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Determining a Water Surface Datum(s) to Measure Hydrographic Elevations

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Definitions:

Determining a Hydrographic Water Surface Datum(s) to Measure Elevations

- **Datum refers to water surface reference.**
- **Hydrographic refers to bathymetric, hydro acoustic or any sub-aqueous measurement to acquire depths.**
- **Elevation refers to any geodetically defined vertical datum or ellipsoid height.**

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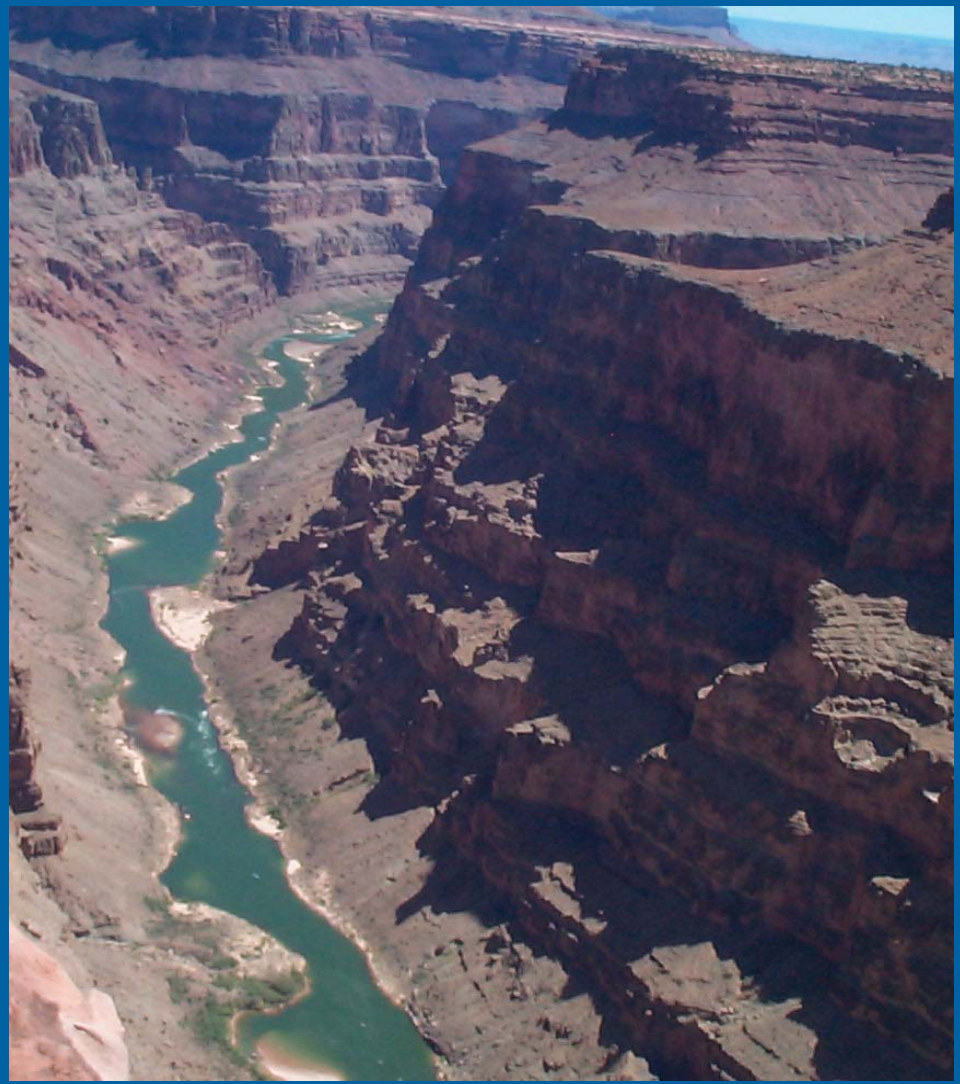
How do we survey the River?



Inconsistencies in gravity models (geoid models) in the CRE make it extremely difficult to transfer reliable, repeatable coordinate values from rim to river. Conventional instruments that rely on gravity (leveling) to make measurements do not easily correlate with GPS measurements, especially in the vertical or elevation.

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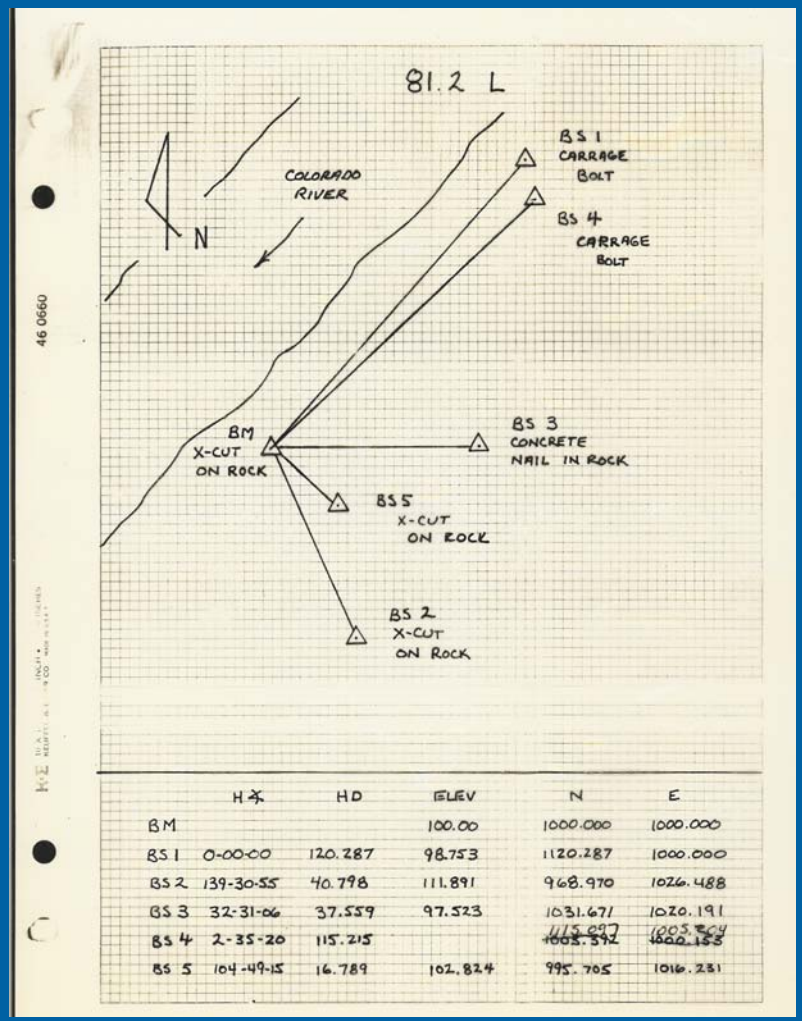
NAU Sand Bar Survey (GCES era)



	H∠	HD	ELEV	N	E
BM			100.00	1000.000	1000.000
BS 1	0-00-00	120.287	98.753	1120.287	1000.000
BS 2	139-30-55	40.798	111.891	968.970	1026.488
BS 3	32-31-06	37.559	97.523	1031.671	1020.191
BS 4	2-35-20	115.215		~~1005.592~~ 1115.097	~~1000.155~~ 1005.804
BS 5	104-49-15	16.789	102.824	995.705	1016.231

Most early site surveys required local coordinate systems for change detection.

