

2. Clean Water Act

C. Public Trust Doctrine

Walston, R. E. "The Public Trust and Water Rights: National Audubon Society v. Superior Court." Land and Water Law Review (1987):701-724.

3. **Social Decision-Making**

Learning Objectives:

1. To gain an understanding of the major ways that public policy decisions about water resources are made, together with an appreciation of the strengths and weaknesses of each approach. More specifically,

2. Be able to describe the current water resources decision-making environment in terms of factors such as presence of multiple interest groups with competing values and priorities, multiple sources of power, etc. and the challenges that this environment presents for decision-making.

3. Describe major public decision-making models, and their strengths and weaknesses in the water resources decision-making environment.

   A. Market Models
   B. Government regulation
   C. Collaboration (public participation, ADR)
   D. Coercive/litigation

I. Current Approach in Water Resources Decision-making
   A. Theories (e.g. pluralism)
   B. Decision-making and Standards (interest groups, membership, etc.)
   C. Future Challenges
   D. Case Studies

II. Market Mechanisms for Public Decisions
   A. Rationale/Key Assumptions
   B. Strengths/Weaknesses
   C. Examples
   D. Methods and Issues in Application

III. Regulation
   A. Rationale/Key Assumptions
   B. Strengths/Weaknesses
   C. Examples
   D. Methods and Issues in Application

IV. Litigation
   A. Rationale/Key Assumptions
   B. Strengths/Weaknesses
   C. Examples
   D. Methods and Issues in Application

V. Collaborative Methods: Public Participation
    A. History/Evolution
    B. Rationale, Theory, Assumptions
    C. Strengths/Weaknesses
    D. Examples
    E. Methods and Issues in Application

VI. Collaborative Methods: Alternative Dispute Resolution
    A. History/Evolution
    B. Rationale, Theory, Assumptions
    C. Strengths/Weaknesses
    D. Examples
    E. Methods and Issues in Application

VII. Collaborative Methods Shared Visioning in Plan Formulation
A. History/Evolution
B. Rationale, Theory, Assumptions
C. Strengths/Weaknesses
D. Examples
E. Methods and Issues in Application

4. **Suggested Course on Fundamentals of Ecology for Water Resource Planners**

Course Description:
Presents fundamental concepts in individual, population, community, and ecosystem ecology. Emphasizes basic principles, which comprise the field of ecology. Based primarily on examples of structure, function, and adaptation in the natural world. Examples of the influence of humans on ecological systems and the use of ecological concepts to better understand human manipulated ecosystems. Use of the concepts of ecology and their application to understanding the interrelationships of society as part of ecosystems. Explore concepts of ecosystem management and adaptive management.

Learning Goals:
- Attain a conceptual understanding of the principles of ecology
- Increased self confidence in personal ability regarding ecology as a science
- Ability to critically analyze a problem or issue from an ecological perspective
- Understand the role of ecological knowledge in determining environmental consequences of human activities
- Recognize the complexity and interrelated nature of ecology relative to other sciences
- Develop understanding of the ecosystem concept, ecosystem services, ecosystem management, and adaptive management.

Course Schedule/Content
Week
1. Organization of the natural world: climate, biomes, evolution, species
2. Ecology of the individual organism -temperature & water relations
3. Energy and nutrient relations of individual organisms
4.Population ecology-distribution and abundance
5.Population dynamics
6.Population growth models
7.Interactions-inter and intraspecific competition, niches
8.Interactions-mutualism, predation, parasitism, disease
9.Community ecology-species abundance & diversity, biodiversity
10.Food Webs, keystone species, energy flow, nutrient cycling
11.Ecosystems-succession & stability, landscape ecology, island biogeography
12.Large scale ecological phenomena-regional & global systems
13.Ecosystem Management-ecosystem services, mitigation, restoration
14.Adaptive management-uncertainty principle, complexity, collaborative process
15.Sustainability, economics, and the social/legal/political framework

5. **Concept for a Course: Introduction to Water Resources Structures**

This course is designed to provide a broad overview of the types of water resources structures, their purpose, their design and their operation. This course is intended for water resources planners from a variety of disciplines. It is intended to provide background and terminology so that planners can effectively interact with engineering design and operation personnel. A further purpose is to acquaint planners with emerging issues and non-structural options.

Learning Objectives

At the end of the course, the successful student should be able to:

1. Identify the types of water resources structures used for various purposes, including flood control, navigation, water supply, hydropower production, channel maintenance and environmental restoration.
2. Describe the types of engineering investigations need to plan, design, construct, and operate water resources structures.
3. Describe the emerging challenges for water infrastructure including maintenance, rehabilitation, decommissioning, and changing operational purposes.
4. Describe the relationships between structural and non-structural solutions to water problems.

