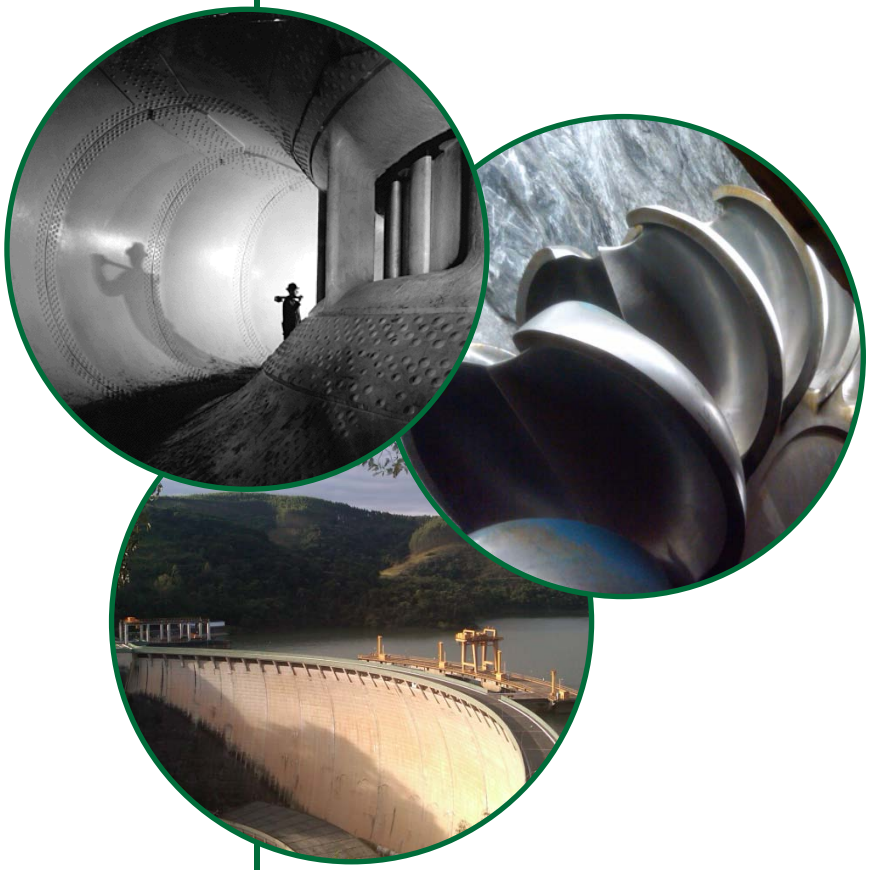
Hydropower New Stream-reach Development Resource Assessment

Introduction and Status Update

April 23rd, 2013



presented by

Shih-Chieh Kao (kaos@ornl.gov)
Oak Ridge National Laboratory

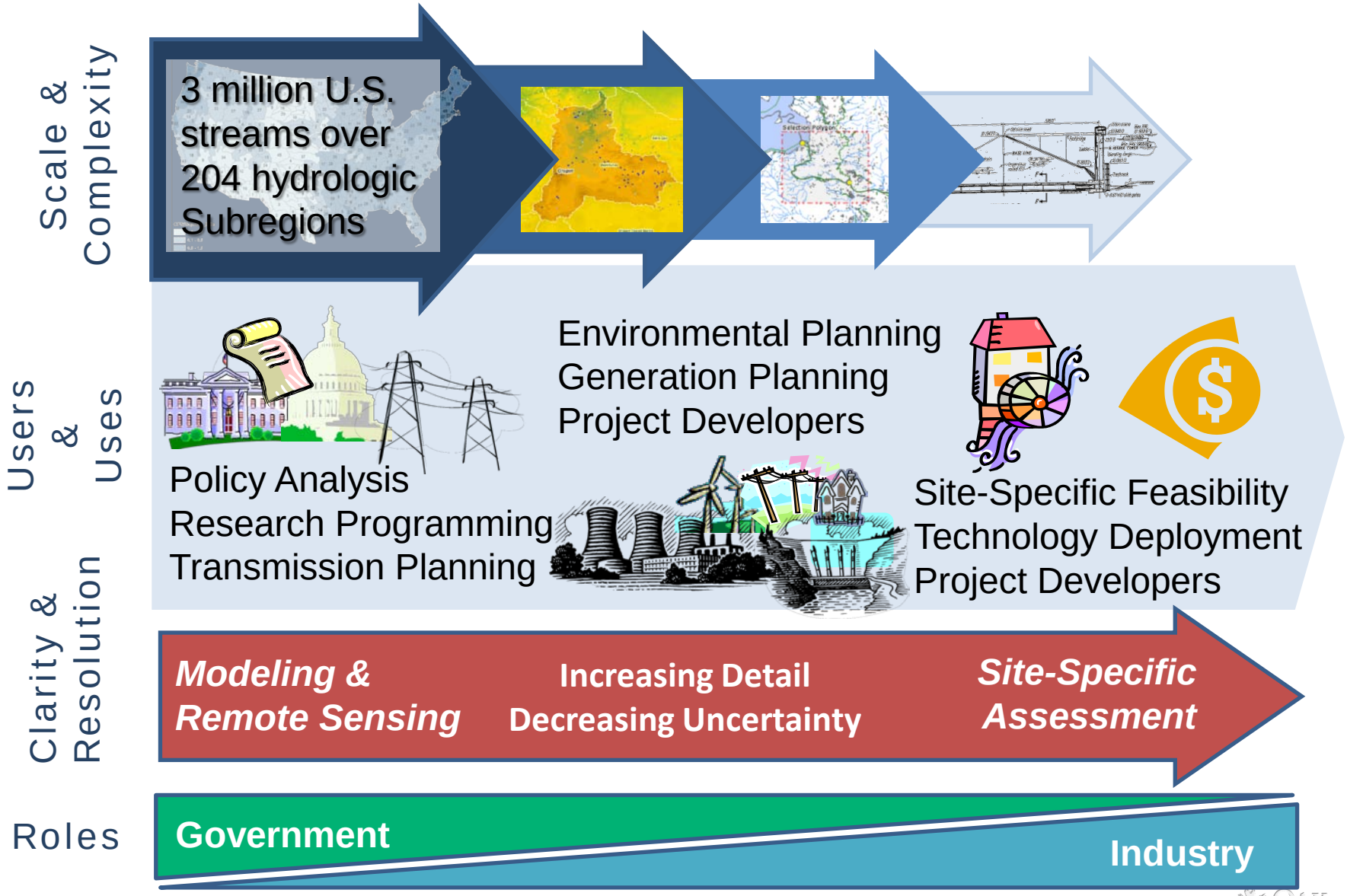
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

DOE/ORNL NSD Overview

- NSD – hydropower New Stream-reach Development resource assessment
- Identify new hydropower potential from undeveloped U.S. stream-reaches
  - AK, HI, and lower 48 states
  - focus on opportunities > 1MW capacity
  - target for run-of-river projects
  - estimate potential capacity (MW), monthly energy (MWh), inundated area (acre), and reservoir storage (acre-ft)
  - provide comprehensive environmental attributes
  - support the future deployment studies
  - site-specific raw data available but not appropriate for preliminary permitting, engineering design or investment decisions.

