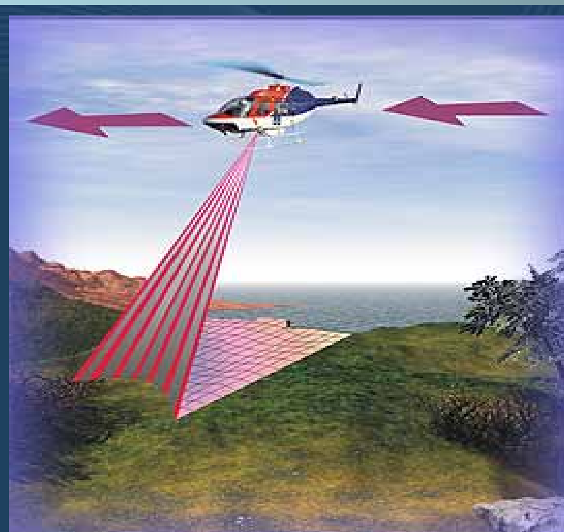
Water Distribution Assessment at Tule-Lake NWR: Using LiDAR Technology to Support Water Resource Management

2009 SAME Water Conference
Sean Ragain – GeoEngineers, Inc.

Background on the LiDAR System



What LiDAR Is:

Active Sensing System:

- Uses its own energy source, rather than reflected natural light or naturally emitted energy
- Features on the ground are “detected” from a reflection of light energy from an airborne source
- Ranging of (distance to) the reflecting object based on time difference between emission and reflection

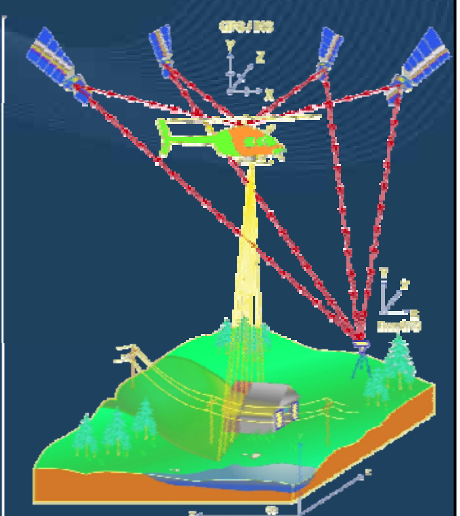
Benefits of LiDAR

- Accuracy
- Volume of data
- Digital format/data quantification (volume calculations, cross sections, profiles, useable databases – GIS)
- Access to difficult/inaccessible terrain
- Cost – similar $/acre as conventional ground survey ($250 - $600/mi^2)
- Speed
- Ability to combine with orthophotos, video, magnetic, thermal etc.

LiDAR Instrumentation

- Laser Source
- Laser Detector
- Scanning mechanism & controller
- Computer timing circuits for emissions & reflections
- Airborne Differential GPS (position)
- Inertial Measurement Unit (attitude)
- High Capacity Data Recorders
- Pan, infrared or multi-spectral cameras for othophotography

LiDAR Instrumentation



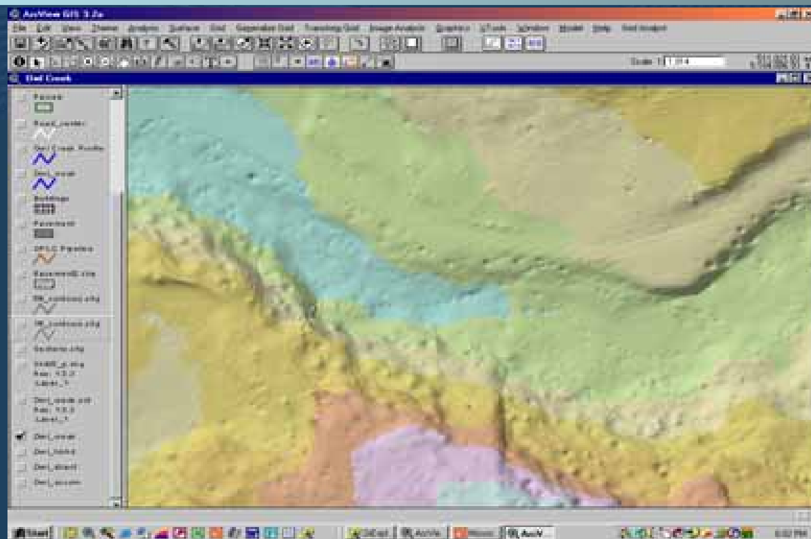
LiDAR Operational Theory

- A pulse of light is emitted, then reflected – precise time is recorded
- Using the constant speed of light, the time delay is converted into a slant-range distance
- Knowing the position and orientation of the sensor, the XYZ coordinate of the reflective surface can be calculated

