Using the Vermont CORS to Access the National Spatial Reference System

Webinar hosted by the Vermont Center for Geographic Information

Wednesday January 26, 2011

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VT State Advisor

What is VECTOR??

Vermont Enhanced CORS & Transmission Of Real-time data

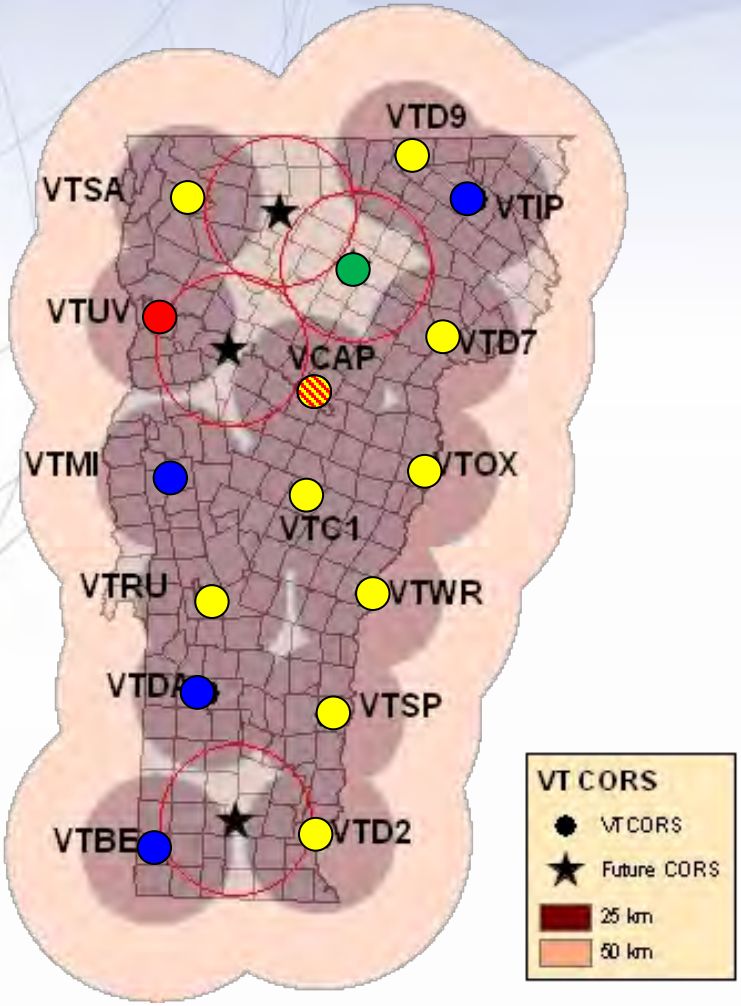
- Network of Continuously Operating GNSS Reference Stations.
- Provides access to the National Spatial Reference System (NSRS)
- Access available for post processing (Static) and Real-time (single base RTK).

VECTOR

Site Criteria

- 50 km spacing along Interstate
- Masonry building <= 2 story
- Secure location
- State owned
- Clear view to sky
- Stable/dedicated power source
- High speed internet connection
- Antenna location < 100 meters from receiver location

VECTOR Expansion



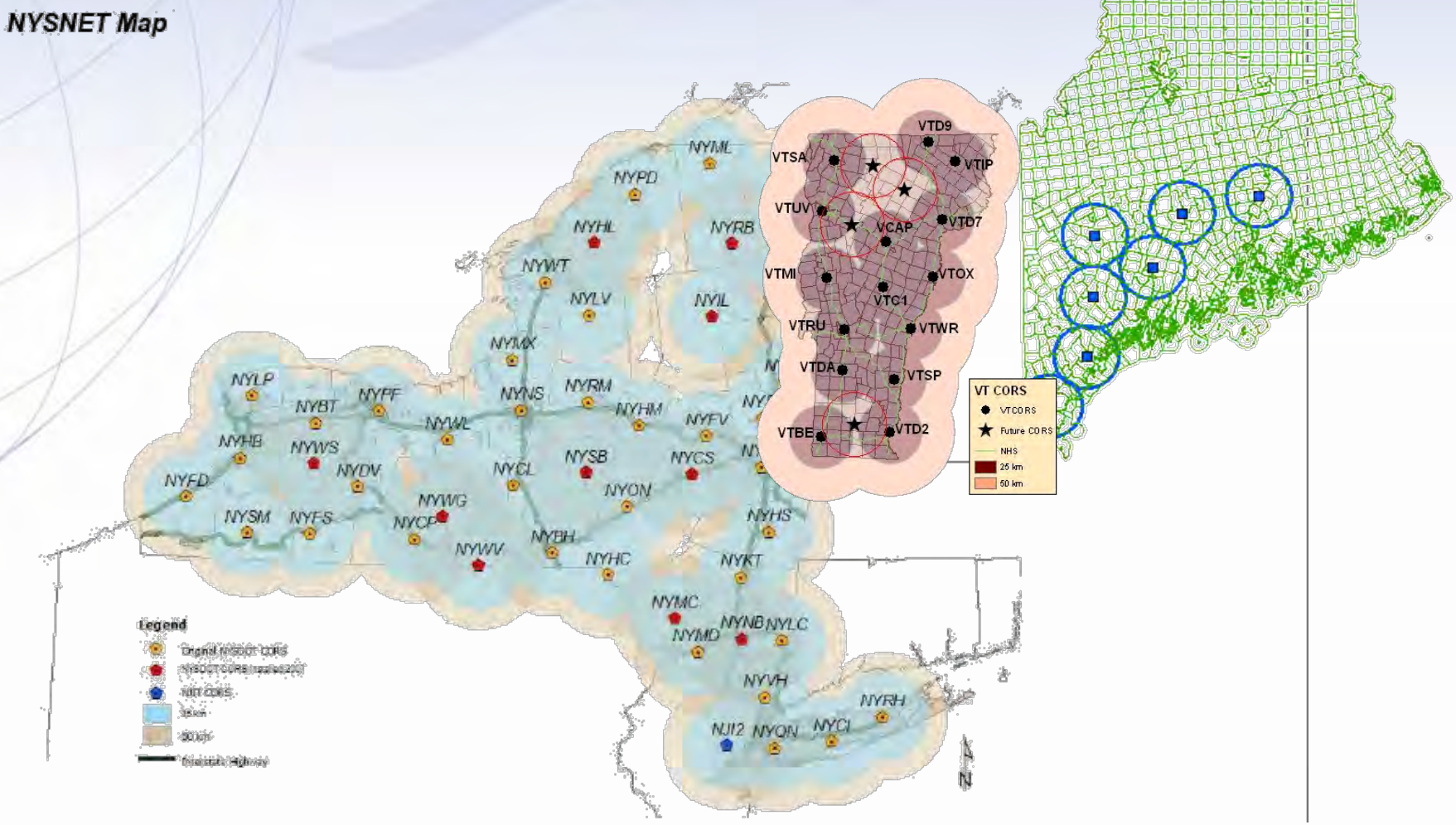
- 1996 - VCAP
- 2004 - VTUV
- 2006 – VTD2, VTSP, VTWR, VTOX, VTD7, VTD9, VTC1, VTSA, VTRU, (VCAP Upgrade)
- 2008 – VTBE, VTDA, VTMI, VTIP
- 2010 - VTHA

- Three stations will be added in 2011 to complete the network - Dover, Richmond, and Eden