Energy-Water Assessment & Development



Identify New Hydro Stream-reaches with Comprehensive Attributes

Basic Attributes
Coordinates
State
County
Hydrologic unit
Site elevation (ft)
River name
Channel Slope
Head (ft)
Flow (cfs)
Capacity (MW)
Energy (MWh/year)
Reservoir storage
Inundated area
Residence time

Federally Listed Fish
Endangered
Threatened
Candidate
Species of Concern
Proposed Endangered
Proposed Threatened
Population Endangered
Population Threatened
Population Candidate
IUCN Critically Endangered
IUCN Endangered
IUCN Vulnerable
IUCN Near Threatened

Critical Habitats
Endangered
Threatened
Species of Concern
Fish
Bird
Plant
Amphibian
Reptile
Mammal
Snail
Crustacean
Fern
Arachnid
Insect

Water Use
Aquaculture
Domestic
Industrial
Irrigation
Livestock
Mining
Public Service
Thermo-Electric
Surface Water Total
Ground Water Total
Total Freshwater Use

Fish Traits
Anadromous Species Serial Spawners Seasonally Restricted Spawners Habitat Specialists Lotic Specialist

Population and Housing
Population Density
Housing Density

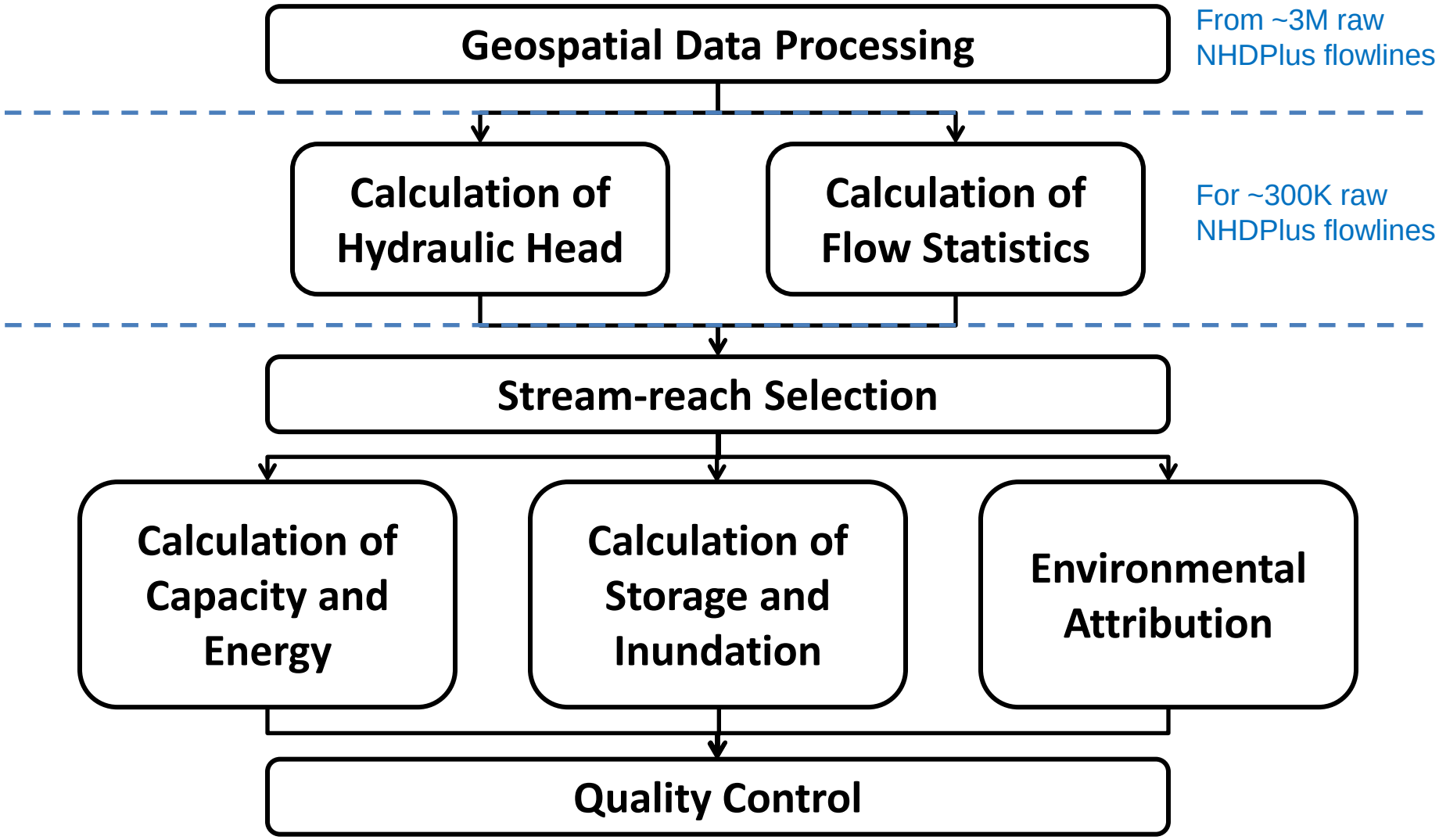