Digital Elevation Models (DEM)

- DEMs are cartographic constructs used to visualize topography
- DEMs produced directly from the LiDAR Triangular Irregular Network (TIN) are not aesthetically pleasing
- LiDAR data is converted into a DEM at the nominal spacing which retains fidelity to the original data and which appropriately smoothes the contours

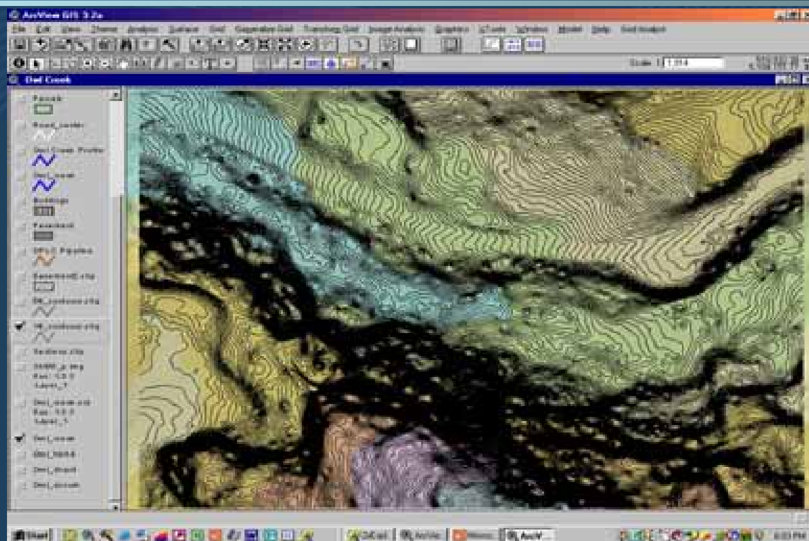
DEM from LiDAR



Contour Generation

- Contours are generated from the DEM and can be exported in CAD format
- The CAD contours are edited to ensure proper cartographic standards
- Contours are converted into ArcInfo format where QC routines ensure quality final product

1-ft. Contours Derived from DEM Be careful what you ask for?



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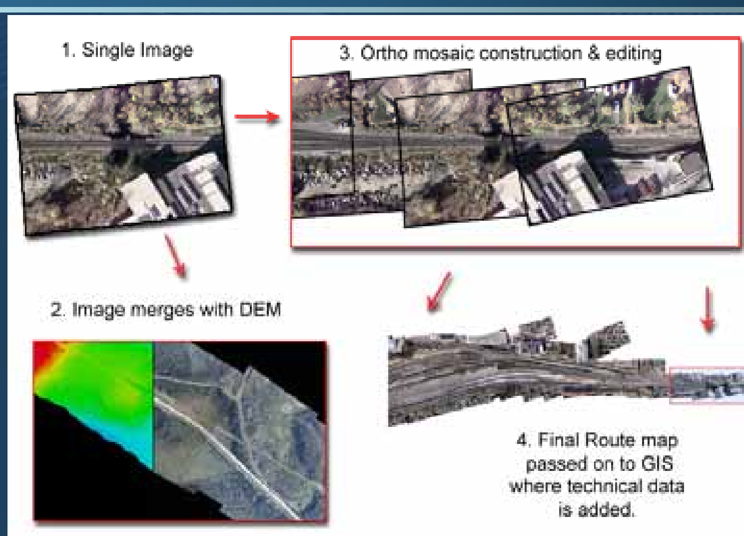
Combining DEMs and Photos



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Common Applications

- General Land Use / Land Cover Classification
- Vegetation Volume / Canopy Characteristics Analysis
- Hydrologic and Watershed Modeling
- Slope Stability
- Habitat Classification
- Property Management
- Linear Corridor Assessment