Current Features and Capabilities

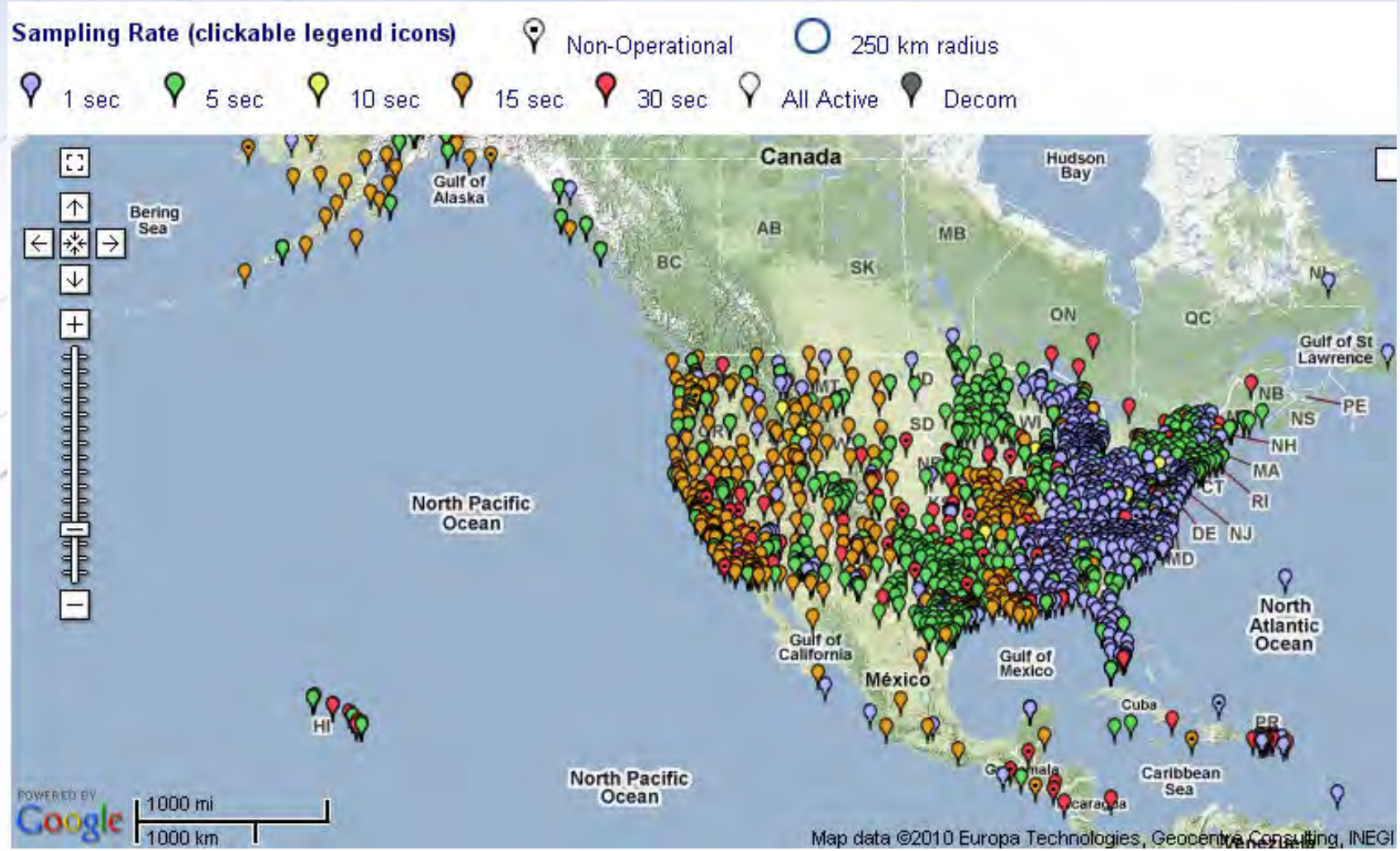
- Dual frequency GPS and GLONASS
  - All stations except VTRU and VTUV
- Ready to receive modernized signals
- 24-7-365 availability
- 1 and 15 second raw data for post-processing on-line for 45 days (VT server) (forever from NGS web)
- Single-based Real-time data
- Direct access to the NSRS

Real Time Networks

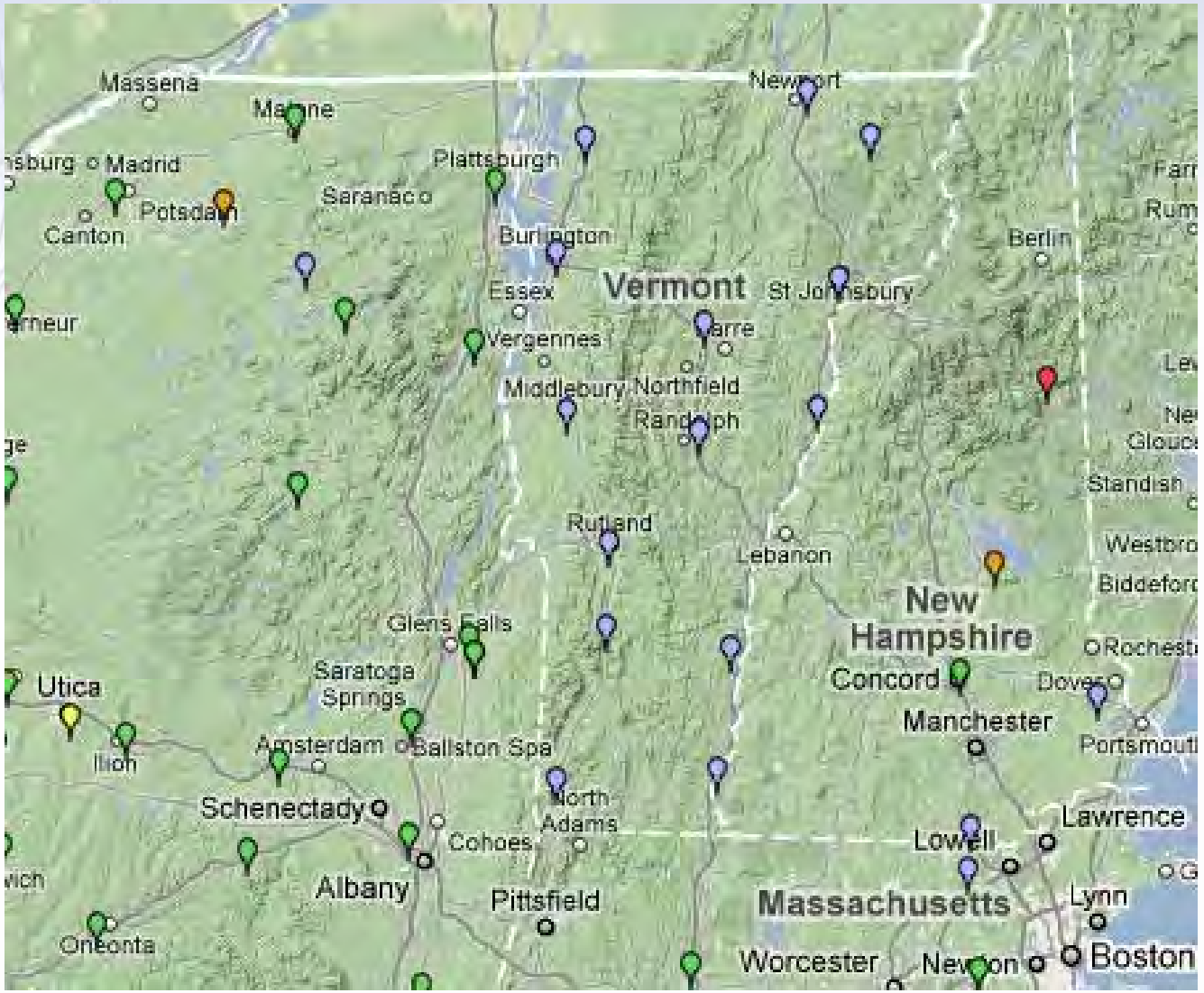


1599 National CORS

As of 01/07/11



National CORS in our Area



So What??

- What is the benefit to having these stations out there?
  - Are they being used?
  - How are they being used?
  - Who is using them?
  - How are they being accessed?
  - How much are they being accessed?

Developing a Continuously Operating GPS Reference Station (CORS) network in Vermont

2008 Network Status and Benefit Analysis

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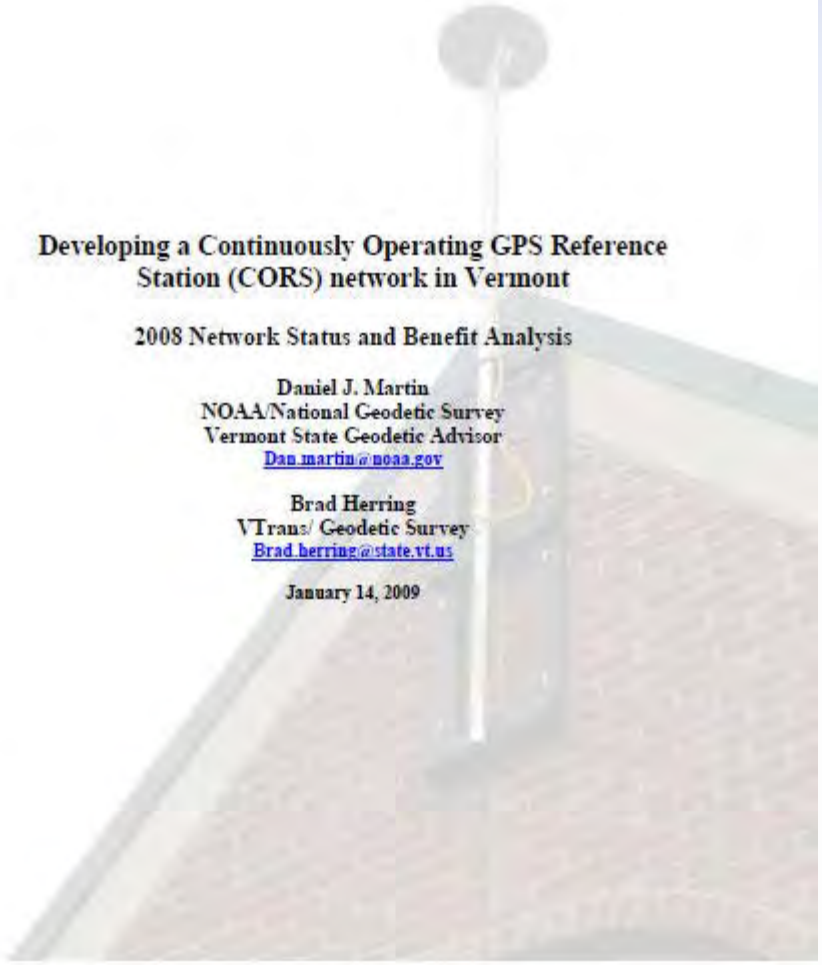
January 14, 2009



How are they being used?