GREY: Environmental attributes

METHODOLOGY

National Geo-spatial Datasets

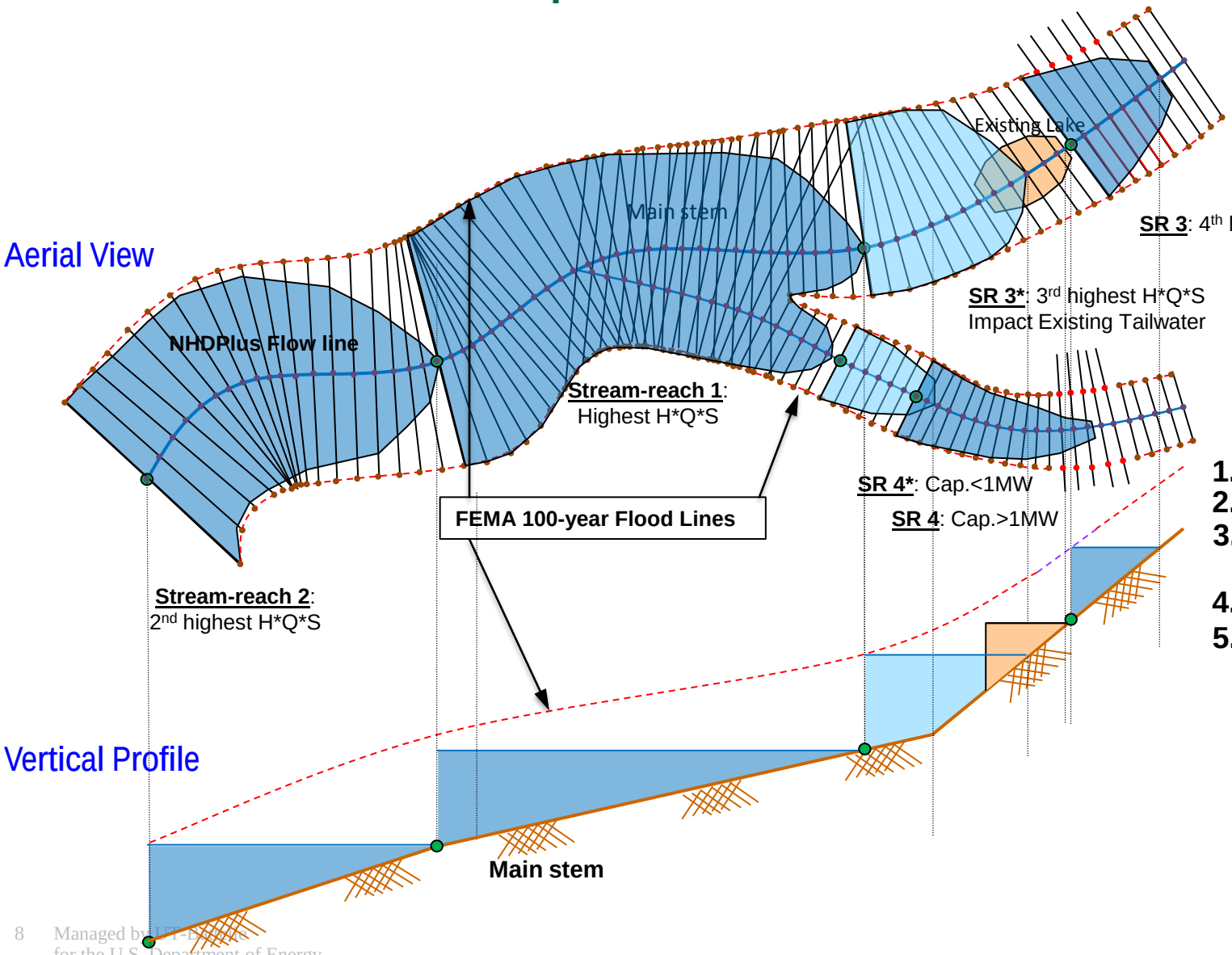
Data Type	Data Source	Note
Watershed Boundary	Watershed Boundary Dataset, NRCS	
River Geometry, Mean Annual Flow, Existing Water Bodies	National Hydrography Dataset Plus (NHDPlus), EPA/USGS	3 million flowlines (NHDPlus version 1)
Existing Dams	National Inventory of Dams (NID), USACE	84,000 dams
Existing Hydropower Plants	National Hydropower Asset Assessment Program (NHAAP), ORNL	
Topography	National Elevation Dataset (NED), USGS	10-meter resolution
Daily Flow Time Series	National Water Information System (NWIS), USGS	22,000 stations
Monthly Runoff Time Series	WaterWatch Runoff, USGS	Unit runoff for each HUC08
Flood Zone	Flood Insurance Study (FIS), FEMA	100-year flood elevation is used as the hydraulic head
Environmental Attributes	Critical Habitats, Wild and Scenic River, Conservation Lands, Water Use, and others	

General Procedures



Note: Given the data limitations and different needs, AK and HI are analyzed through a different approach.