Lower Klamath Basin
California National Wildlife Refuges

ACEC
GRAND AWARD WINNER

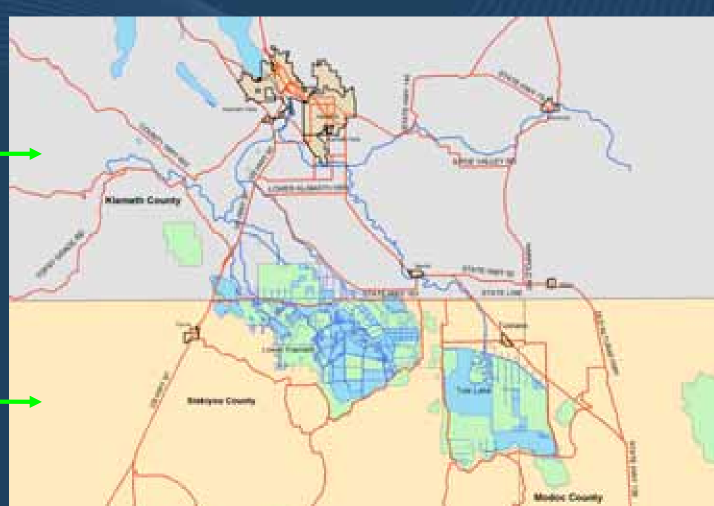
Background

- The U.S. Fish and Wildlife Service (FWS) manages the Lower Klamath and Tule Lake National Wildlife Refuges
- The Refuges are dependent on water supplies from the Bureau of Reclamation's Klamath Project
- Drought in 2001 brought water resource issues to a head
- Controversy made national news
- Conflict became political

Project Location

Oregon

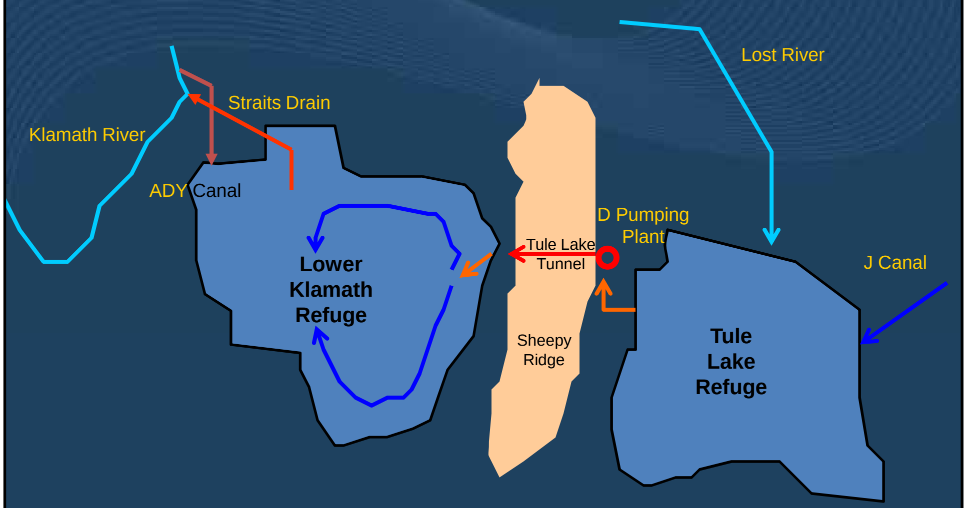
California



Background | REFUGE HABITAT

- Over 350 water-control structures and more than 230 habitat management units
- Habitat Types
  - Permanent and Seasonal Open Water and Marsh
    - Lost River and Shortnose Suckers
    - Waterfowl
  - Permanent and Seasonal Wetlands
  - Leased Agricultural Lands (>15,000 acres)
  - Uplands

Water Schematic



Challenges

- No new water sources available
- Potentially diminishing volume from current sources
- Significant water losses to evaporation and seepage
- Limitations and inefficiencies in moving water from A to B

Project Goals

- Document and evaluate the current water system
- Recommend facility improvements and analyze management alternatives that:
  - Improve wetland productivity
  - Increase efficiency – decrease costs
  - Enhance water reuse capabilities
  - Increase water storage capacity

Constraints

- Competing demands for water – Endangered Species, Tribes, Agriculture
- Kuchel Act – Requires Refuge land dedicated to wildlife with consideration for optimum agricultural use
- Funding limitations restrict improvement options
- Limited topographic information available

Accurate Maps

Detailed topographic information and accurate maps are critical for:

- Documenting current conditions
- Confirming water flow directions
- Calculating areas and volumes
- Evaluating how water can be moved and reused more efficiently
- Designing new structures
- Water budgeting

Right Tool for the Job

- >90,000 acres to survey
- Accuracy in *x,y,z* of 15 to 30 cm required.
- One *x,y,z* data point for every 2 m^2 (approximately 114 million data points - both Refuges)
- Creation of detailed DTMs
- 3-Dimensional modeling necessary for volume/ capacity calculations
- Fully GIS-compatible

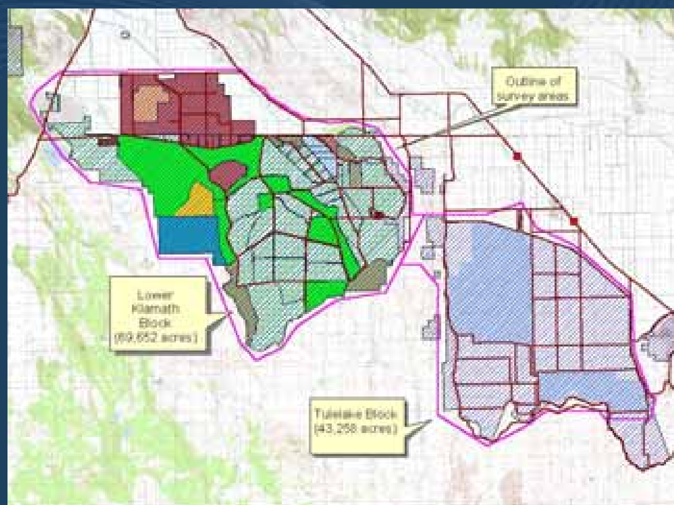
Supplemental GIS Mapping

Custom Datalogger Menu developed to prompt recording of:

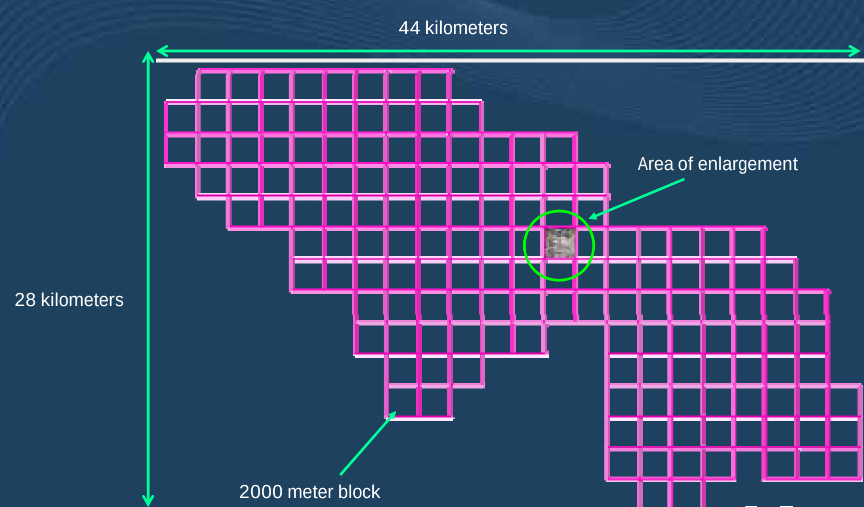
- Structure Name
- Type and Condition
- Dimensions