- Highway Surveys
- Collection of inventory and resource data
  - Culvert inventory, Rest Area re-design, and ITS elements such as RWIS, PCMS/VMS, and WIMS location and planning
- Control surveys for photography and LiDAR
- Topo
- Boundary
- Flood Plane mapping
- Wetland Surveys
- Precision Agriculture
- Construction stakeout
- Geodetic and Geophysical applications
  - Ionospheric modeling
  - Plate tectonics
  - Precipitable Water Vapor modeling (weather forecasting)

Who is using them

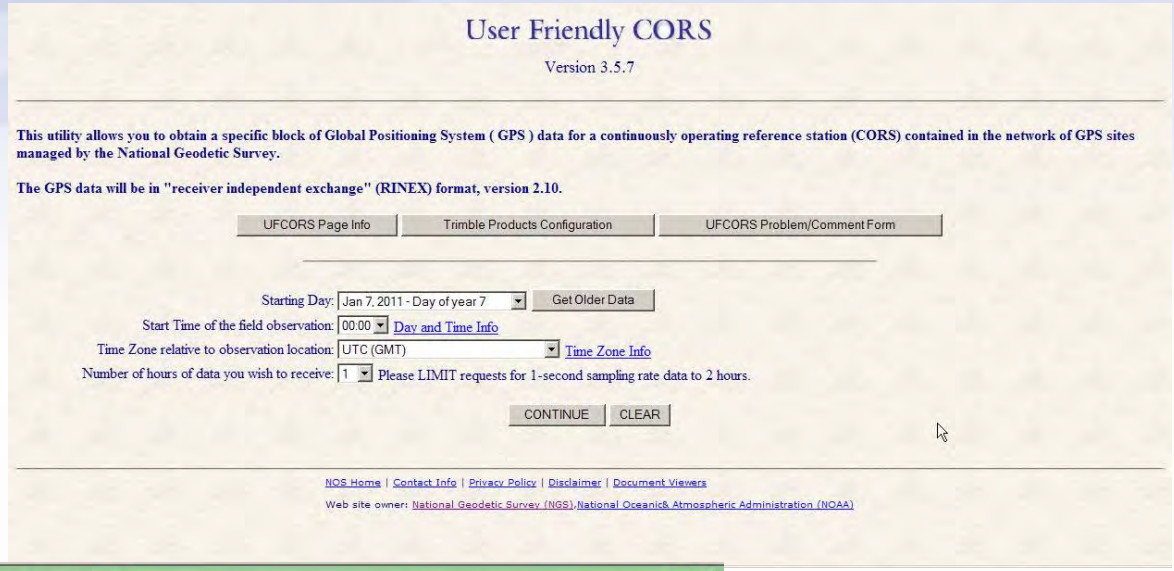
- VTrans
- Land Surveyors
- Engineering firms
- GIS Professionals
- Foresters
- Other State Agencies Such as Agency of Natural Resources and Department of Agriculture
- Other non-VT State Agencies

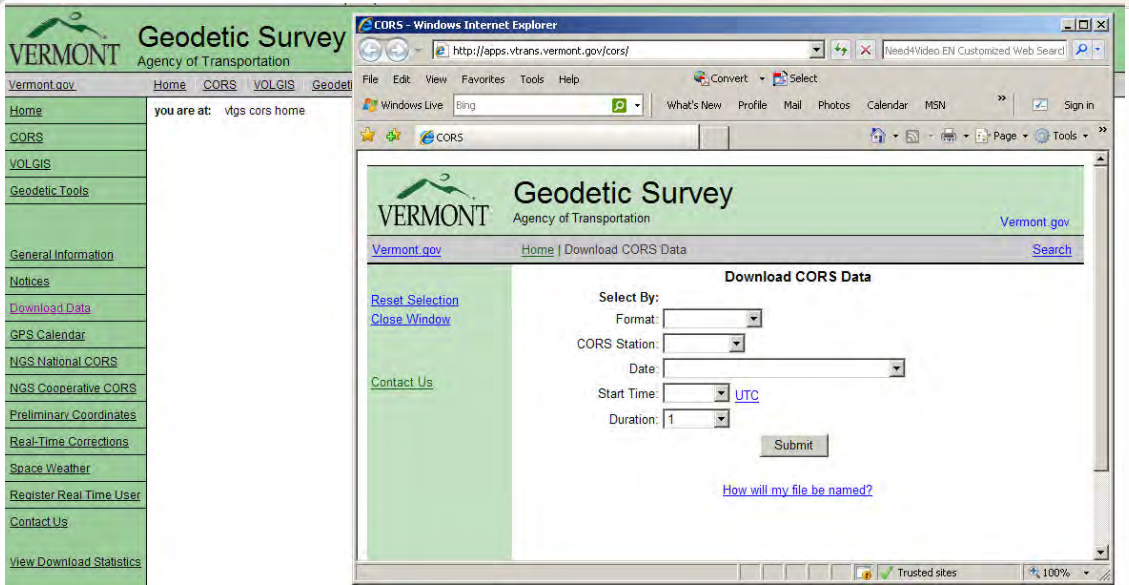
- Federal and International Agencies and educational institutions
  - National Weather Service
  - National Geodetic Survey
  - US Geological Survey
  - Geodetic Survey Canada
  - International GNSS Service
  - UVM, UNH, UMaine, Lyndon and Johnson State, Norwich University

How are the VT CORS being Accessed?

- Raw Data (post processing)
  - VTGS Web
  - VTGS and NGS FTP
  - NGS Web (UFCORS)
- Derived Products
  - OPUS_S
  - OPUS_RS
  - OPUS_DB
  - RTK Corrections
- Incorporated into other networks (NYSNet, Keynet, Bunce)

Raw Data (NGS and VT)





Derived Product

OPUS: Online Positioning User Service

upload | view | about

compute an accurate position for your GPS data file

1. enter your email address

2. attach your DATA file of GPS obs, dual-freq.(L1/L2) only
   Browse...

3. select your antenna type
   NONE no antenna selected - see FAQ #6

4. add your antenna height
   0.0 meters

5a. customize your solution, report, and publishing options
   OPTIONS

-or-

5b. choose a processor
   Upload to RAPID-STATIC for data > 15 min. < 2 hrs.

   Upload to STATIC for data > 2 hrs. < 48 hrs.