Stream-reach Selection based on Head*Flow*Slope



Steps

1. Discretization
2. Cleaning
3. Extracting NED elevation
4. Interpolation
5. Start searching stream-reaches

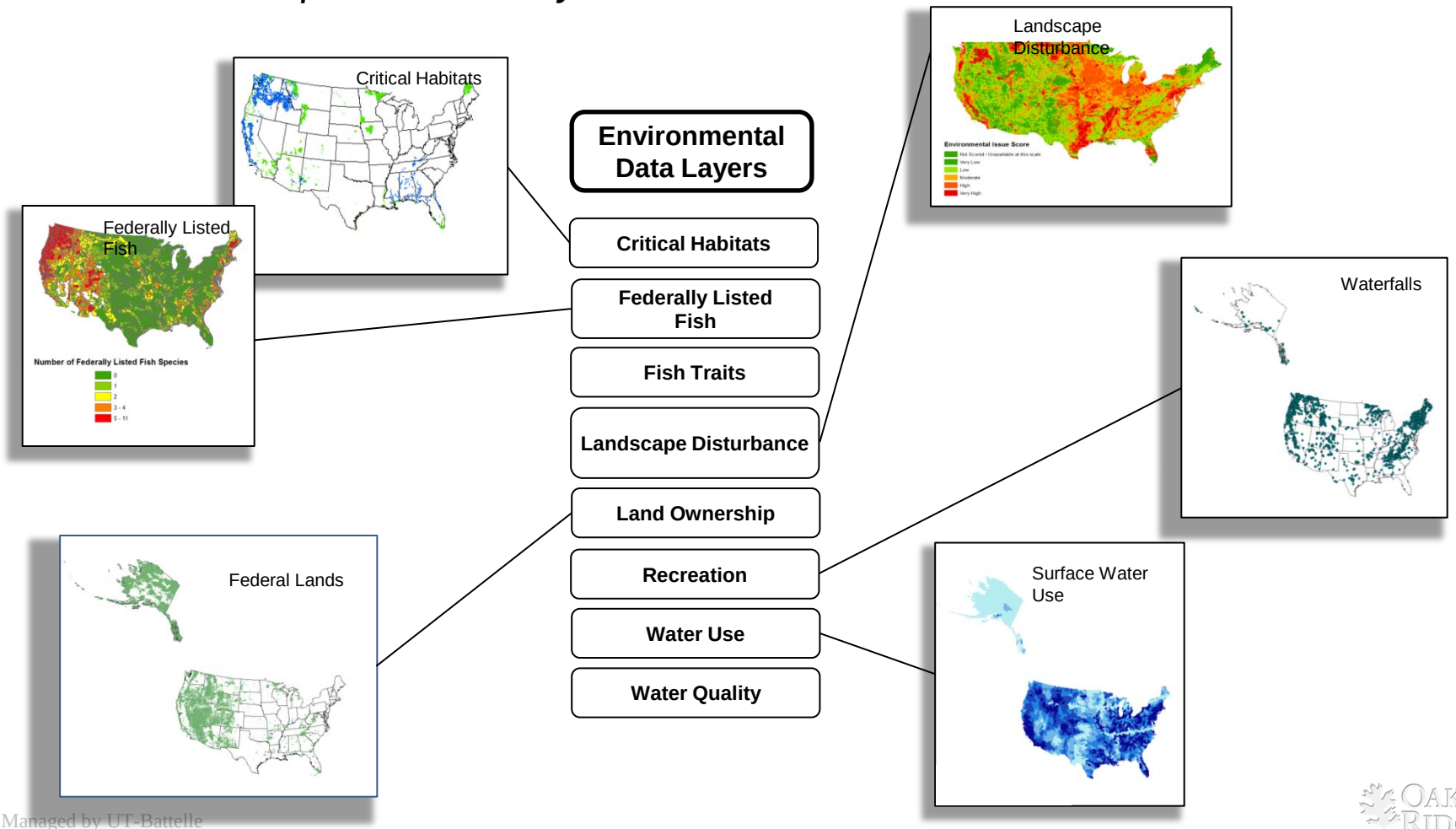
Environmental Attribution

"New potential is not all bad, not all good"

Issues Include:

- Ecological
- Socio-Economic
- Geopolitical

Existing and potential development locations are tagged with an ever-expanding set of ecological and socio-economic attributes that can be used to model developmental difficulty.

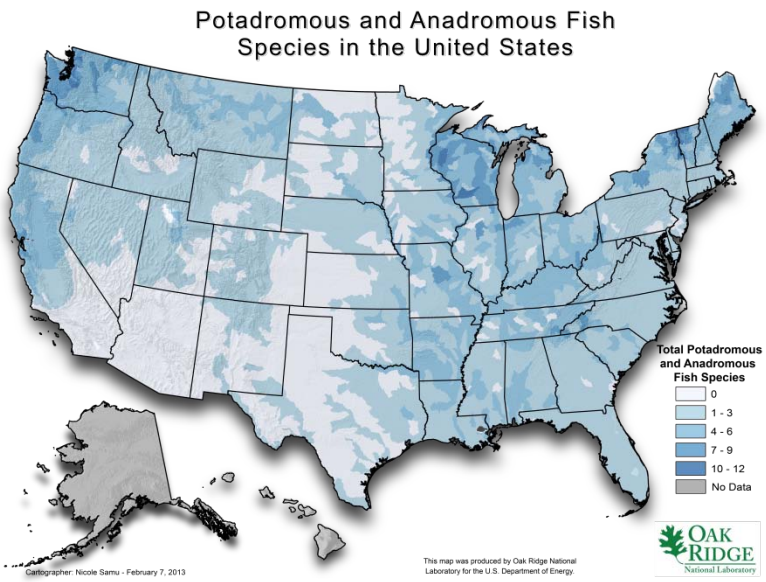


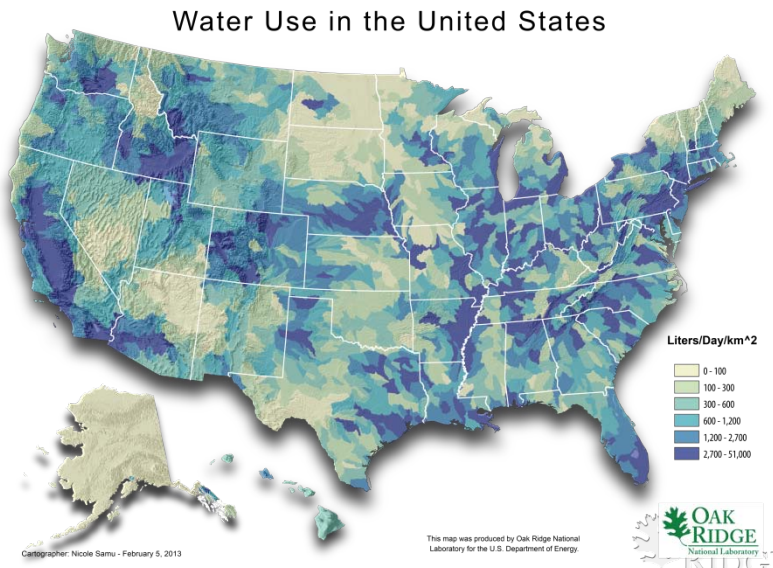
Managed by UT-Battelle
for the U.S. Department of Energy

Examples of Environmental Data

National Scale Layers

Environmental Layers	Descriptions
Ecological	
ESA Critical Habitats	Spatial coverage of critical habitats for species listed under the Endangered Species Act (1973).
Fish Species of Concern	Spatial distribution of fish species listed under ESA or ranked under IUCN
Fish Traits of Concern	Spatial distribution of fish characteristics potentially vulnerable to hydropower development
Protected Lands	
GAP Protected Lands	Stewardship coverage of conservation lands across US
US Wild and Scenic Rivers	River segments listed under the Wild and Scenic Rivers Act
Landscape Development	
EPA Waters Database	Provides water quality information previously available from independent and disparate sources
National Fish Habitat Action Plan (NFHAP)	Nationwide database of fish habitat quality delineated by National Hydrography Data (NHD) plus catchments. Includes land use, dams, road crossings and habitat quality metrics.
USGS Water Use Estimates for the United States	Provide estimates of total consumptive water usage in various categories
Recreation/Aesthetics	
Fishing and Boating Access	Point locations of boat ramps and fishing access locations
American Whitewater National Whitewater Inventory	Recreational boating launch and takeout access points along waterbodies
Geology.com Waterfalls	US waterfall point locations