Grapevine beach control sheet 1991

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Vertical Triangle

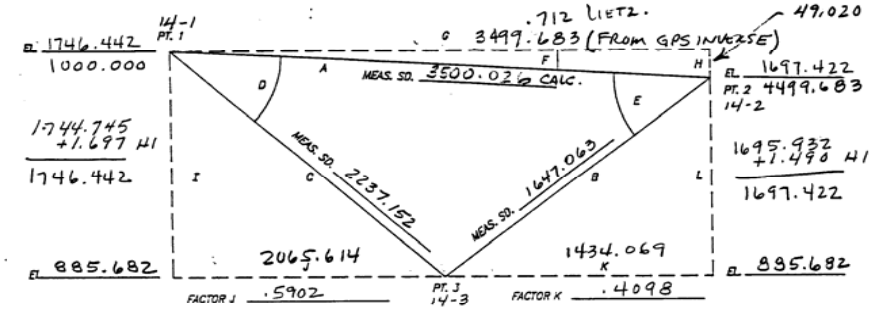
GLEN CANYON ENVIRONMENTAL STUDY — 5 MILE

VERTICAL TRIANGLE COMPUTATION

SITE LCR - MILE 5, AT SALT TRAIL CANYON DATE 9-15-92

CREW MCDONALD, GONZALES, BROD, PROTIVA

Z COORDINATE



887.322
-1.640 HI
885.682

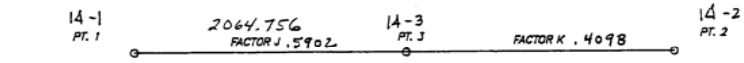
LOOKING D/S ✓ LOOKING U/S ____

H=PT.1 − PT.2 I=C*SIN(D+F) L=B*SIN(E−F) FACTOR J=J/G

F=ARCSIN(H/A) J=C*COS(D+F) K=B*COS(E−F) FACTOR K=K/G

G=COS F*A

X–Y COORDINATES



N 574368.293	N 575548.214	N 576367.487
E 228885.866	E 230580.270	E 231756.760

N 55° 08' 53" E 3498.401

C/F = .999633691

1–3 = 1–2 (FACTOR J) 2–3 = 1–2 (FACTOR K)

(ALL DISTANCES ARE GRID)

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Replaced vertical angles by measuring vertical distances and calculating intersections to determine elevations.

In 1992, GCES survey department measured rim stations with static GPS. Then control traverses in the LCR and Glen Canyon were established by the Vertical Triangle method.

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GCMRC with support from NGS is currently using modern GPS methods to establish repeatable coordinates and ellipsoid heights.

All spatial data for GIS can now be on the same coordinate system!
Now, let's bring it to the water!

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Different Types of Hydrographic Positioning:

- Tag Line Surveys
- Total Station Surveys
- Range-Azimuth Tracking Surveys
- Robotic Tracking Surveys (ATS)
- GPS Surveys
    - Autonomous Surveys
    - Real Time Kinematic Surveys (RTK)
    - Differential Surveys (DGPS)

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Different Types of Hydrographic Sensors

- Lowrance fish finder
- Echosounder, Single Beam
  - Supervised Seabed Classification (Roxxan)
- Acoustic Doppler
- Side Scan Sonar
- Multibeam Echosounder (MBES)
  - Acoustic Backscatter
  - Unsupervised Seabed Classification (QTC View)

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Hydrographic Applications

- Topographic maps
- Digital Terrain Models (DTM)
- Triangulated Irregular Network models (TIN)
- Single beam centerline profile
- Aquatic habitat models
- Sediment or river channel change detection
- Hydrologic stage discharge modeling
- Cross-section analysis
- Seabed Classification
- Eyeball and Video Transects

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Tag Line Survey

Advantages:

*** Water Surface level is measured from monument then depths are subtracted to generate cross-section.**

*** Instant results to analyze an event.**

*** Simple and straight forward.**

Disadvantage:

*** Position is relative, must be adjusted and georeferenced to tie into real world.**

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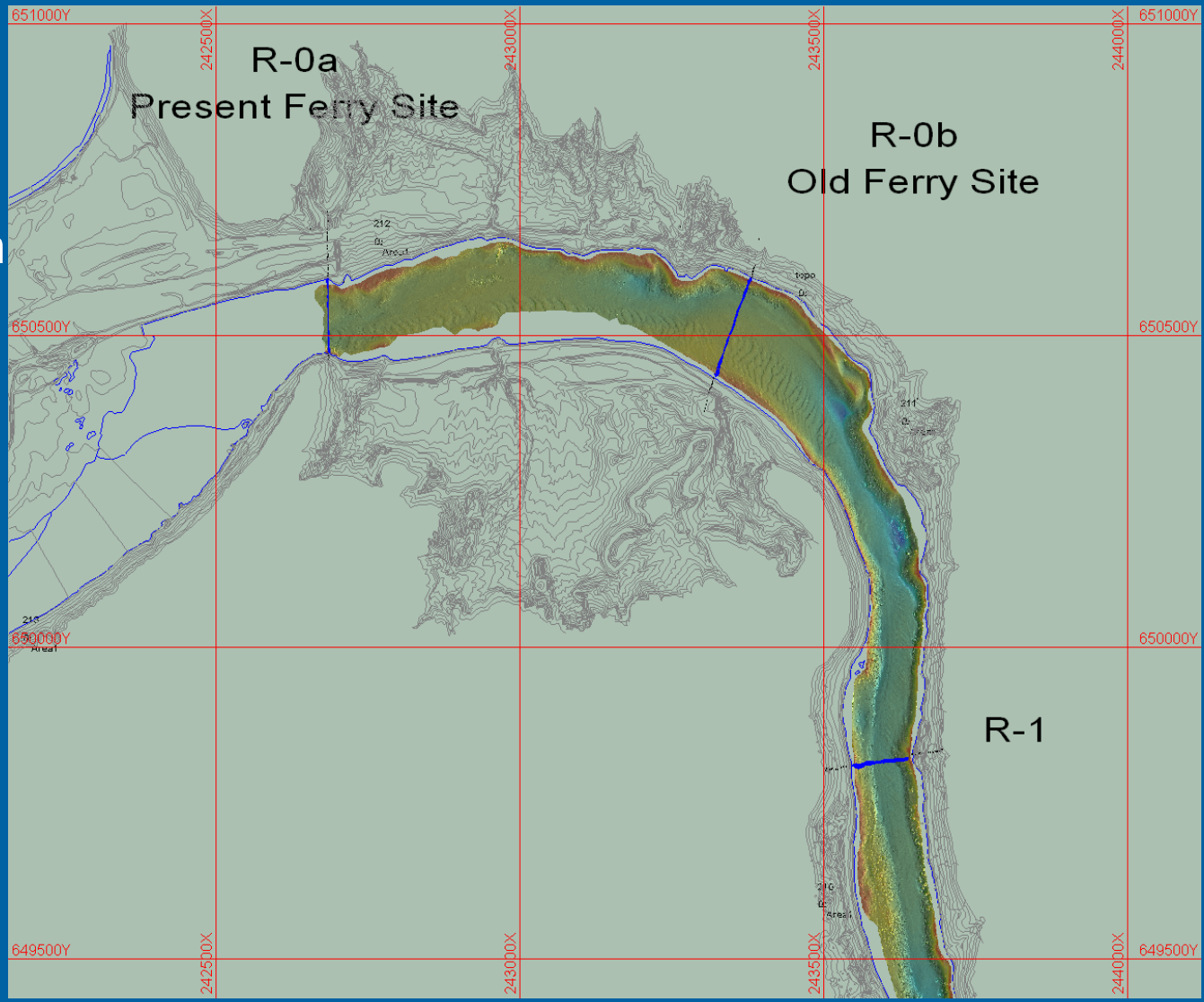
Tag Line Cross-sections at Lee's Ferry

"R" transect lines first established by the BOR in pre-dam construction.