Total Station GPS used in Field for Structural Details

Survey Area



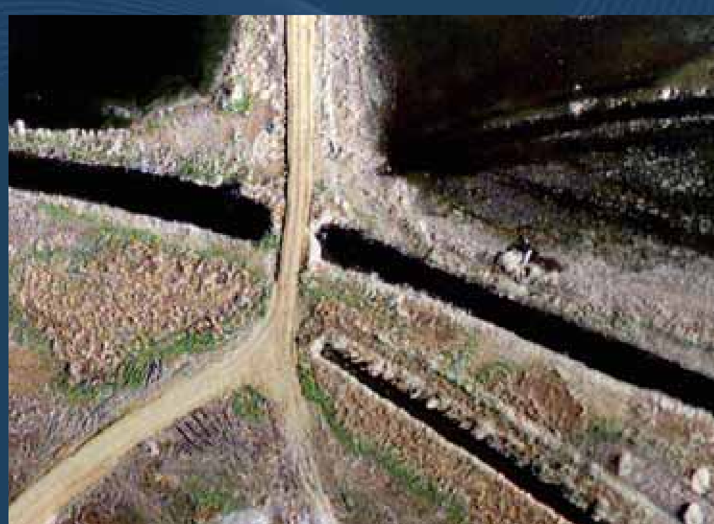
Klamath Data Index



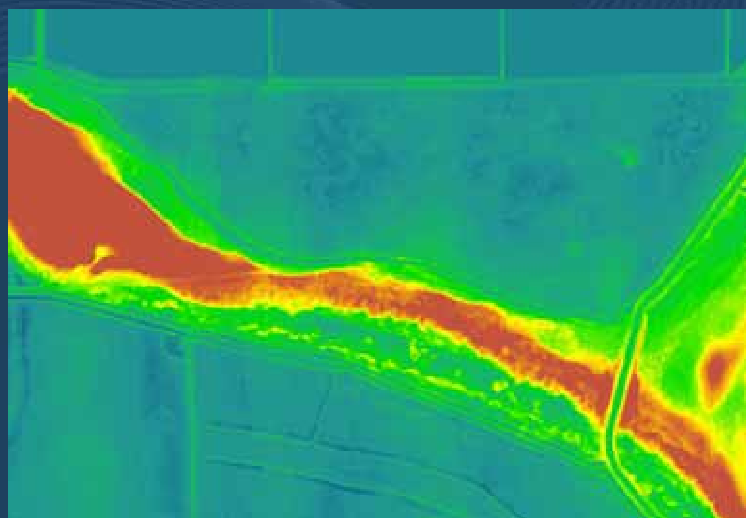
Orthophoto

Area of enlargement

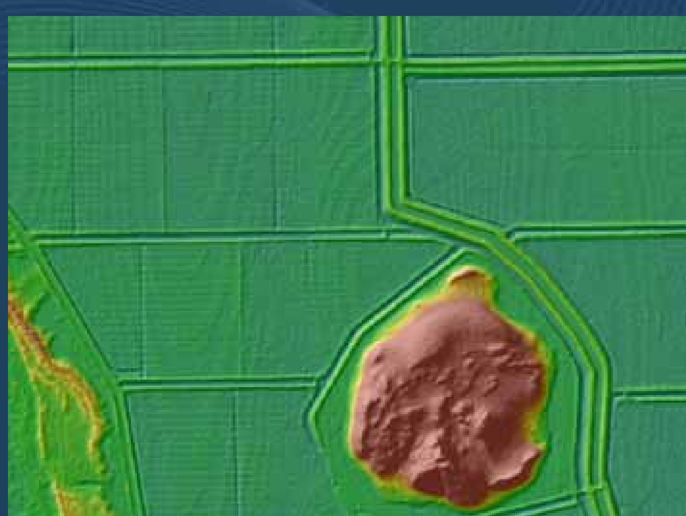
Orthophoto Zoom



Digital Elevation Model

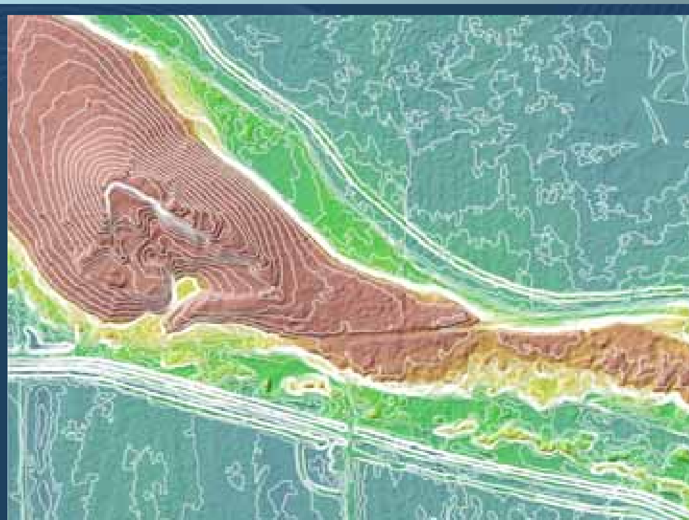


Shaded Elevation Model

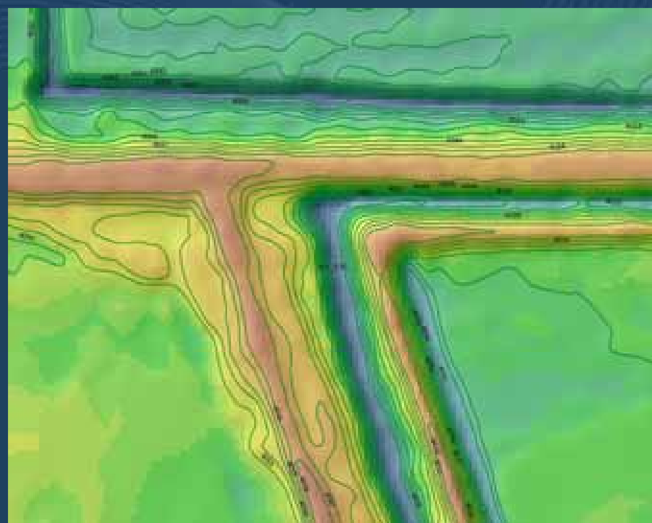


Shaded Elevation Model

DEM with Contours



DEM with Contours



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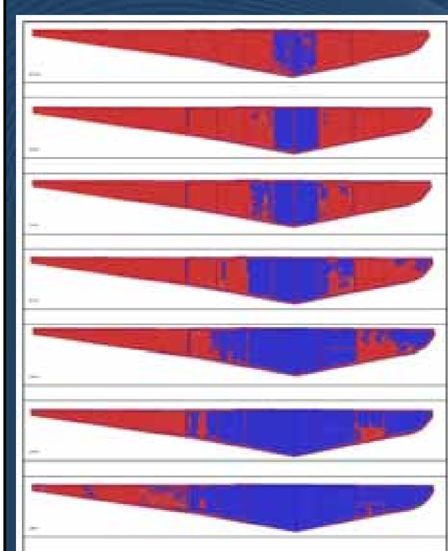
GIS Inundation Model



Plan view of extent of flooding in five (~150A) management units at various water-level stages.

Used to determine if installing structures to gravity flow water between the units would allow a large area to be periodically flooded.

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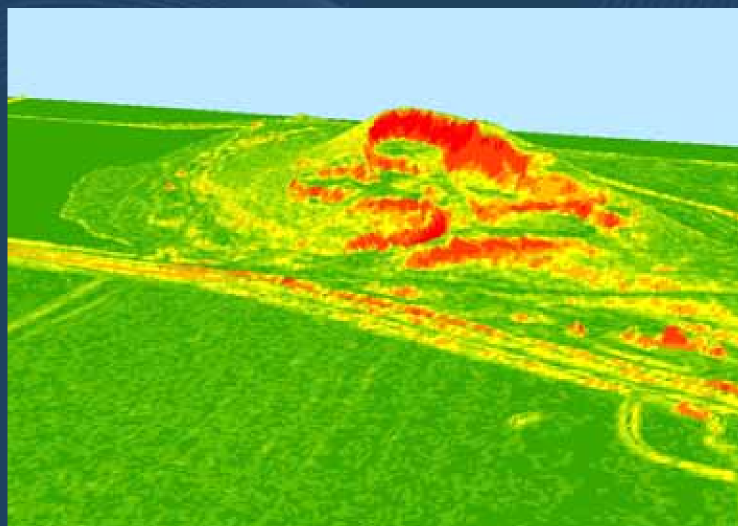
Slopes in 3D



3D-Rendering

Project Results

- Documented current physical conditions of Refuge
- Provided highly detailed GIS database supported by orthophotography
- Facilitated analysis of water management alternatives by thoroughly documenting:
  - Infrastructure
  - Habitat
  - Management practices (water rights, etc.)

Conclusions

The survey data will have substantial utility for other purposes, including:

- Preparing accurate area-capacity curves for the wetlands
- Estimating seepage and evaporation losses needed as part of calculating water-storage balances
- Identifying the optimum use of water at the refuges
- Providing a detailed snapshot of the current site conditions, infrastructure and habitat distribution for future comparison

Conclusions

- LiDAR is a cost-effective tool for application to numerous mapping, science, and engineering type projects.
- FWS provided with long-term tools to identify, analyze and implement water-management improvements that will facilitate the efficient storage, movement and reuse of the water available to the Refuges.

Conclusions

- LiDAR technology has tremendous potential to facilitate water-resource management, and its use should be considered in scoping all large-scale engineering and water resource projects.

THANK YOU!

Questions?