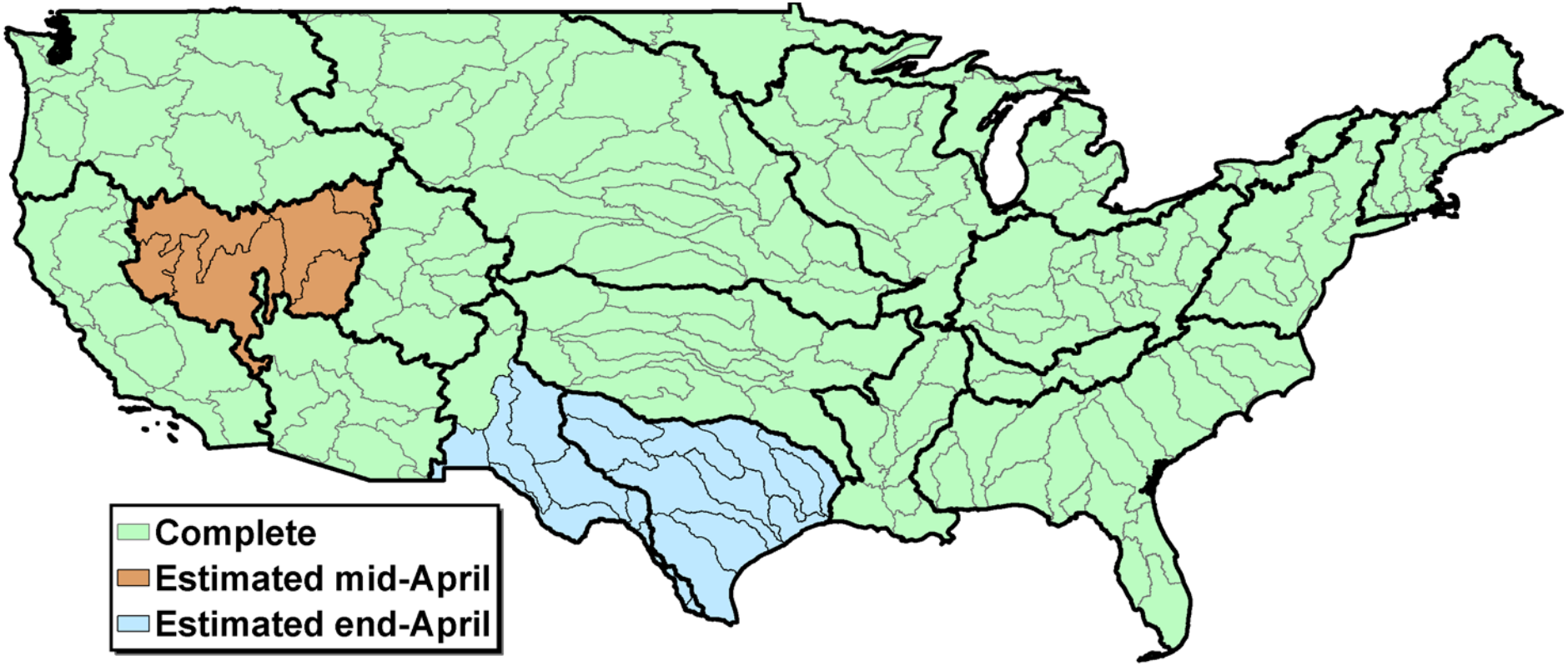




Technical Contact:
Dr. Ryan A. McManamay, mcmanamayra@ornl.gov

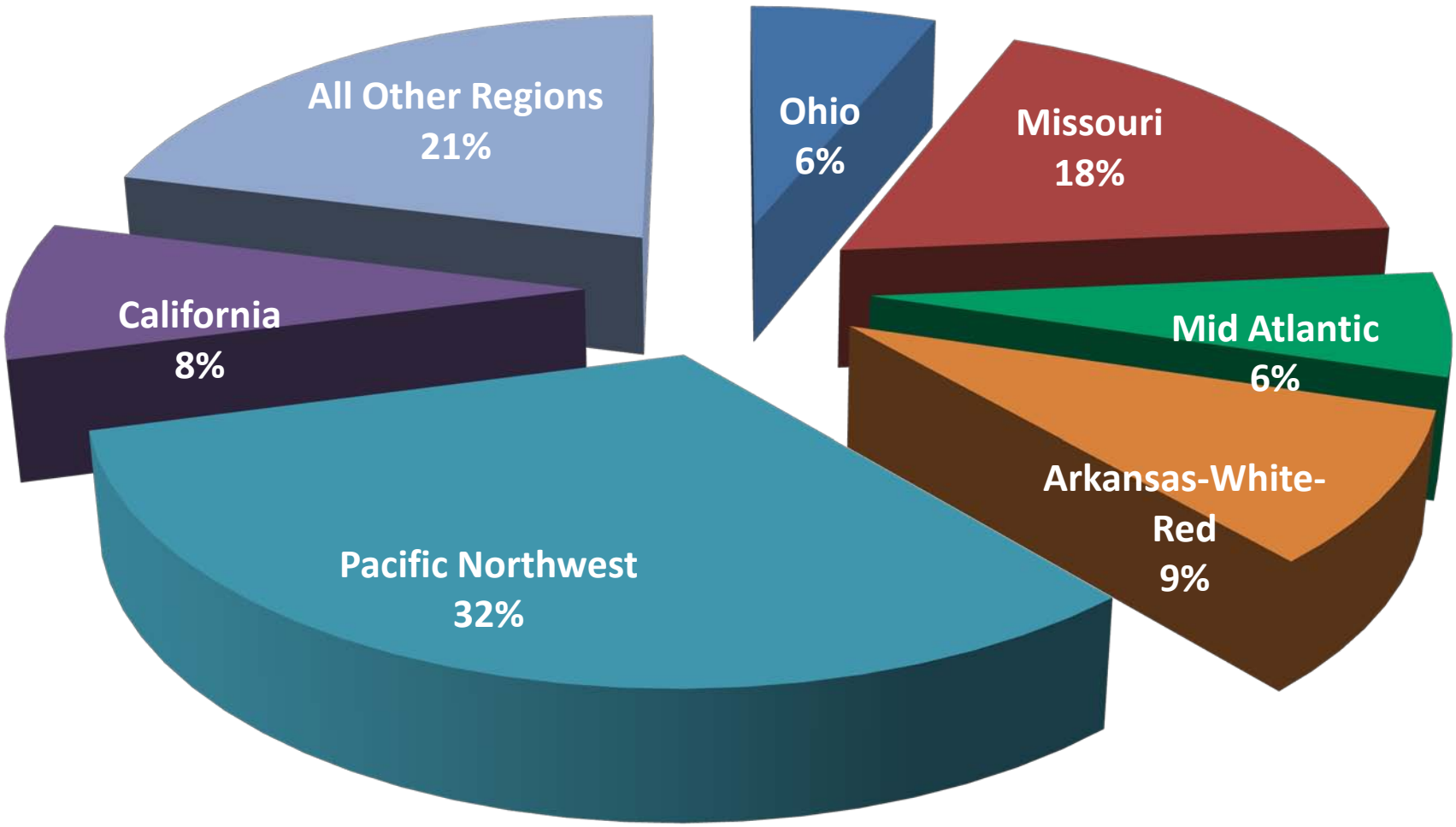
PRELIMINARY RESULTS

Status of Resource Evaluation (~4/10/13)