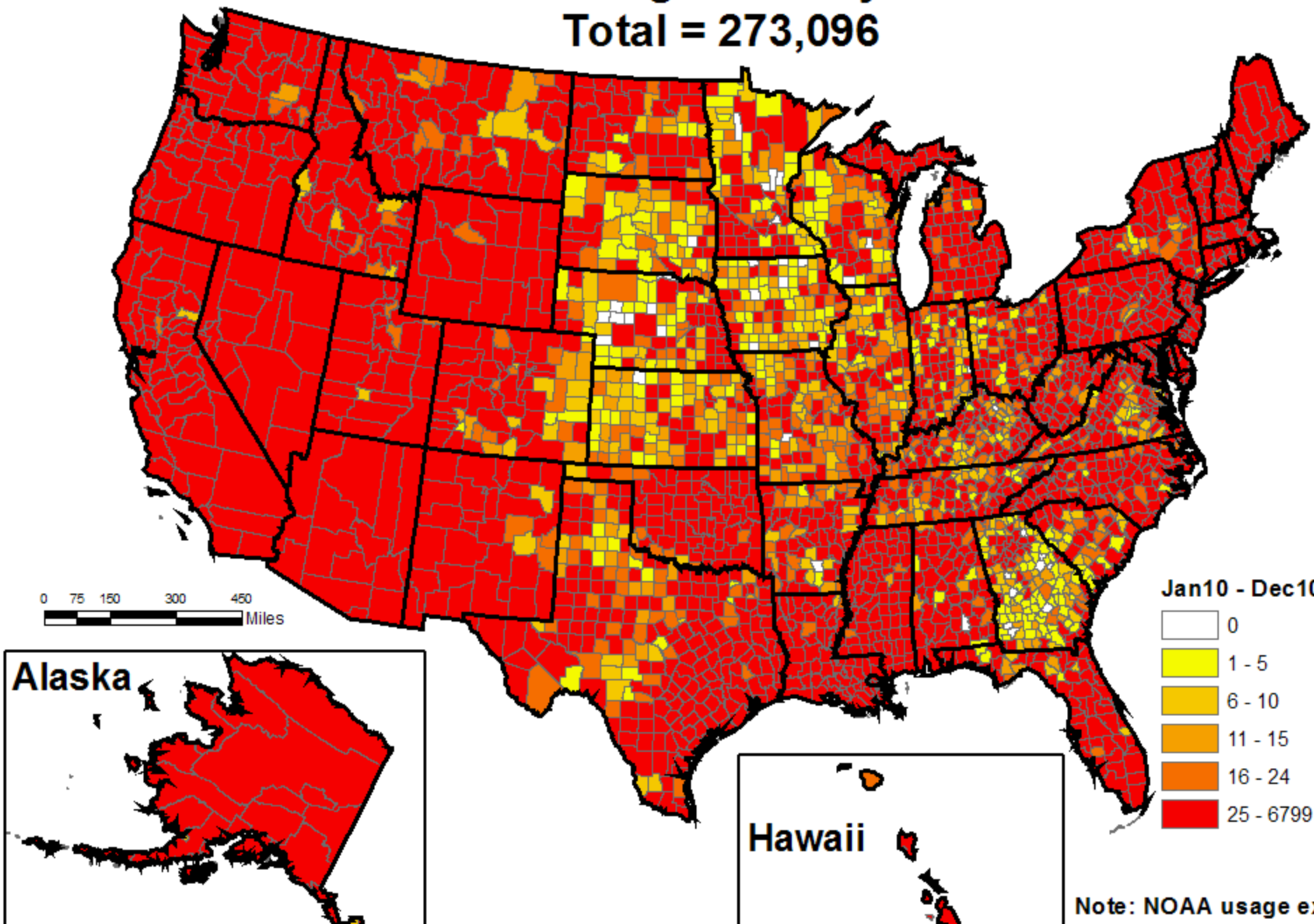
Your data may be retained for internal evaluations of OPUS use, accuracy, enhancements, or related research

OPUS-S & OPUS-RS

- OPUS-S
  - Minimum of 2 hours of data max of 48 hours
  - Process against 3 National CORS
  - Solution is average of three processed vectors
  - Results returned in minutes via e-mail
- OPUS-RS
  - Minimum of 15 minutes of data max of 2 hours
  - Processes against up to 9 National CORS
  - Solution is least squares adjustment of all vectors
  - Results returned in minutes via e-mail

OPUS-S and OPUS-RS Usage January 2010 - December 20

Total = 273,096



OPUS-RS Accuracy and Availability

Version: 0.82

HELP:

ABOUT THIS MAP

OPTIONS:

Choose Map:

NS or EW 15-min Data

CORS Sites:

Show Hide

Predicted Accuracy:

Latitude :

Longitude:

Retrieve Accuracy

Overlay Opacity:

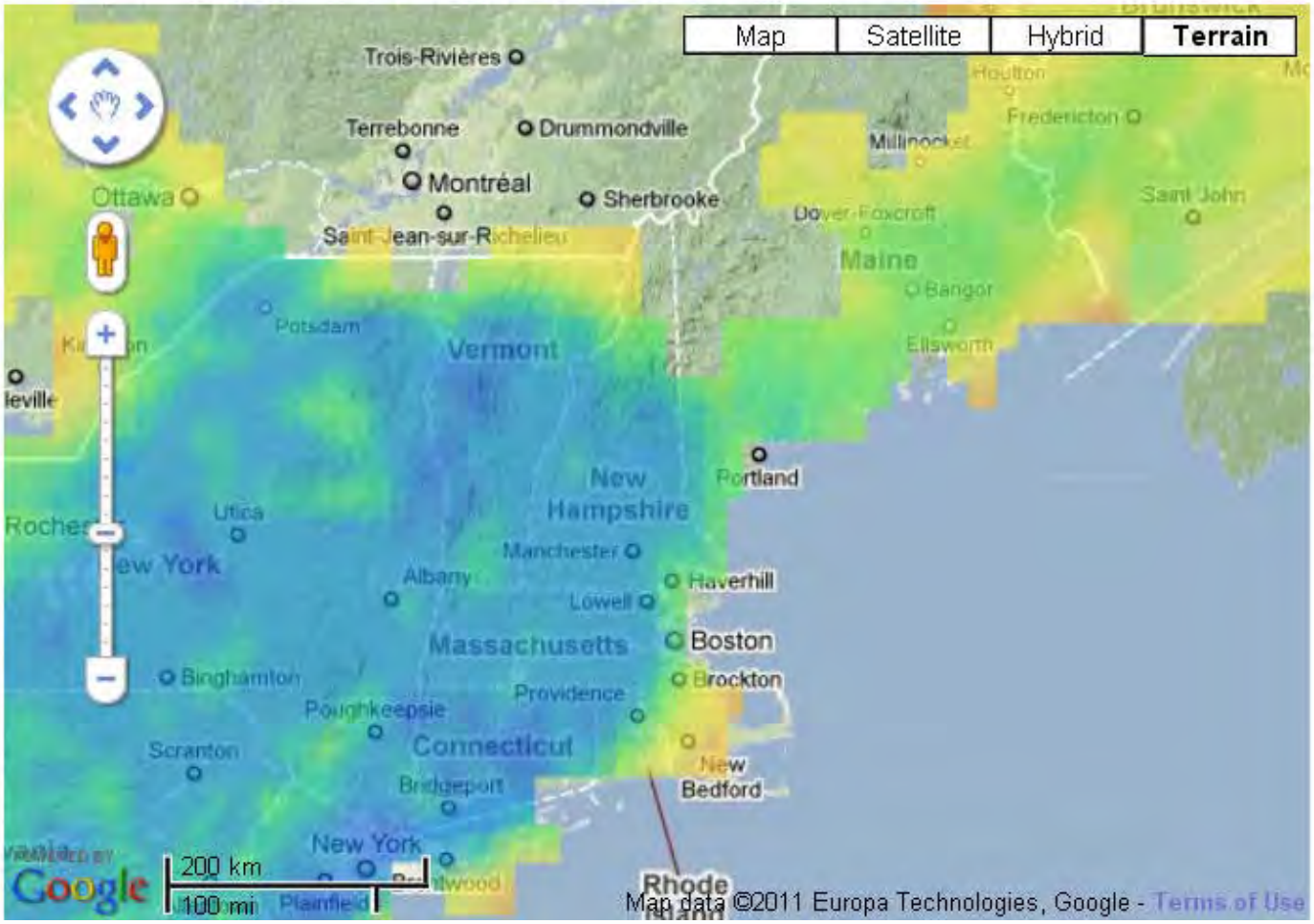
60%

LEGEND:

Horizontal Standard Error (cm)

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+

Data as of Jan 10 2011



HELP:

ABOUT THIS MAP

OPUS-RS Accuracy and Availability

Version: 0.82

OPTIONS:

Choose Map:

NS or EW 1-hour Data

CORS Sites:

Show Hide

Predicted Accuracy:

Latitude :

Longitude:

Retrieve Accuracy

Overlay Opacity:

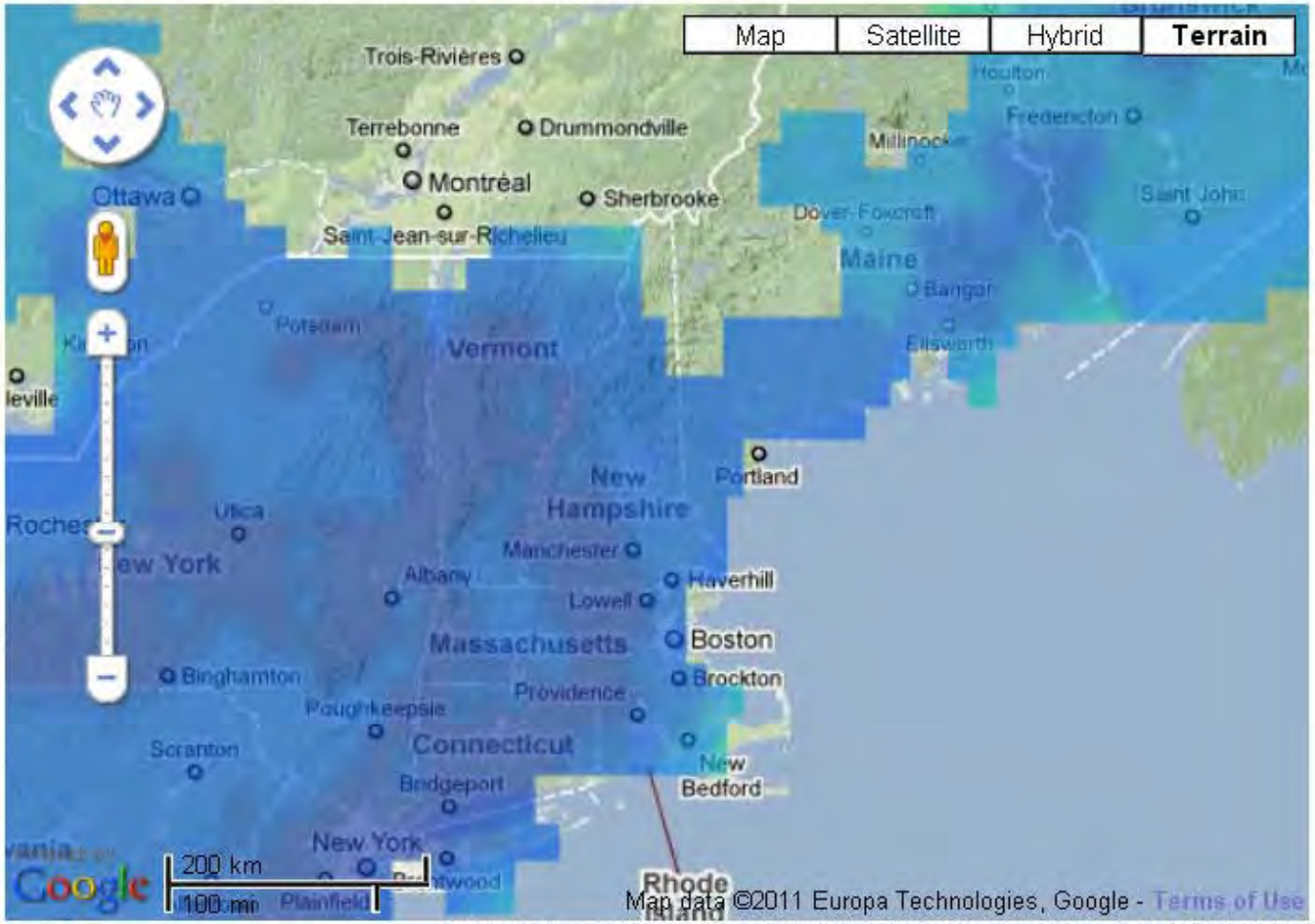
60%

LEGEND:

Horizontal Standard Error (cm)

0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0+

Data as of Jan 10 2011



Website Owner: National Geodetic Survey / Last modified by Kevin Choi May 17 2010

Publish/Share your Data

PID: BBBV27
Designation: VERMONT POPULATION CENTER
Stamping: NO STAMPING
Stability: Monument will probably hold position well
Setting: Unspecified setting
Description: WARREN, VT. OWNERSHIP, WAYNE KAHAN, 795 SENOR ROAD, WARREN, VT 05674.
THE MARK IS SET APPROXIMATELY 0.44 MI NORTHEAST OF THE TRUE LOCATION OF THE VERMONT 2000 CENSUS POPULATION CENTER ON PRICKLY MOUNTAIN.
IT IS A 20 CM DIAMETER, CENTER OF POPULATION DISK SET IN THE TOP OF A 30 CM SQUARE GRANITE POST. IT IS 12.0 M SOUTH-SOUTHWEST OF AND ABOUT 0.3 M HIGHER THAN THE CENTERLINE OF FULLER HILL ROAD, 29.3 M WEST-NORTHWEST OF POLE NO 28, AND 2.9 M SOUTH-SOUTHWEST OF AN HISTORIC PRESERVATION SIGN.
Observed: 2010-03-24T13:14:00Z
Source: OPUS - page5 0909.0S

Close-up View

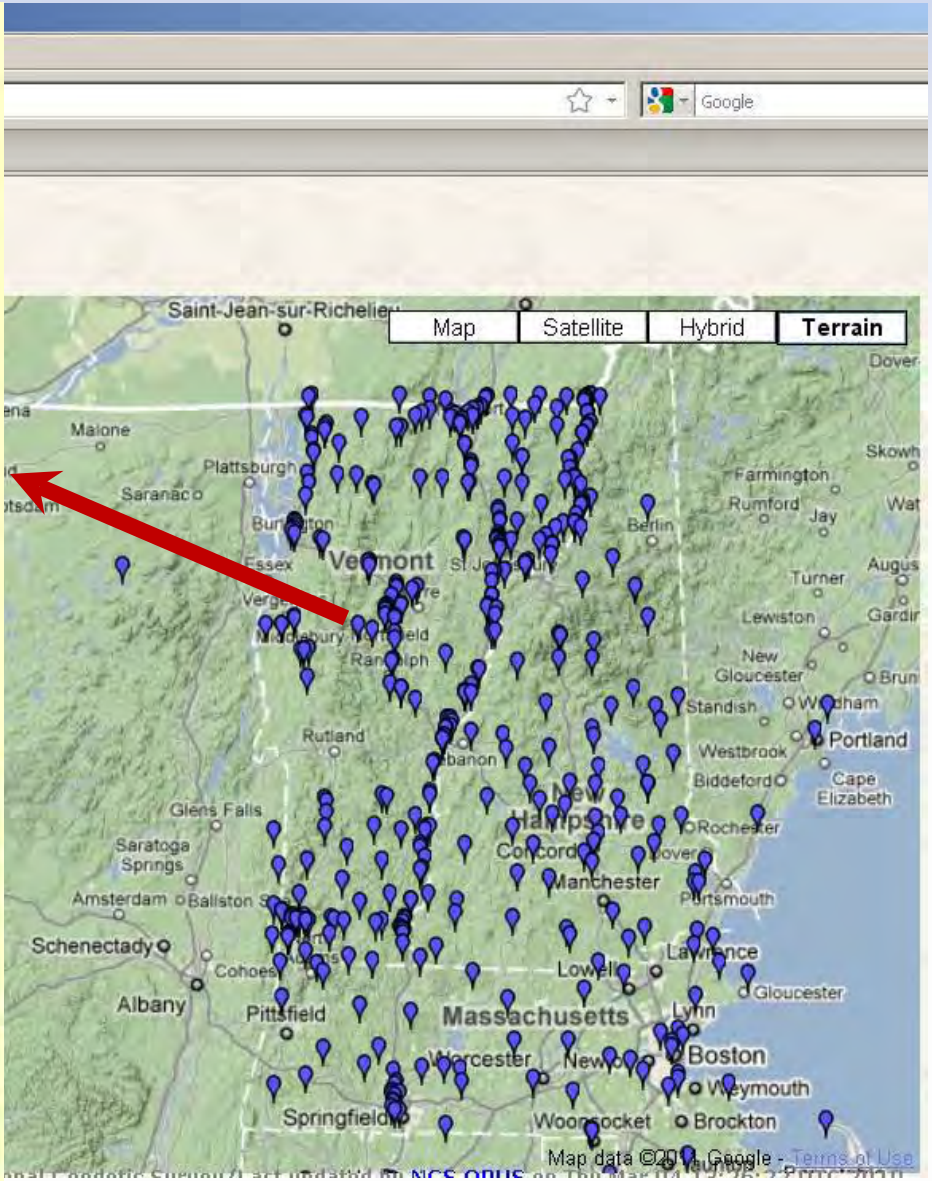
SRF FRAME: NAD_83(CORS96)	EPOCH: 2002.0000	SOURCE: NAVD88 (Computed using GEOID09)	UNITS: m	SET PROFILE	DETAIL

LAT:	44° 5' 21.19440"	± 0.005 m
LON:	-72° 49' 13.80495"	± 0.008 m
ELL HT:	399.777	± 0.014 m
X:	1355397.570	± 0.009 m
Y:	-4384134.772	± 0.013 m
Z:	4415495.685	± 0.008 m
ORTHO HT:	427.144	± 0.020 m

	UTM 18	SPC 4400(VT)
NORTHING:	4884092.055m	174403.710m
EASTING:	474478.699m	474333.270m
CONVERGENCE:	1.51482784°	-0.22299892°
POINT SCALE:	0.99997442	0.99997238
COMBINED FACTOR:	0.99991174	0.99990970