Re-surveyed and georeferenced in 2002 by GCMRC survey department.



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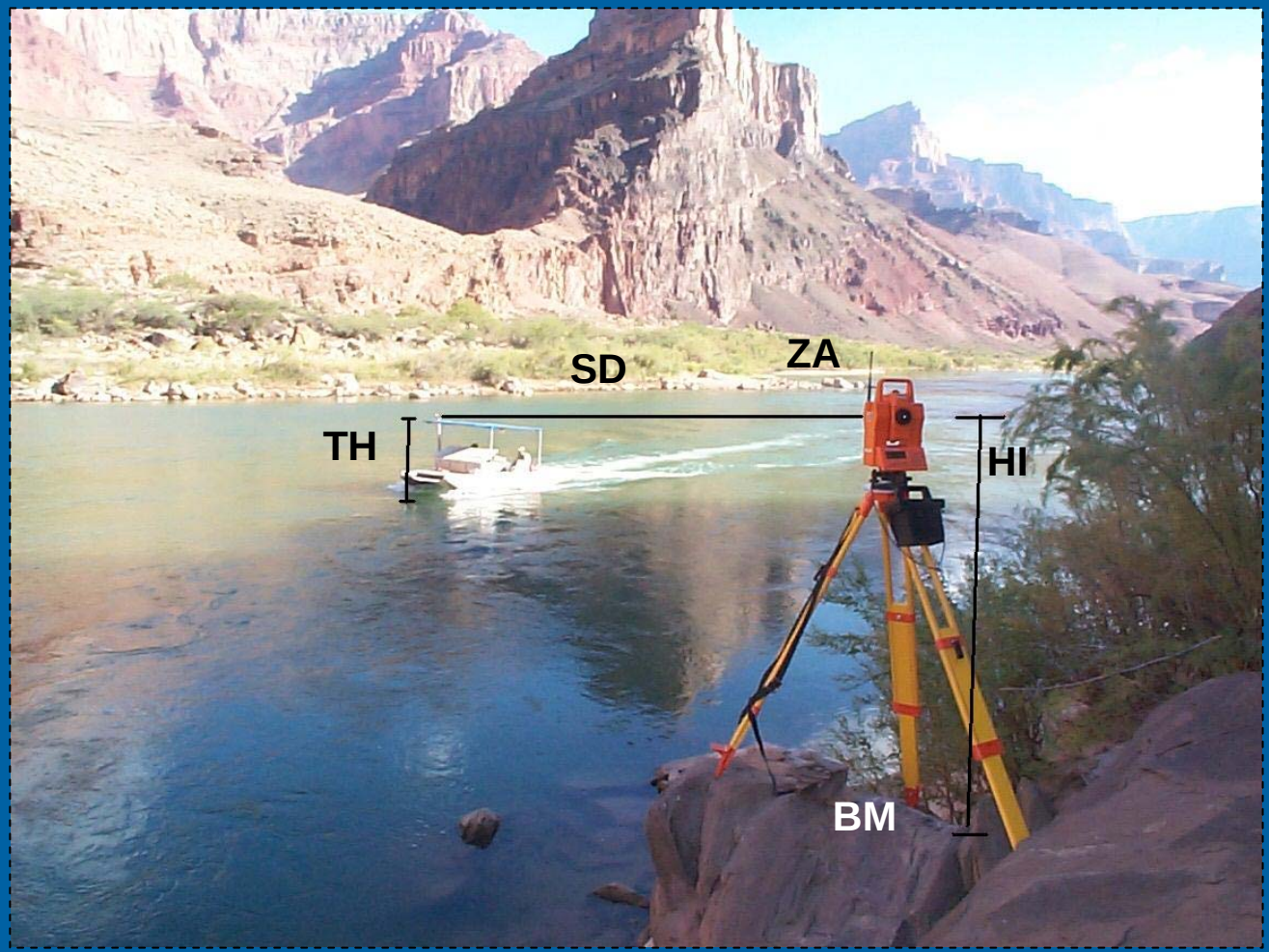
Vertical reduction from control point to Water Surface for Total Station, Range Azimuth, and Robotic Tracking Instruments



BM= bench mark
HI= Height of Instrument
ZA= Zenith Angle
SD= Slope Distance
TH= Target Height

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BM + HI - cos(ZA) -TH = tide elevation

Total Station Survey

Advantages:

*** Boat is positioned with accurate xyz coordinate.**

*** Water surface is accurately measured.**

Disadvantages:

*** Difficult to keep the boat still on moving water with each measurement.**

*** Depths must be manually correlated with positions.**

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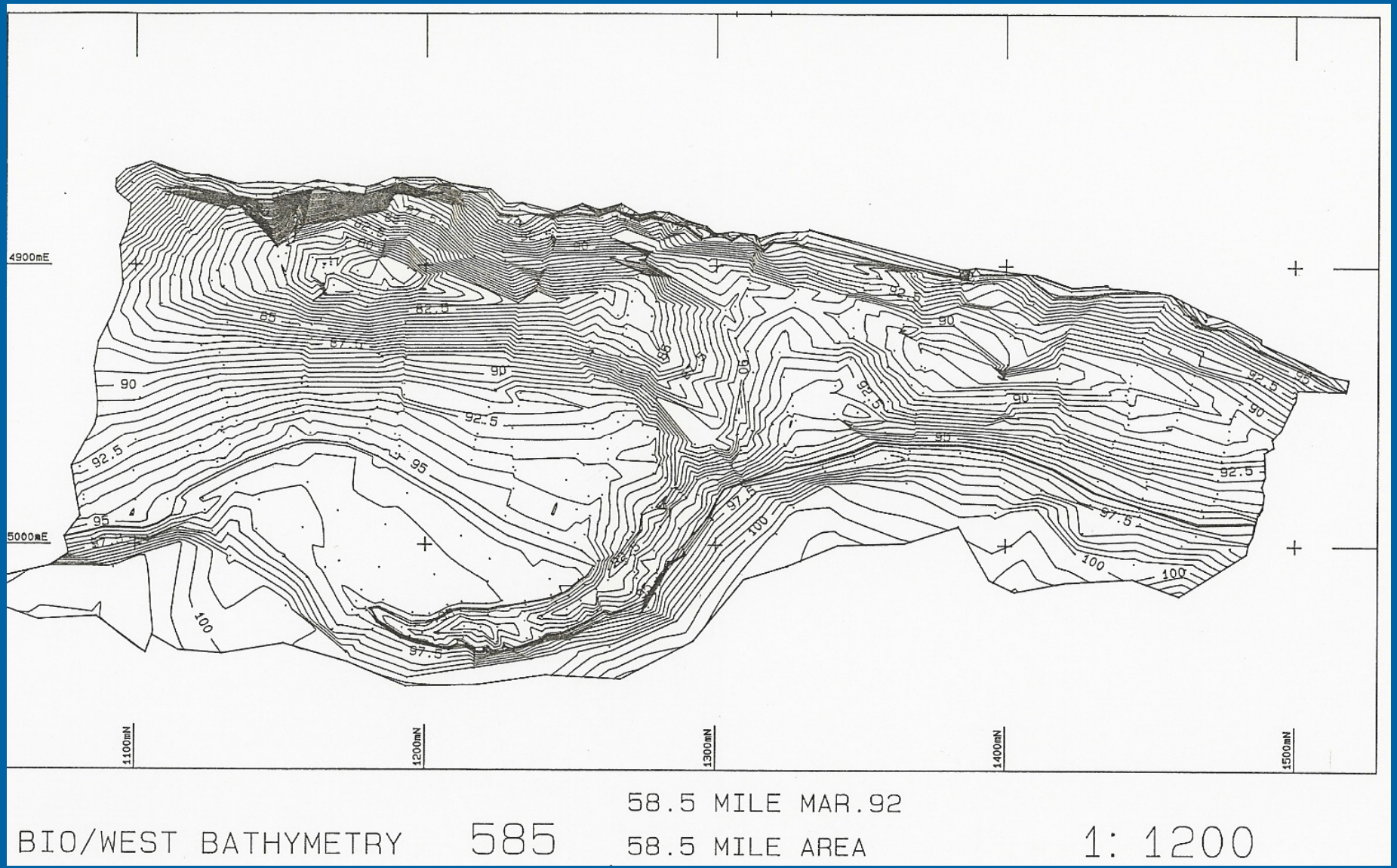
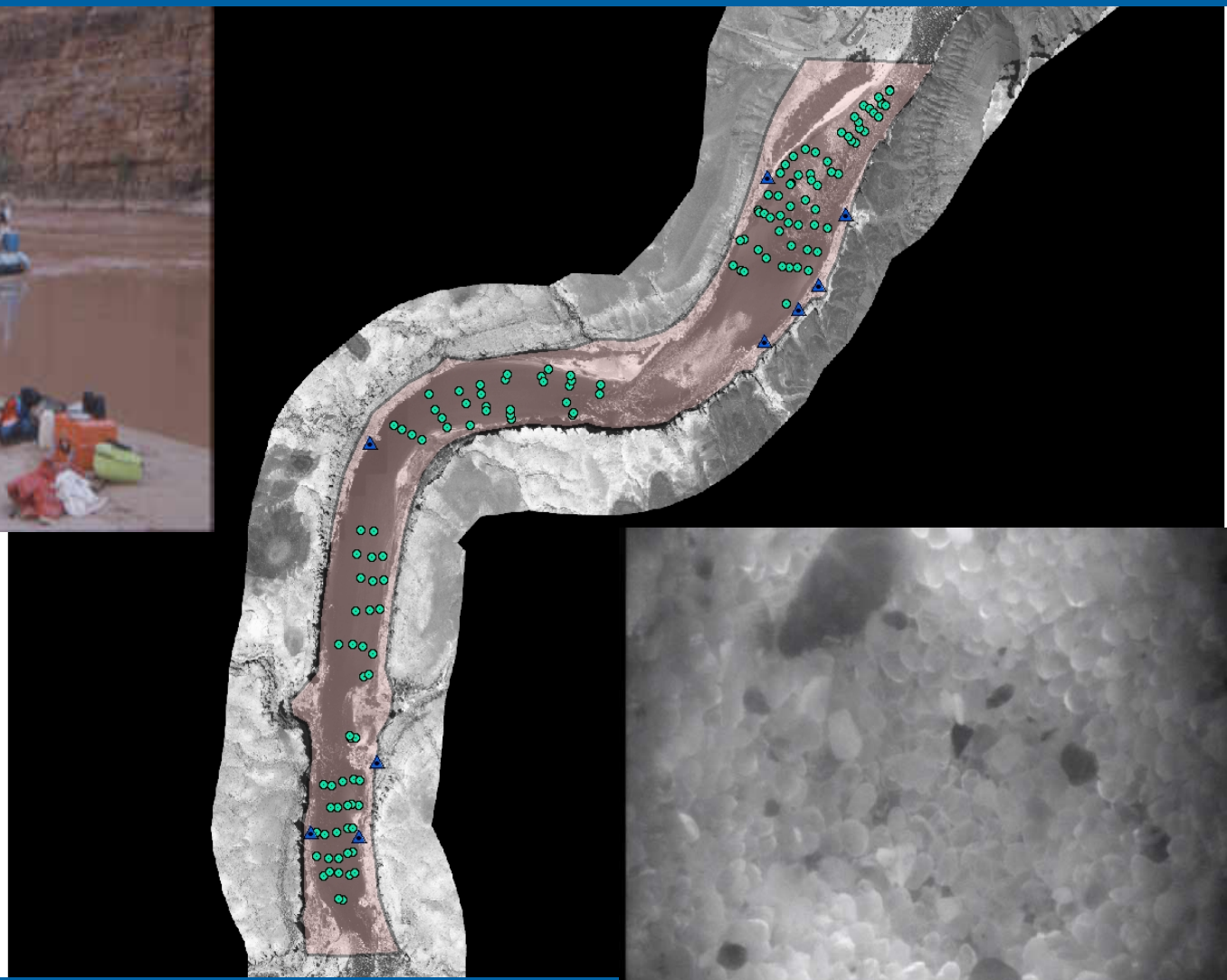
Bathymetric Map for Aquatic Habitat



Total Station positioning of Eyeball and Video Transects



FIST sediment studies

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Range Azimuth Surveys

Advantages:

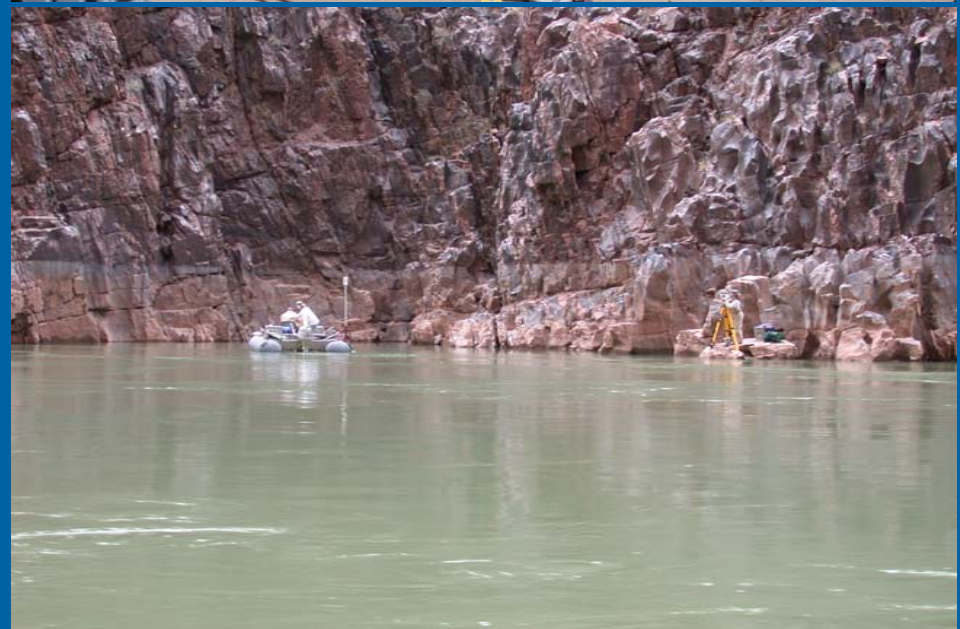
- **Continuous dynamic positioning.**
- **Depths and positions are correlated in real-time.**
- **Water surface elevation is measured from the ground survey control.**