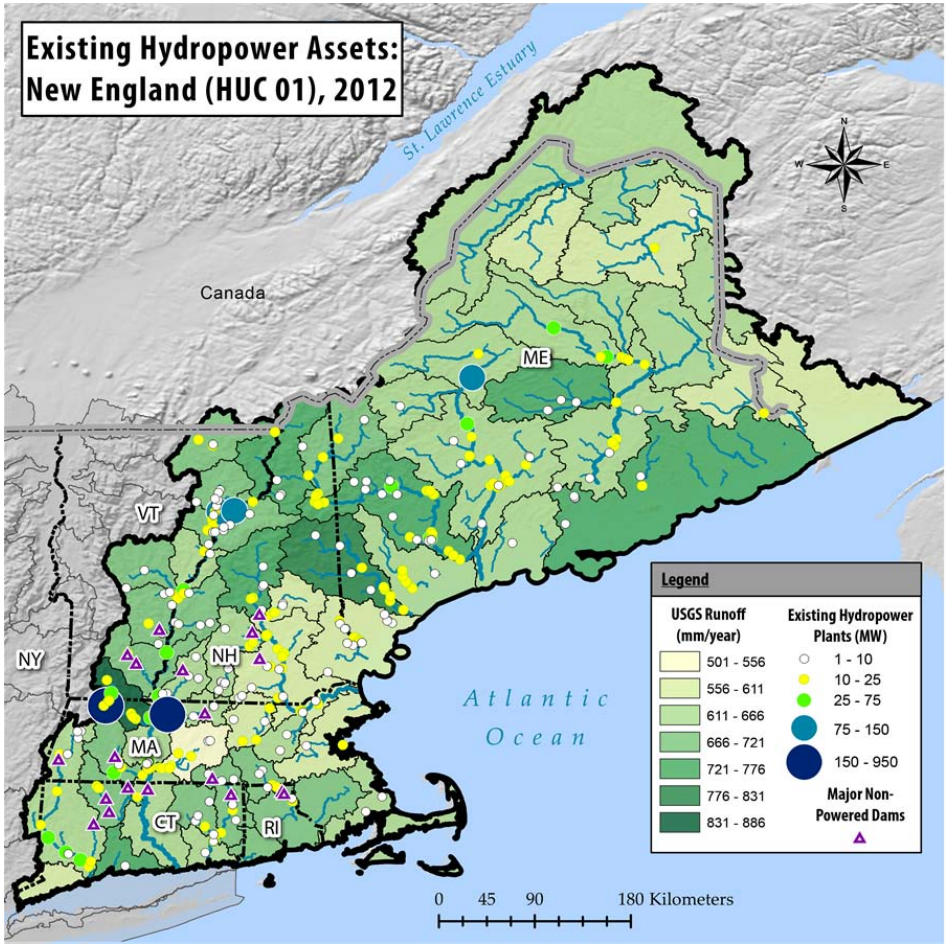
- The national assessment is about to be completed
- The PROVISIONAL data will be released region by region
- National summary report to be expected around end-2013

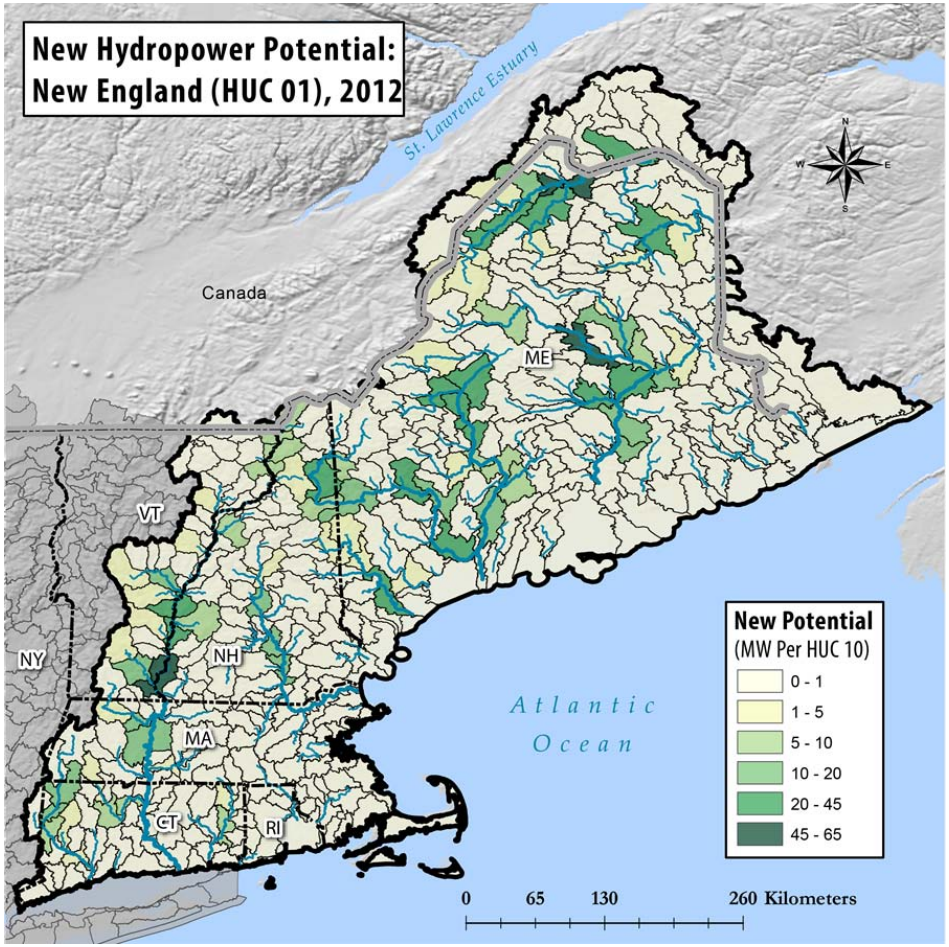
Greatest Potential in Pacific Northwest



Note: Status of 4/10/2013. Great Basins, Texas, Rio Grande, AK and HI are still in process.