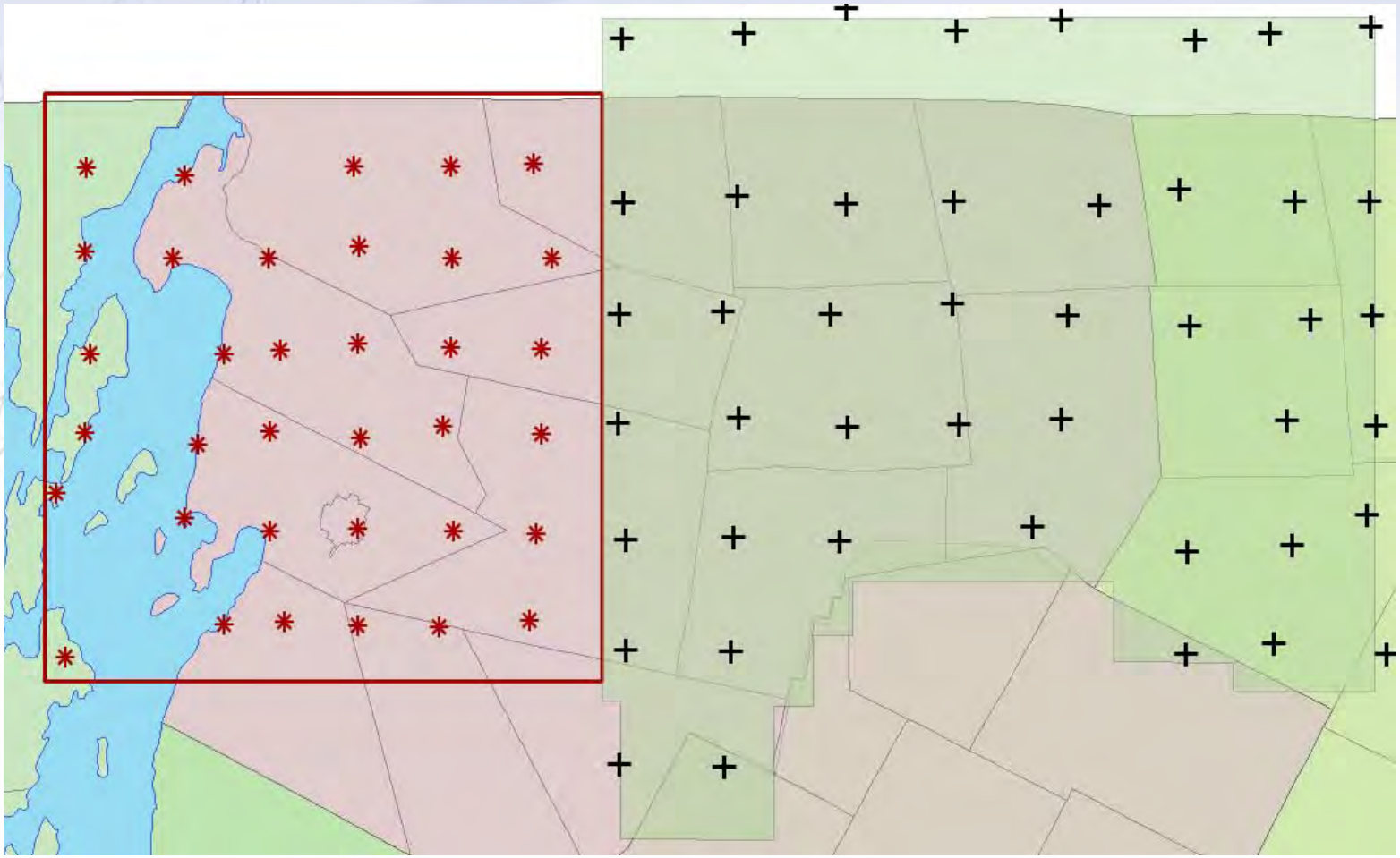
CONTRIBUTED BY
michael avery
Vermont Geodetic Survey

Horizon View



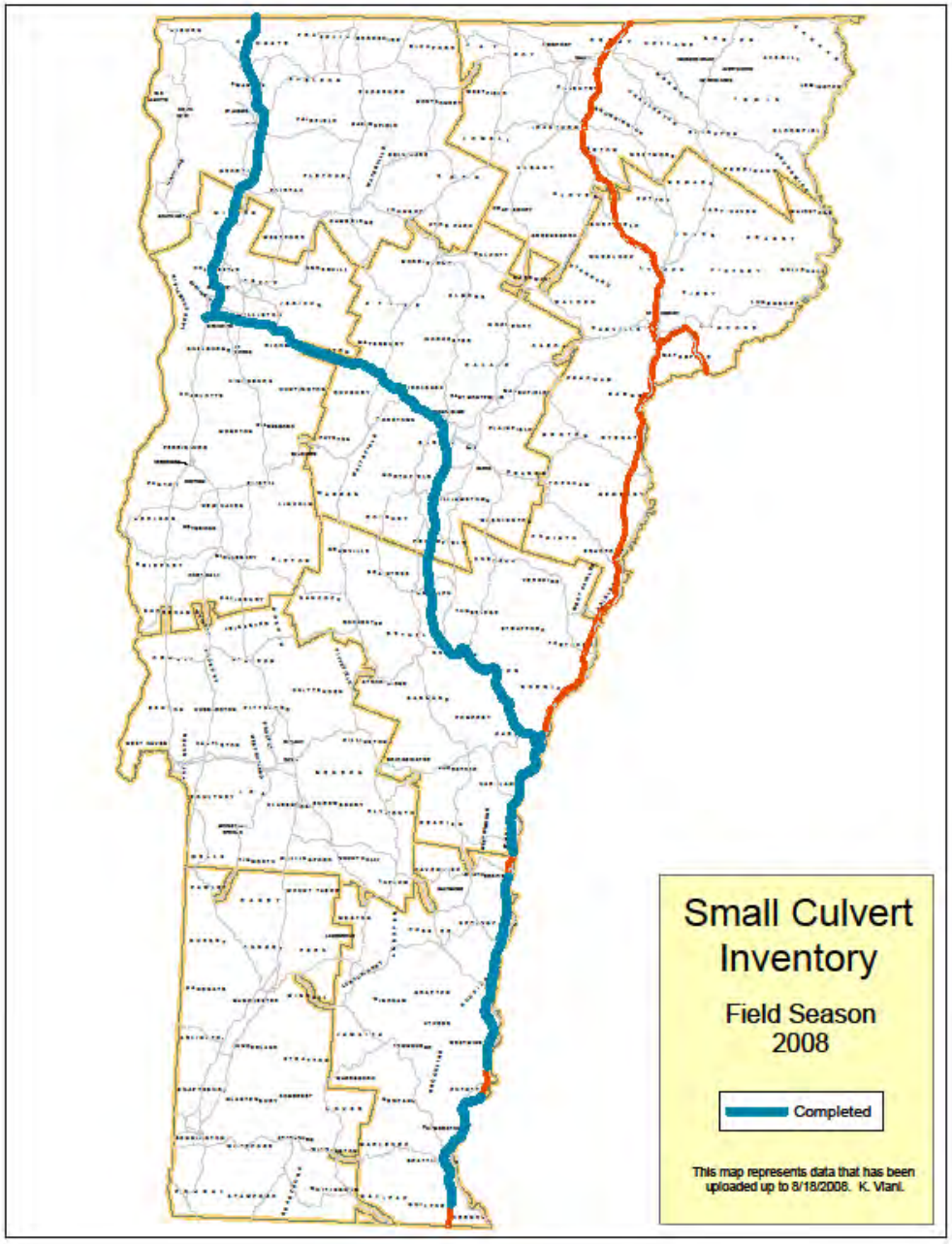
Derived Product (RTK)