Disadvantage:

- **Extreme operator fatigue.**

Range-Azimuth Tracking Instruments

Superhydro & Lasertrak



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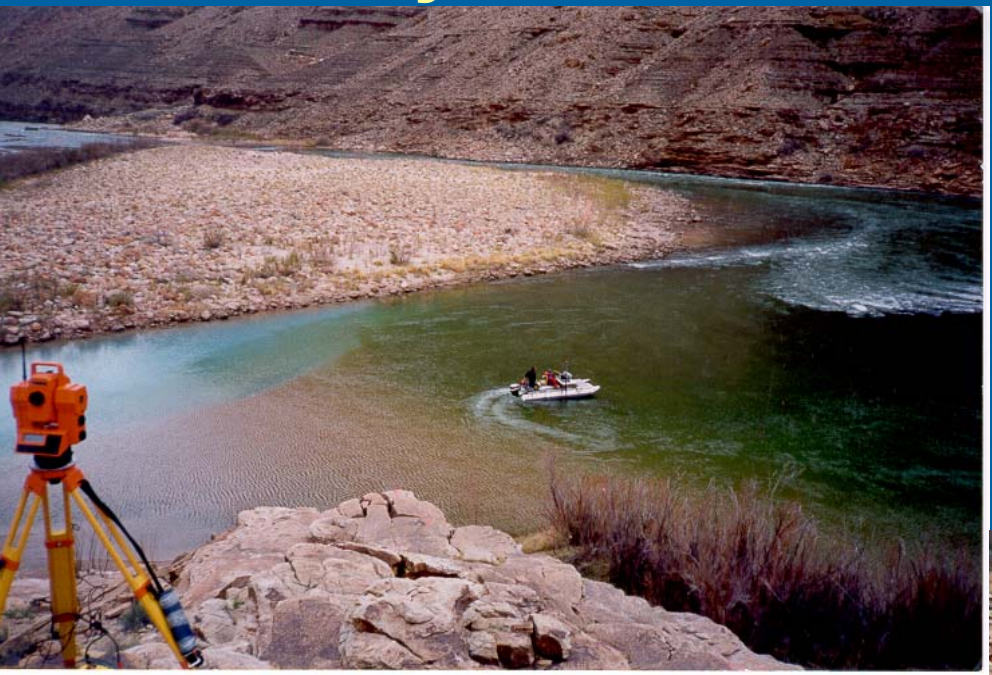
Robotic Tracking Surveys



Geodimeter ATS

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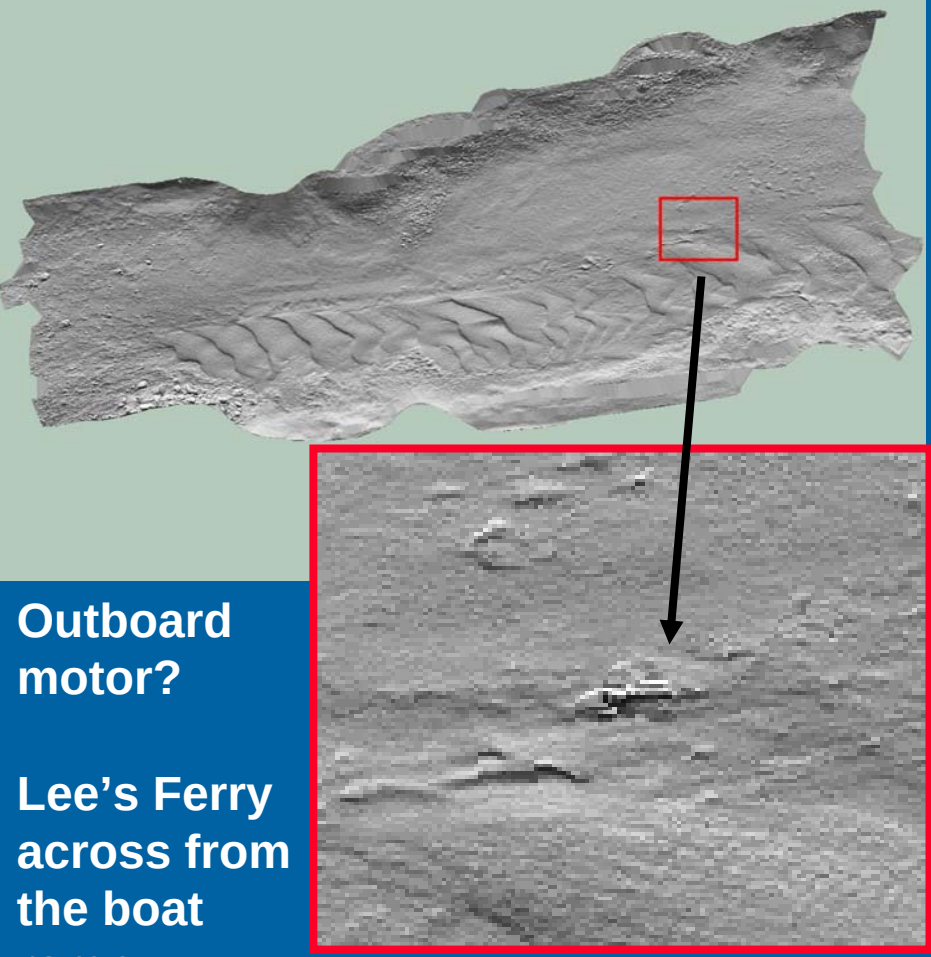
Advantages:

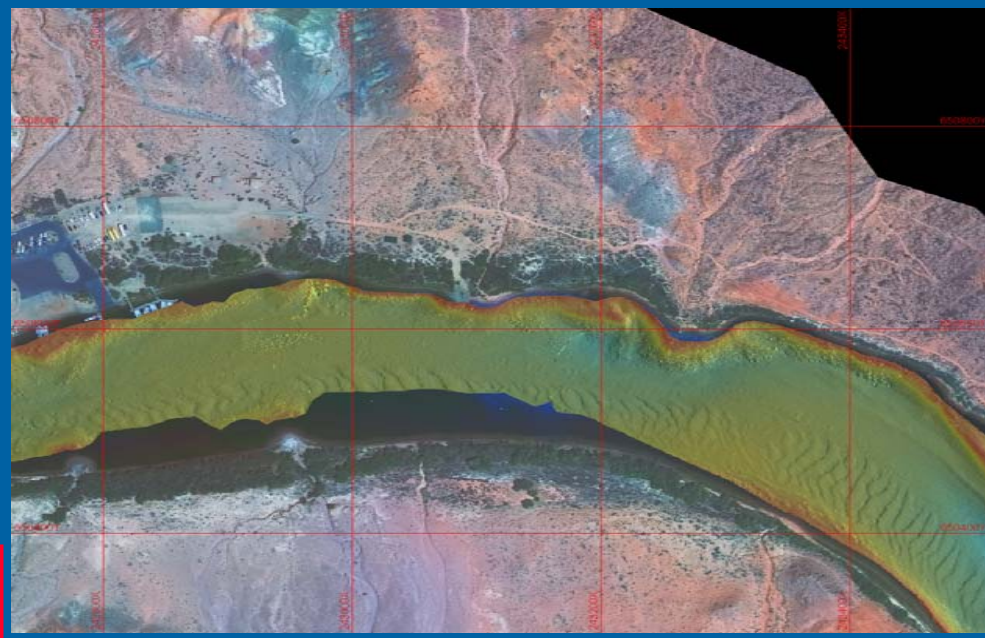
- **Centimeter accuracy xyz.**
- **High update rate.**
- **Radio link allows remote control from boat.**