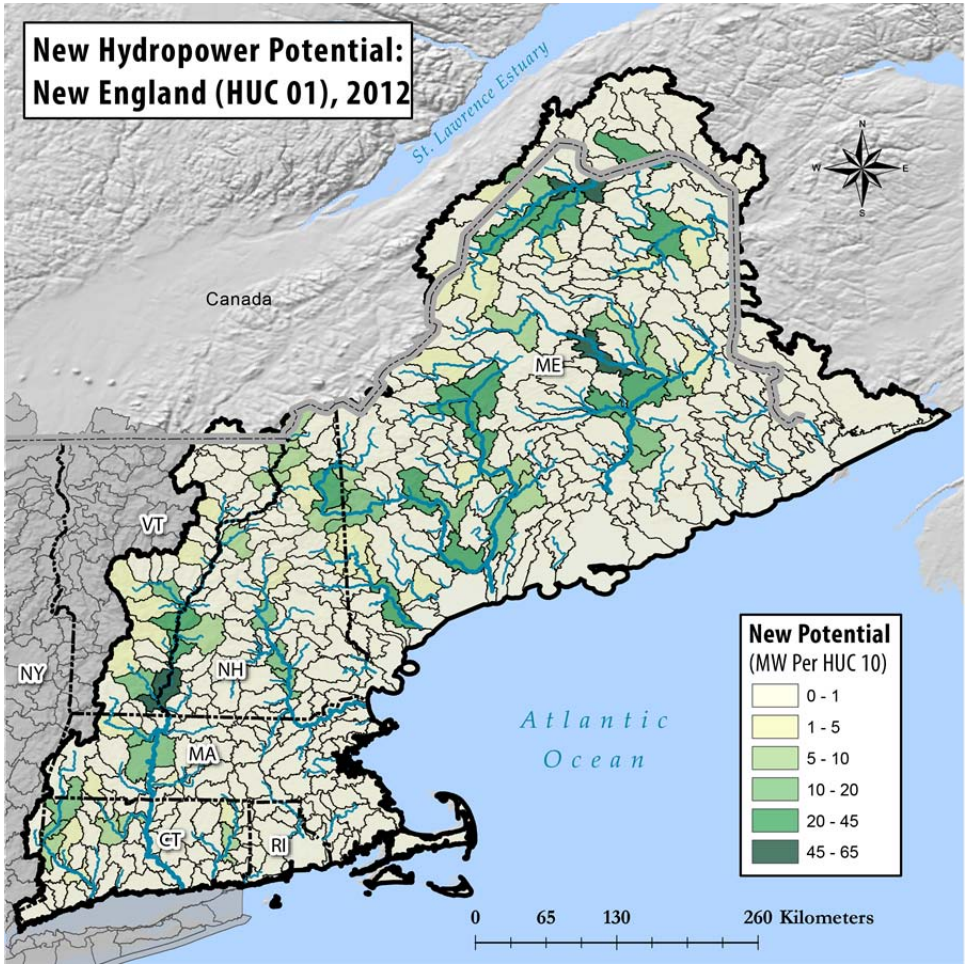
NSD Potential – New England (Region 1)

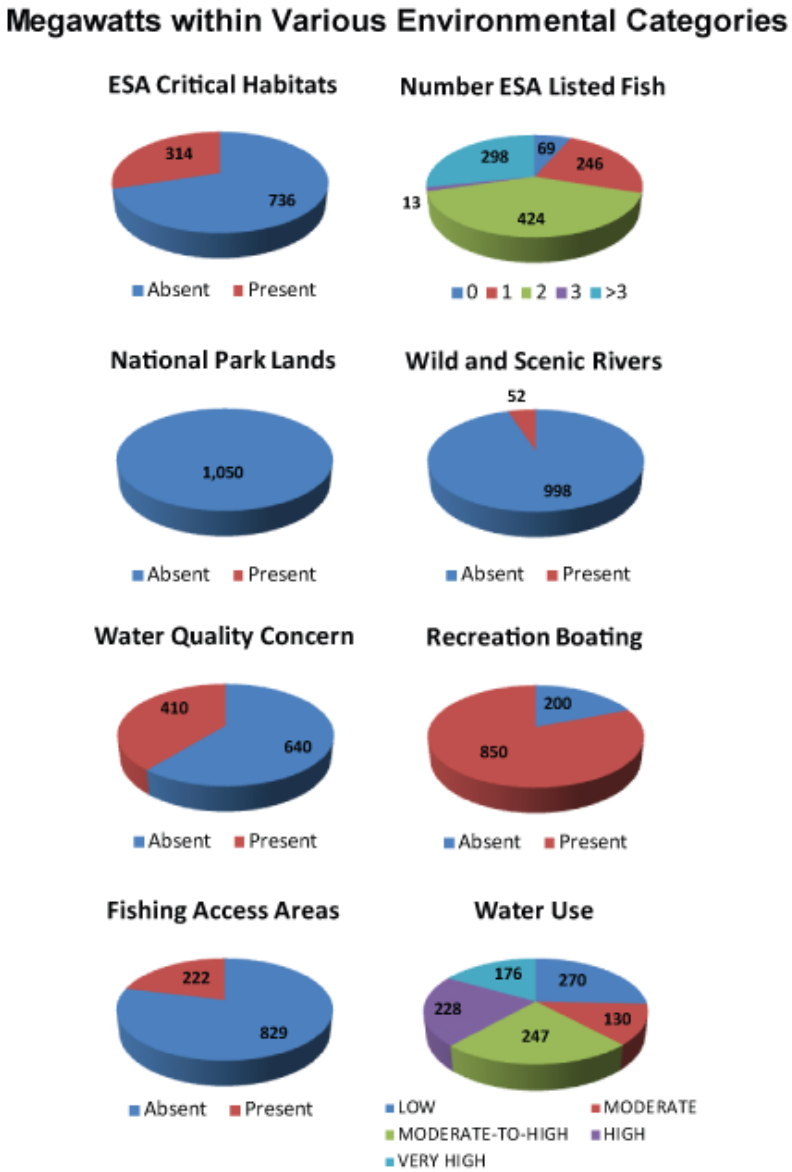




	Stream-reach (>1 MW)	Stream-reach (<1 MW)
Potential Capacity	1.05 GW	1.09 GW
Potential Energy	6.16 TWh	6.27 TWh

Environmental Attributes – Region 1

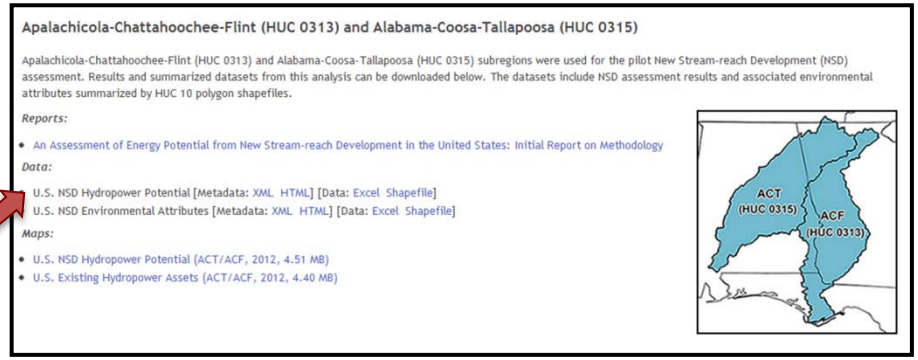




Product Dissemination via DOE/ORNL NHAAP Website

National Hydropower Asset Assessment Program (NHAAP)
http://nhaap.ornl.gov/nsd

Regional Results



- Clickable NSD Availability Map
- NSD Methodology Report
- Webpages for each hydrologic region
  - Maps for existing hydro, non-powered dams, and NSD potential
  - Public data package in both GIS and xls formats
  - Detailed data will be provided upon further request
- Final nationwide Summary Report

Takeaway Messages

- DOE/ORNL will publish a hydropower resource potential dataset and findings of unprecedented spatial, temporal, and functional detail in 2013.
  - Hydropower feasibility and design will always require site-specific assessment that is outside the scope of this effort.
  - The methodology and results are reviewed by a panel of industry, agency, and NGO experts engaged at the beginning of the effort.
  - Energy (MWh) and capacity (MW) estimates are dependent on industry guidance for assumptions of powerhouse flow capacity as a function of hydrology.
  - Due to the updated data sources and refined assessment approach, the findings could be different comparing to the pervious assessment. Further discussion will be provided in the following reports.