2009-2010 LiDAR QA

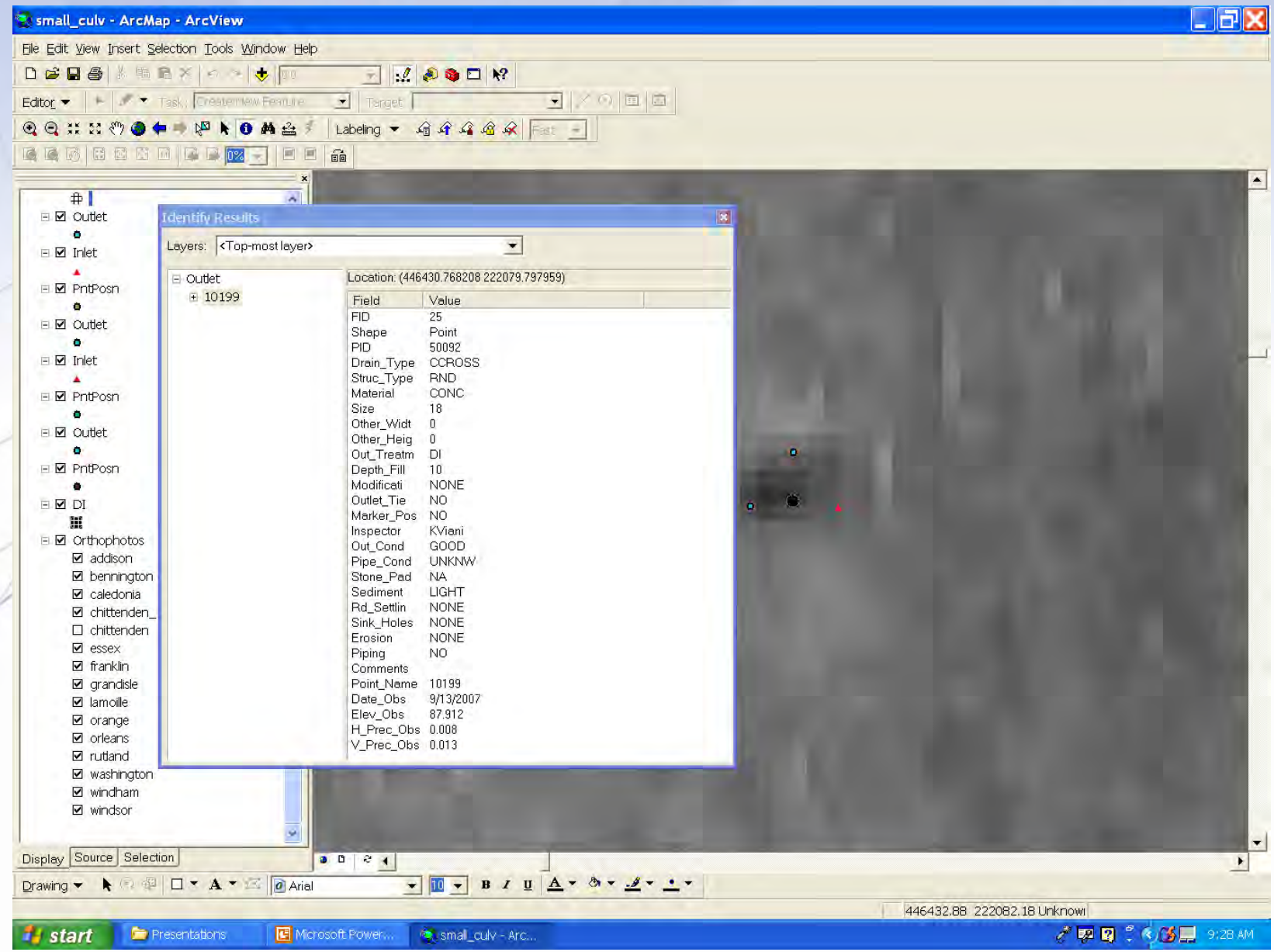


Interstate Small Culvert Inventory 2007-2008

- I89
  - ≈4000 Culverts
  - ≈2800 DI's
  - ≈10,800 Total Shots
- I91 (first 95 miles)
  - ≈2700 Culverts
  - ???? DI's
  - ≈5400 Total Shots+DI's
- 59 crew weeks
  - ≈ $60k savings



Small Culvert Inventory


small_culv - ArcMap - ArcView
File Edit View Insert Selection Tools Window Help
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essex
franklin
grandisle
lamoille
orange
orleans
rutland
washington
windham
windsor
Display
Source
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Identify Results
Layers: <Top-most layer>
Outlet
10199
Location: (446430.768208 222079.797959)
Field Value
FID 25
Shape Point
PID 50092
Drain_Type CCROSS
Struc_Type RND
Material CONC
Size 18
Other_Widt 0
Other_Heig 0
Out_Treatm DI
Depth_Fill 10
Modificati NONE
Outlet_Tie NO
Marker_Pos NO
Inspector KViani
Out_Cond GOOD
Pipe_Cond UNKNW
Stone_Pad NA
Sediment LIGHT
Rd_Settlin NONE
Sink_Holes NONE
Erosion NONE
Piping NO
Comments
Point_Name 10199
Date_Obs 9/13/2007
Elev_Obs 87.912
H_Prec_Obs 0.008
V_Prec_Obs 0.013
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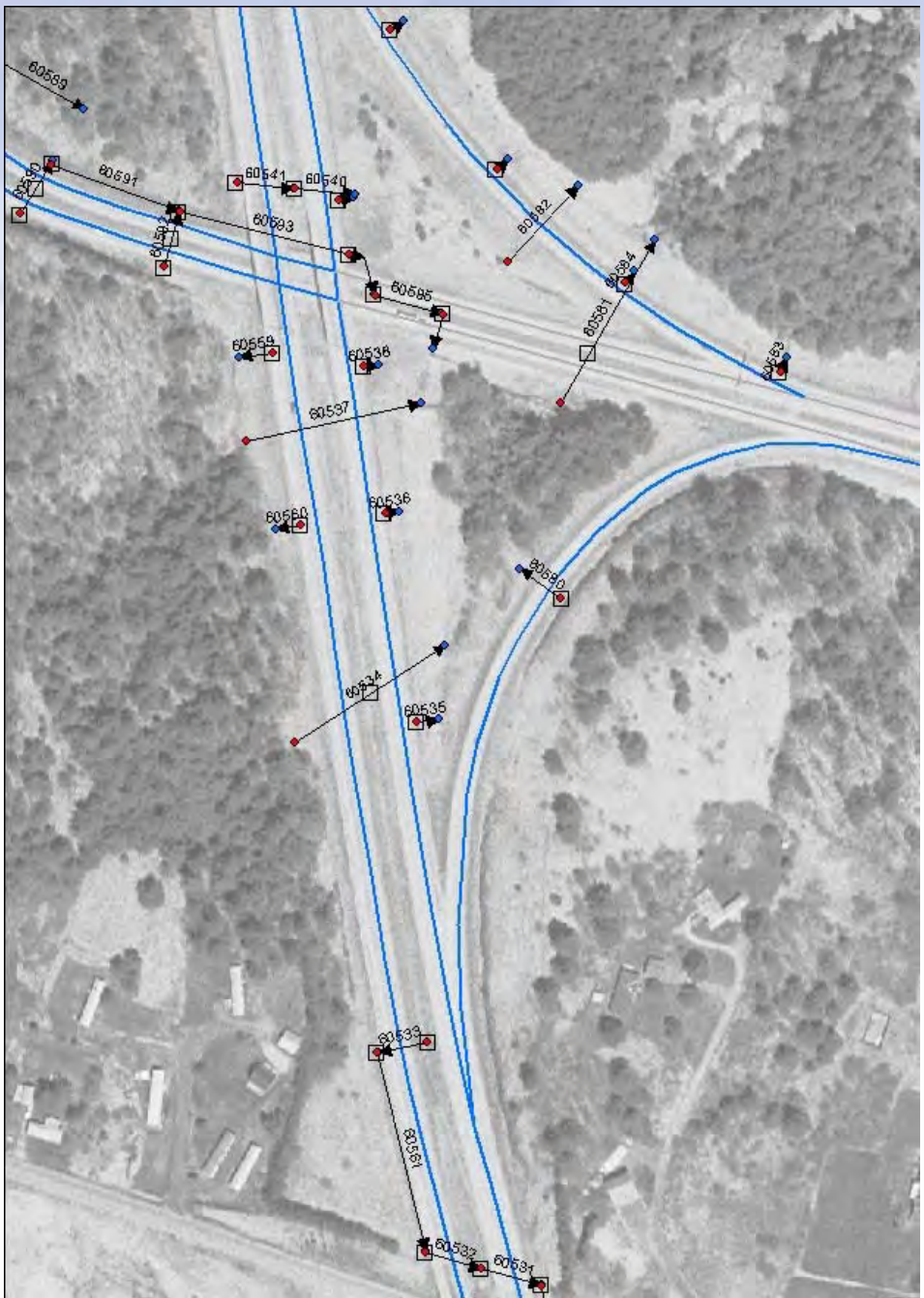
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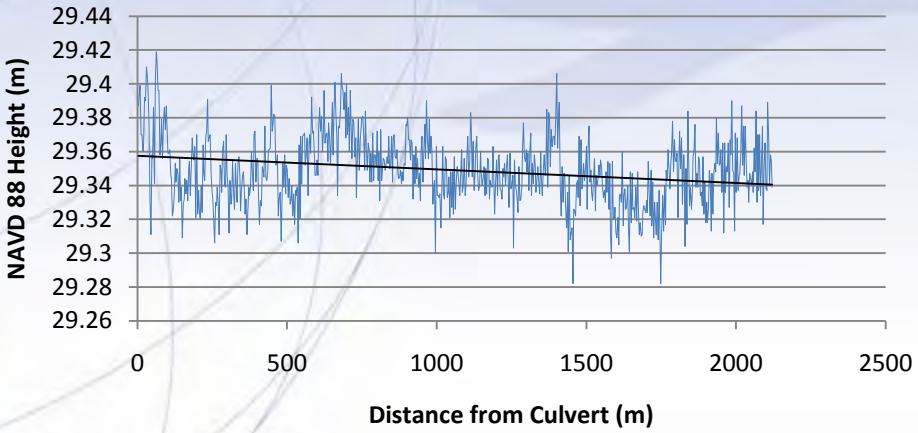
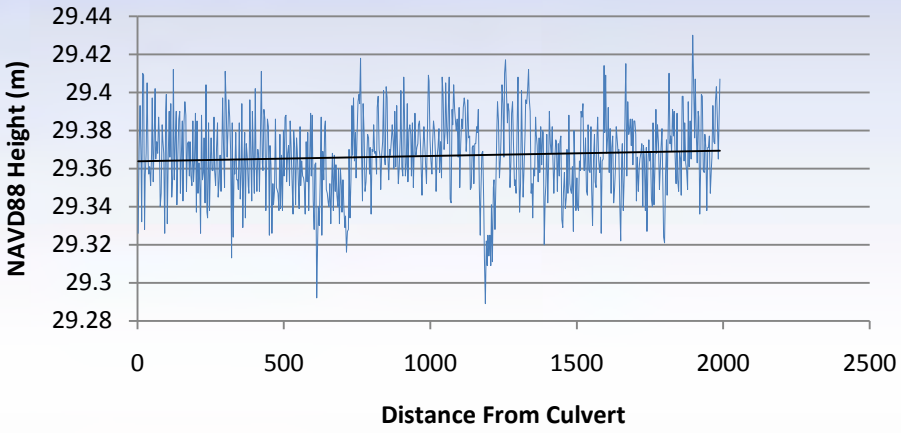
60531