Course Outline

Week	***Topic***
1	Course Overview and Introduction to Engineering Analysis
2	Basic Physical Principles of Structural Design
3	Types of Engineering Studies: Planning, Design, Maintenance/Rehabilitation, and Operational
4	Dams and Reservoirs
5	Dams and Reservoirs
6	Hydropower Structures
7	Flood Control Structures
8	Navigation Structures
9	Channel Regulating Structures
10	Water Supply Structures, including Groundwater Systems
11	Environmental Maintenance and Restoration Issues
12	Environmental Maintenance and Restoration Structures
13	Non-Structural Options
14	Emerging Issues: maintenance, rehabilitation and de-commissioning

6. Economics: Microeconomics for Water Resource Planning

Learning Objectives: To develop familiarity with those components of microeconomic theory which underlie the principal economic tools used in water resource planning. This objective requires attention to both theory and applications. The theory section is presented at an intermediate level, although calculus is used throughout. The remainder of the course consists of an introduction to applications including discounting, price and cost indices, benefit cost analysis, economic forecasting, and public sector pricing. Problem sets are used throughout the course to develop quantitative analytical skills and to emphasize key concepts.

Course Outline:

1. Mathematical Review
    - A. Classical optimization
    - B. Constrained optimization
        1. Lagrangian multipliers
        2. Kuhn-Tucker method

2. Consumer Demand
    - A. Consumer behavior, utility theory
    - B. Individual demand
    - C. Choice under uncertainty
    - D. Market demand

3. Supply
    - A. Production technology, objectives
    - B. Cost minimization
    - C. Expansion paths, cost functions
    - D. Firm supply, market supply

4. Markets
    - A. Seller behavior
    - B. Pure monopoly, pure competition, oligopoly
    - C. Game theory
    - D. Perfect competition

5. Time Value of Money
    - A. Discounting, discounting formulae

B. Discount rates

6. Introduction to Welfare Economics

   A. Social welfare, welfare functions
   B. Producers' and consumers' surpluses
   C. Exchange
   D. Externality
   E. Pure and impure public goods

7. Other Engineering Economics Tools

   A. Price and cost indices
   B. Inflation

8. Benefit Cost Analysis

   A. History, evolution with U.S. Government
   B. Principles and practices
   C. Application examples

9. Economic forecasting

   A. Forecasting principles
   B. Population forecasting
   C. Water use forecasting

10. Public Sector Pricing

   A. Principles and role of prices
   B. Marginal cost pricing
   C. Alternative pricing bases

7. **Concept for a Course: Introduction to Hydrology, Hydraulics and Climatology**

This course is designed to provide an introduction to the sciences of hydrology, hydraulics and climatology. This course is intended for water resources planners from a variety of disciplines. It is intended to provide basic background and terminology so that planners can effectively understand the relationship of the hydrologic cycle and water flow processes to the design and management of a water resources system.

Learning Objectives

At the end of the course, the successful student should be able to:

1. Identify the basic atmospheric processes that influence the hydrologic cycle.
2. Describe the hydrologic cycle.
3. Describe the basic concepts of surface and sub-surface hydrology.
4. Describe the basic principles governing the flow of water.
5. Understand how land use impacts the water resources system.
6. Understand how the stochastic nature of the hydrologic cycle impacts water management.

Course Outline

Week	***Topic***
1.	Introduction to Physical Geography
2.	Geomorphology and Fluvial Processes
3.	Basic Concepts of the Hydrologic Cycle
4.	Principles of Hydrometeorology: The Earths Atmosphere
5.	Climatic Processes
6.	Precipitation Processes
7.	Watershed Processes: Interception, Infiltration, Evaporation, Transpiration, surface and sub-surface flows
8.	Groundwater Hydrology
9.	Streamflow Hydrographs
10.	Introduction to the Principles of Fluid Mechanics
11.	Streamflow Hydraulics
12.	Hydraulics of Pipe Systems
13.	Flow in Estuaries
14.	Flood Processes
15.	Risk and Uncertainty Considerations

8. **Quantitative Methods**

(Topic outline not yet available. List of brainstormed topics is shown)

- Integrated resources planning
- Sensitivity analysis
- Optimization techniques
- Forecasting techniques; sampling methods
- GIS
- Statistics – philosophy and basic concepts
- Shared vision planning – simulation models

Independent Study (3 semester hours)

Course would be an elective within a range of possible choices; or credit received for the completion of the Corps' "core curriculum" of seven short courses in water resources planning. Core curriculum courses:

- -Planning Principles and Procedures
- -Civil Works Orientation Course
- -Plan Formulation
- -Economic Analysis
- -Environmental Analysis
- -Consensus Building
- -Hydrologic Engineering for Planners

Capstone Course – Advanced Planning Practicum (3 semester hours)

Course would be developed in conjunction with a Corps expert planner program. This program would provide a team learning experience over a six month period for Corps employees, and would be mentored by senior Corps planners, and academic advisors. Example content of expert planner program:

- -Team leadership training
- -Washington policy and Congressional procedures seminar and visits
- -Team teaching of Corps core curriculum courses
- -Team assignment in planning study and/or policy development