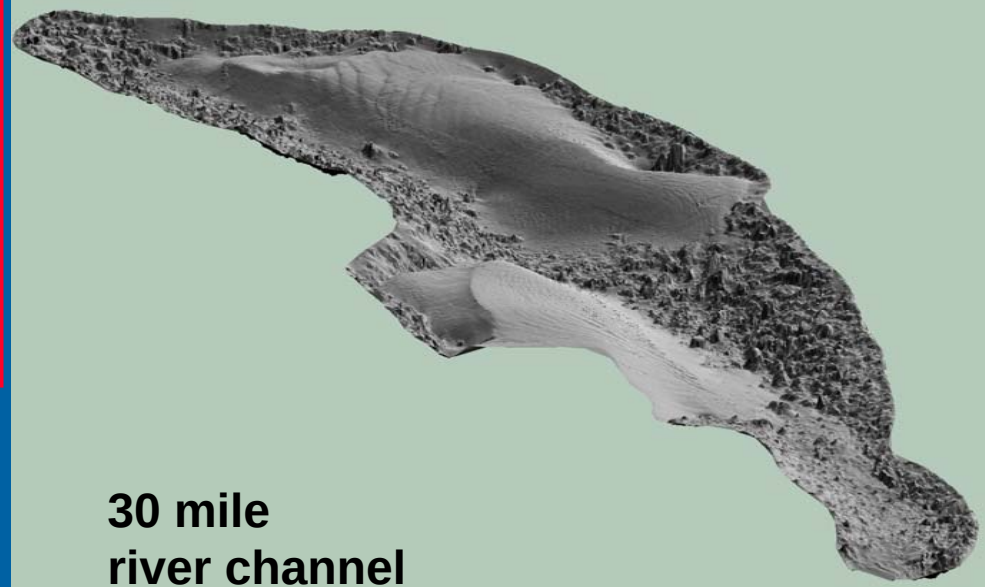
Disadvantage:

- **Boat is tied to limited range and visibility of the Geodimeter.**

Robotic Tracking Technology facilitates high resolution sensors like Multibeam and Side Scan Sonar







Outboard motor?

Lee's Ferry across from the boat ramp.

30 mile river channel

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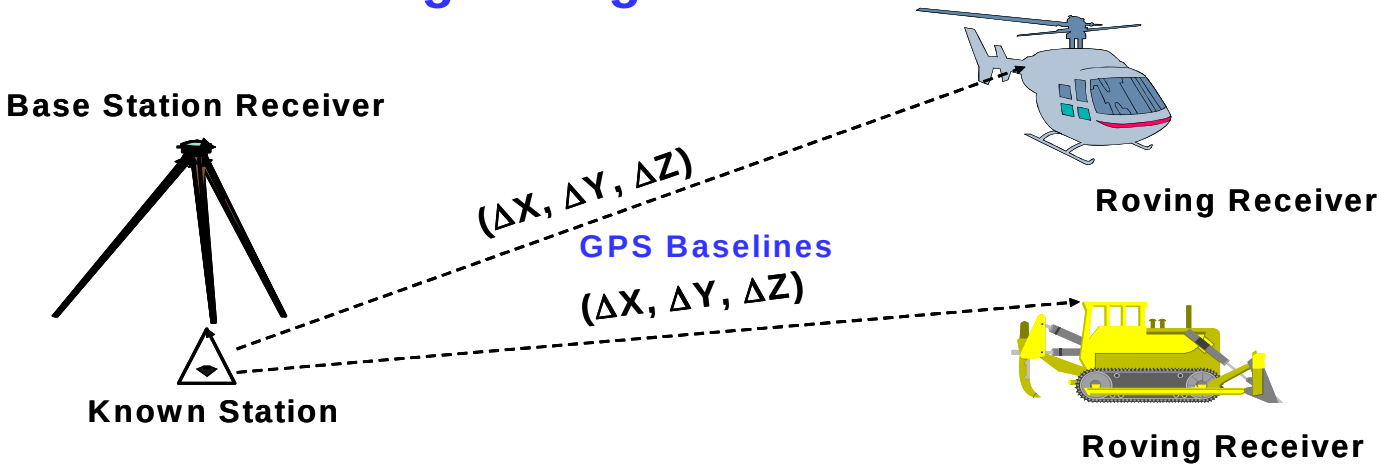
GPS Surveys (RTK) Real Time Kinematic

Real Time Kinematic (RTK) X-Y-Z Positioning using GPS Carrier Phase



- Based on 19 cm & 24 cm carrier phase observations.
- Accuracy at "centimeter-level" ... 1 to 5 cm typical.
- Positions determined with respect to the fixed (known) station.
- Redundant/multiple base stations ... eg, Trimble VRS
- On-the-Fly initialization & ambiguity resolution.
- Communication link: RF, cell phone, VRS
- Either real-time or post-mission processing possible.