Thank you
Questions?

DOE Water Power Program
(alphabetical order)

Hoyt Battey, Rajesh Dham, Thomas Heibel, Patrick O'Connor, Michael Reed, Michael Sale, Michael Spray

ORNL NSD Team
(alphabetical order)

Mark S. Bevelhimer, Robert W. Blackwell, Maria I. Martinez Gonzalez, Boualem Hadjerioua, Shelaine L. Hetrick, Shih-Chieh Kao, Aaron McClellan, Ryan A. McManamay, Clement O. Oigbokie II, Abdoul A. Oubeidillah, Esther S. Parish, MD Fayzul K. Pasha, Angela M. Pelle, Nicole M. Samu, Brennan T. Smith, Kevin M. Stewart, Michele M. Thornton, Dilruba Yeasmin, Cynthia Webb, and Yaxing Wei

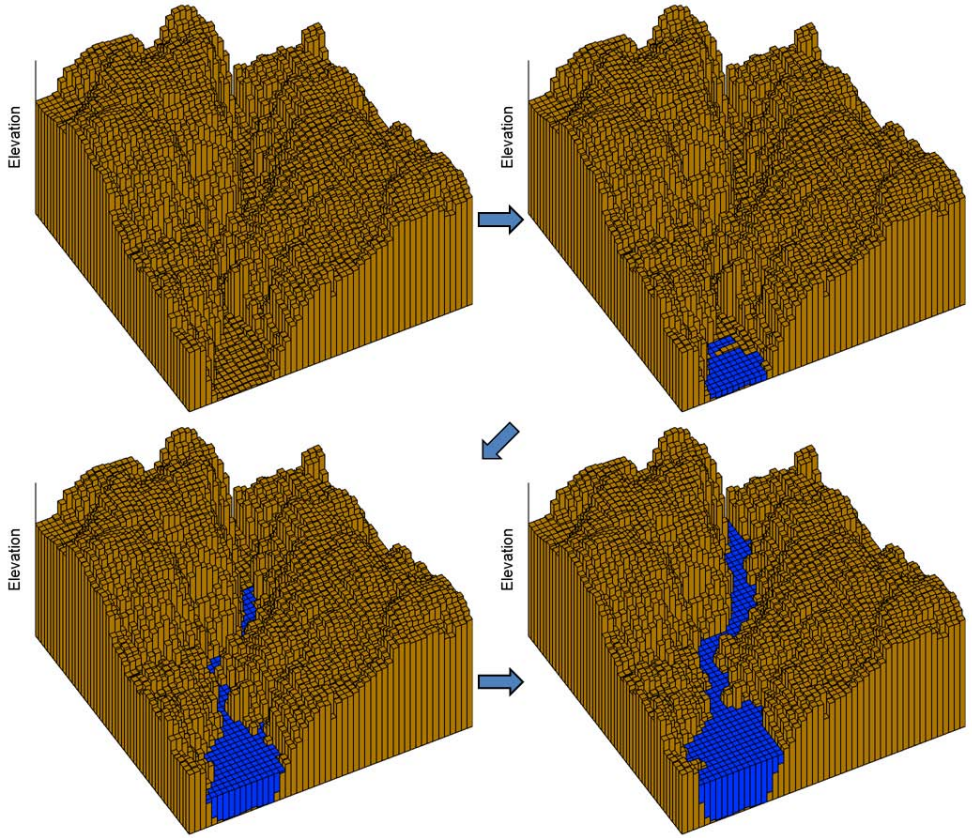
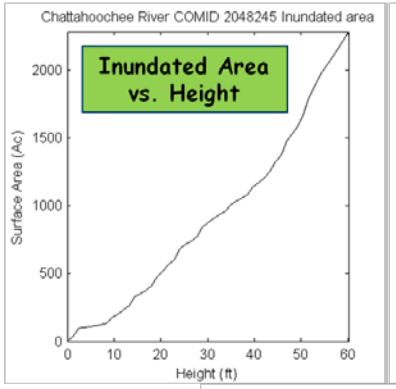
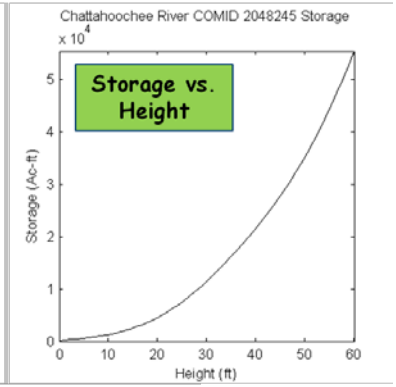
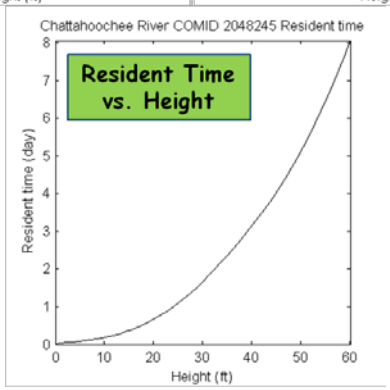
BACK UP SLIDES

Calculation of Capacity and Energy

$$P = c * \gamma * \eta * H_{ref} * Q_{30}$$

- P: capacity (W)
- η: efficiency, assumed to be 0.85
- H_{ref}: head (ft), 100-year FEMA flood elevation
- Q_{30}: flow (cfs), 30% exceedance quantile

- The assessment is designed for the dam-development model
- Diversion model equivalent is also provided:
  - The outlet of penstock placed at the location of dam
  - The penstock is placed along the river reach for the entire reservoir length.
  - Based on the assumed penstock characteristics, reduce head to account for head loss.
- Numerically integrate energy from flow-duration curve (synthesized from the USGS WaterWatch Runoff dataset).

Calculation of Storage and Inundation

- Estimate the relationships between height, storage, and inundated area
  - Automated algorithm for national-scale assessment.