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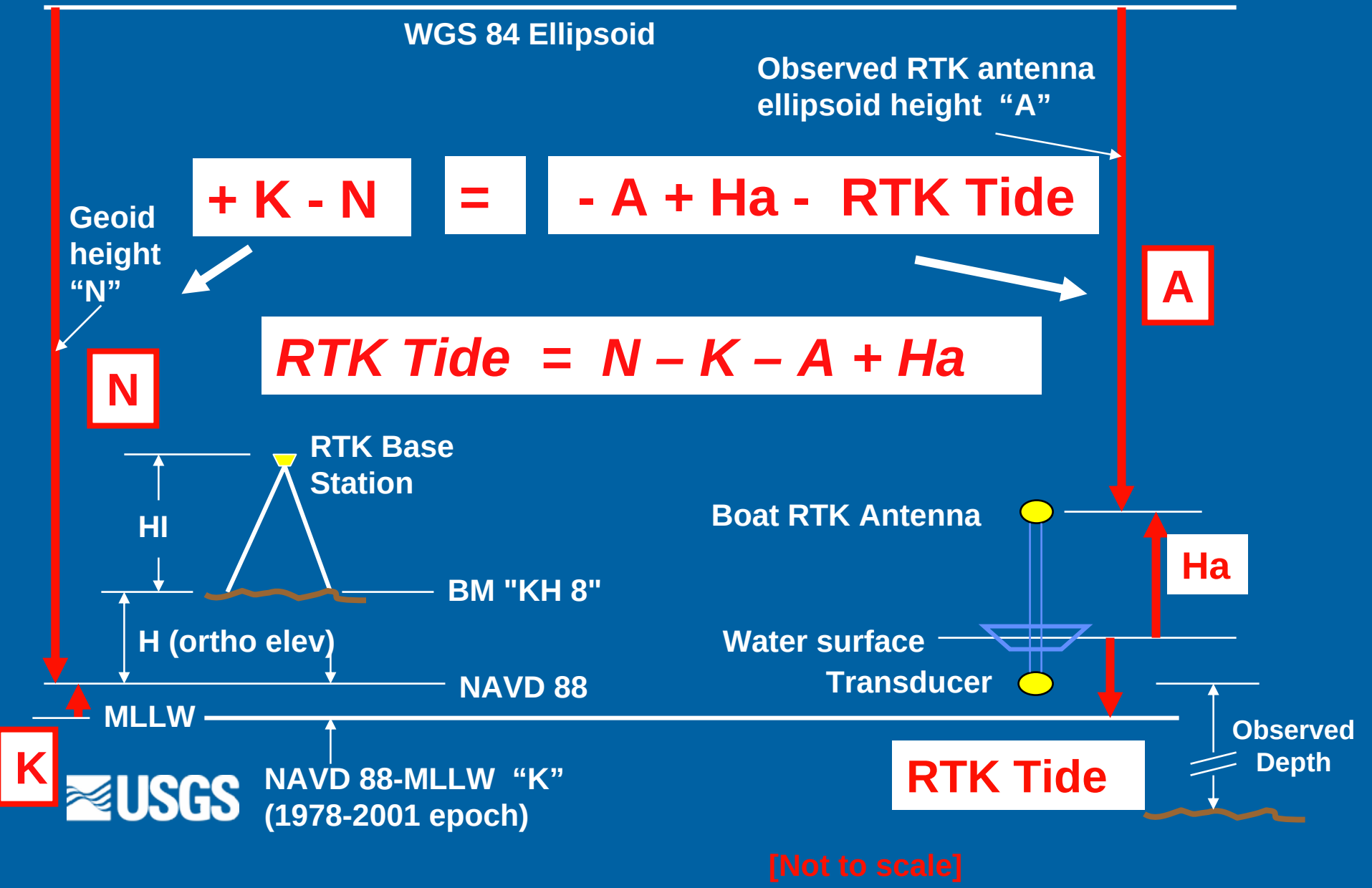
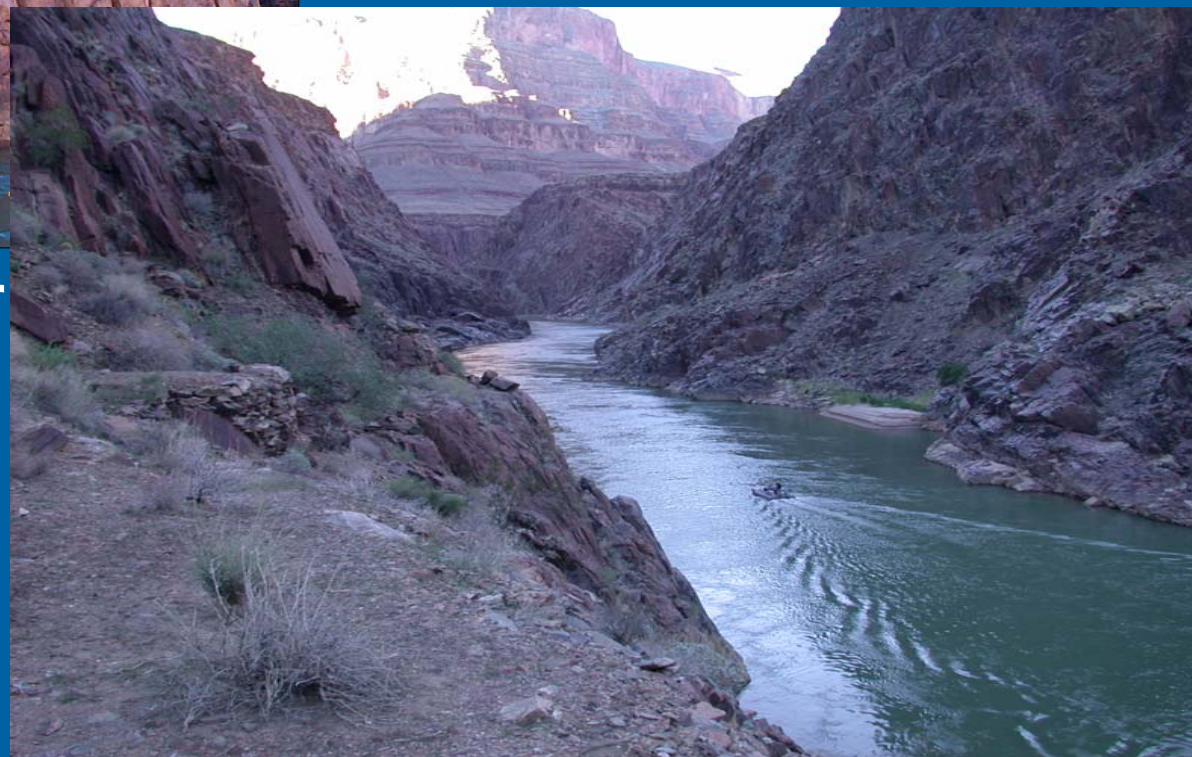
Understanding the Geometry of a RTK Tide & Depth Measurement



RTK GPS in the Canyon

Boat traverses cliff wall to cliff wall continuously acquiring different satellite constellations.



Base station and Rover must see the same five GPS satellites.

Problematic!

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Differential GPS (DGPS)

Omnistar DGPS receives differential corrections from a geosynchronous satellite. This technology produces .5 meter accuracy.

Unlike RTK, DGPS only requires 4 satellites.
Vertical accuracy still a problem!

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Omnistar DGPS Applications

- All types of hydrographic surveys: Cross-sections, Singlebeam, Multibeam, surveys that lack locally established control.
- Continuous long reaching hydrographic surveys such as the centerline trace.
- Terrestrial Surveys that do not require extreme vertical accuracy such as campsite surveys.
- Remote Sensing verification.

Topcon Hiper-Omnistar now offers a high accuracy version that is rated at 10cm positional accuracy. This version has not been evaluated.

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Centerline River profile

Omnistar DGPS was used to track positions of a singlebeam trace of the channel centerline.

Positions and depths were correlated with Hypack software.

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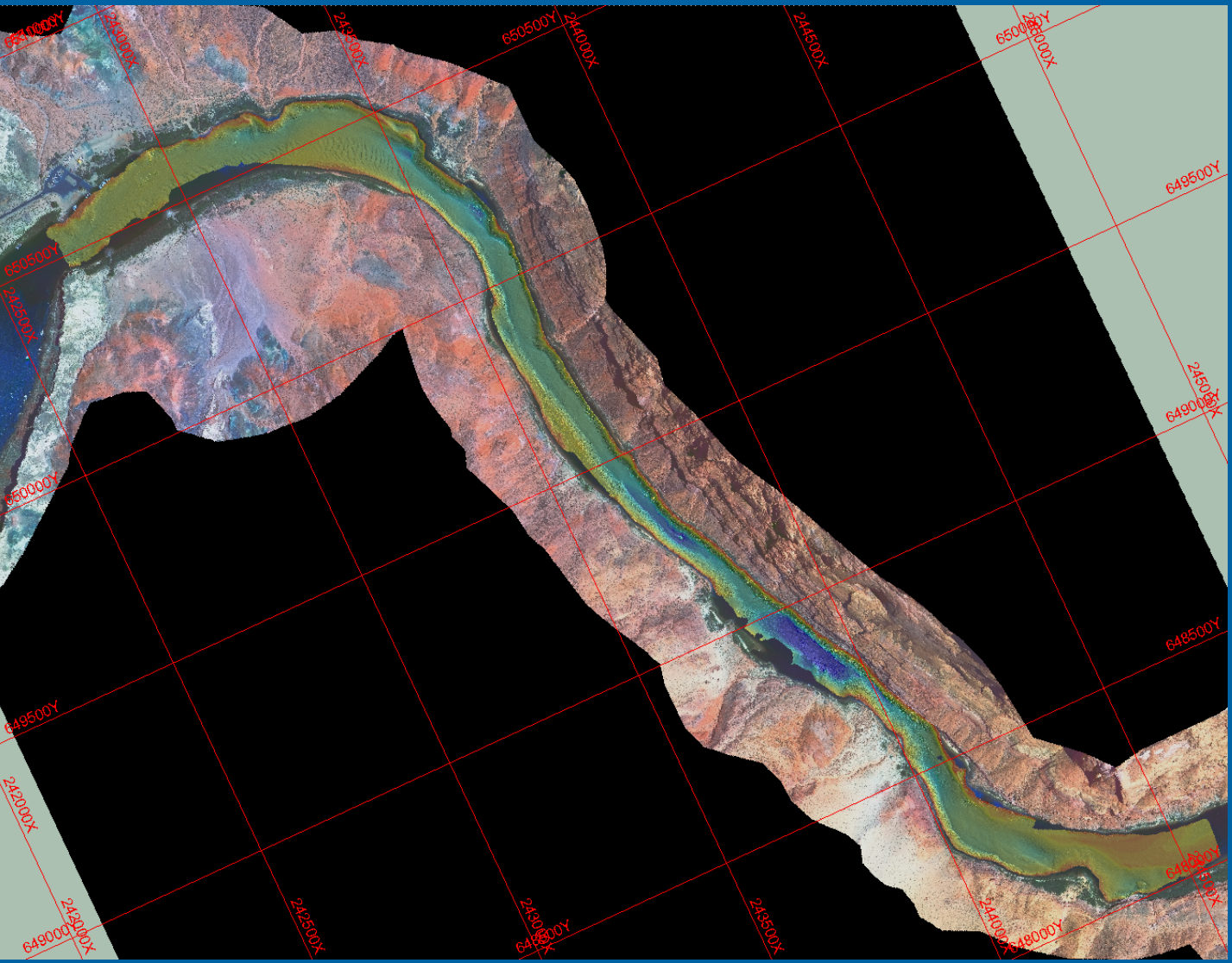
Multibeam Survey with Topcon Omnistar DGPS



Advantages:

- 2.4 miles of channel was mapped without multiple ground control set ups.
- Horizontal accuracies were typically better than 10 cm.

Disadvantage:

- An accurate water surface elevation was required to plug in as a Tide value.

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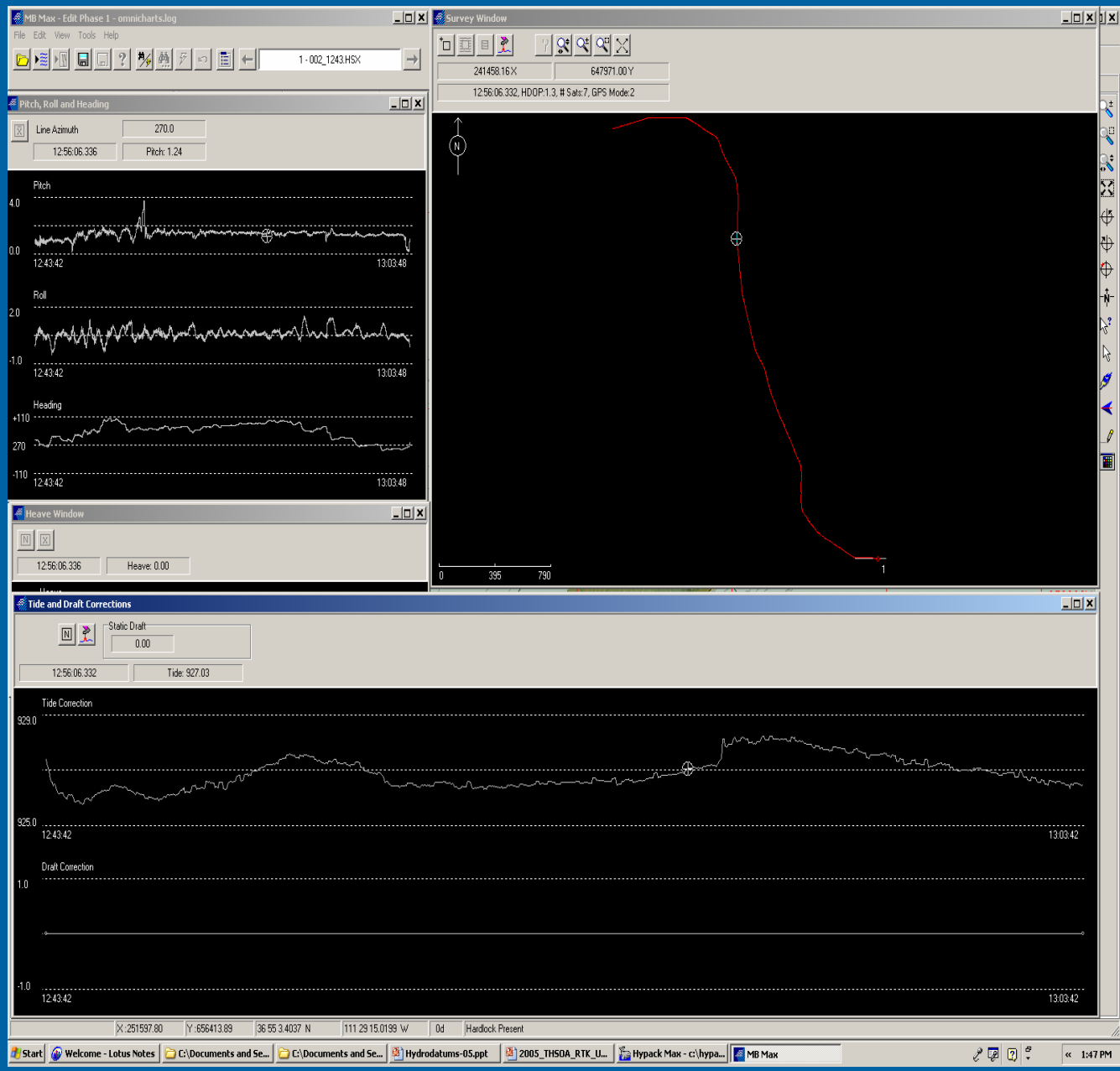
Omnistar water surface vs Geodimeter (in meters)

- Geodimeter surface at 927.65
- Omnistar lowest was 925.79
- Omnistar highest was 928.23
- Omnistar median was 927.02
- Standard deviation was 2.44 meters
- Omnistar average with 12,425 samples measured was 927.56



Conclusions

- Measuring the Water Surface Datum is extremely difficult without available Geodetic Control.
- Range Azimuth and Robotic Tracking systems are the best methods to measure water surface datum(s) from reliable control.
- RTK GPS can be effectively used in very specific environments with adequate satellite visibility.
- Omnistar DGPS shows promise if the vertical measurement can be statistically normalized and/or independently measured and verified.

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The End

Any Questions?

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