Hospital Creek surface profile

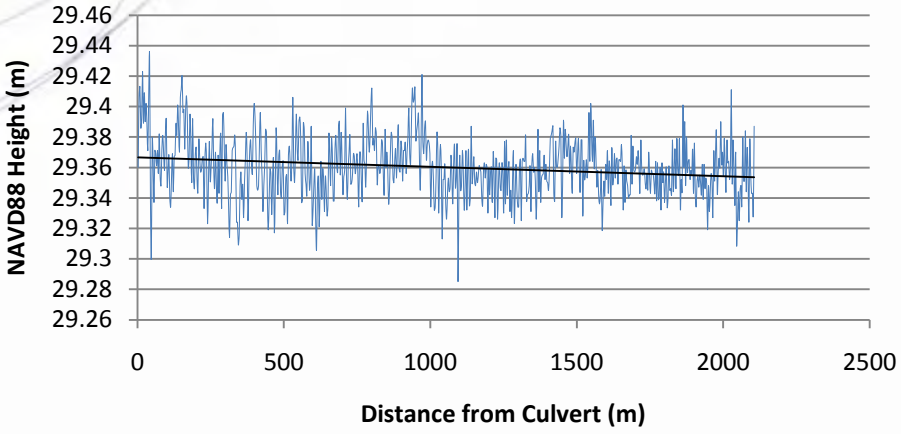
Morning Profile 1



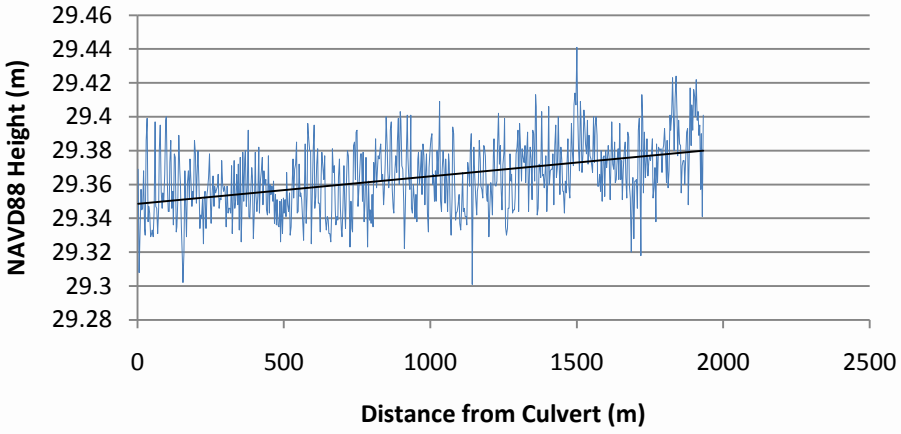
Afternoon Profile 1



Morning Profile 2



Afternoon Profile 2



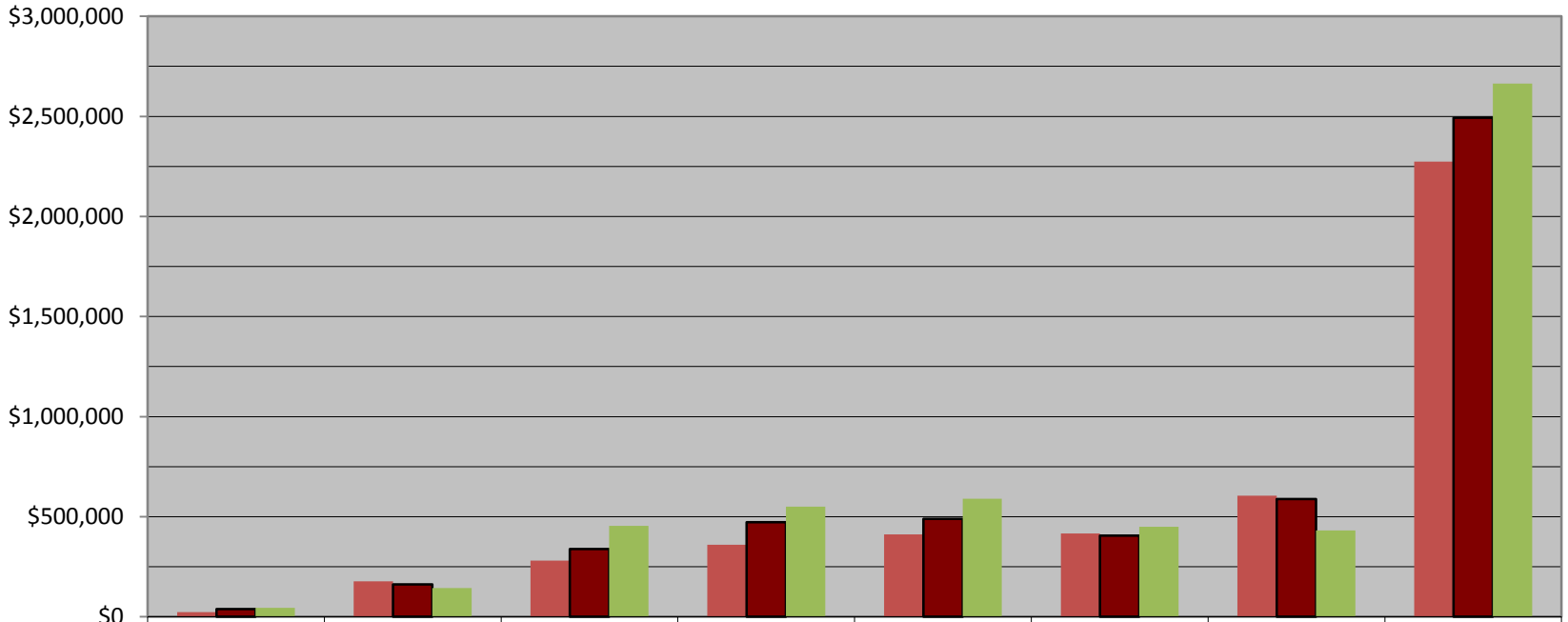
2010 VT CORS Statistics

Product	*2010 Usage*
UFCORS Downloads	2753 2-hr files (ave)
VT Web Download (VTDL)	4308 1-hr files
VT FTP Download	8987 1-hr files
OPUS_S	983 Solutions
OPUS_RS	758 Solutions
OPUS_DB	112 Submissions
RTK	1432 Hours (41 Unique Users)

Benefit for VT CORS Products

Product	*User Benefit*
UFCORS	**$200/download**
VT Web Download (VTDL)	**$100/1-hour file**
VT FTP Download	**$50/1-hour file**
OPUS_S	**$600/solution**
OPUS_RS	**$600/solution**
OPUS_DB	**$400/submission**
RTK	**$100/hour**

VT CORS Benefits 2008-2010

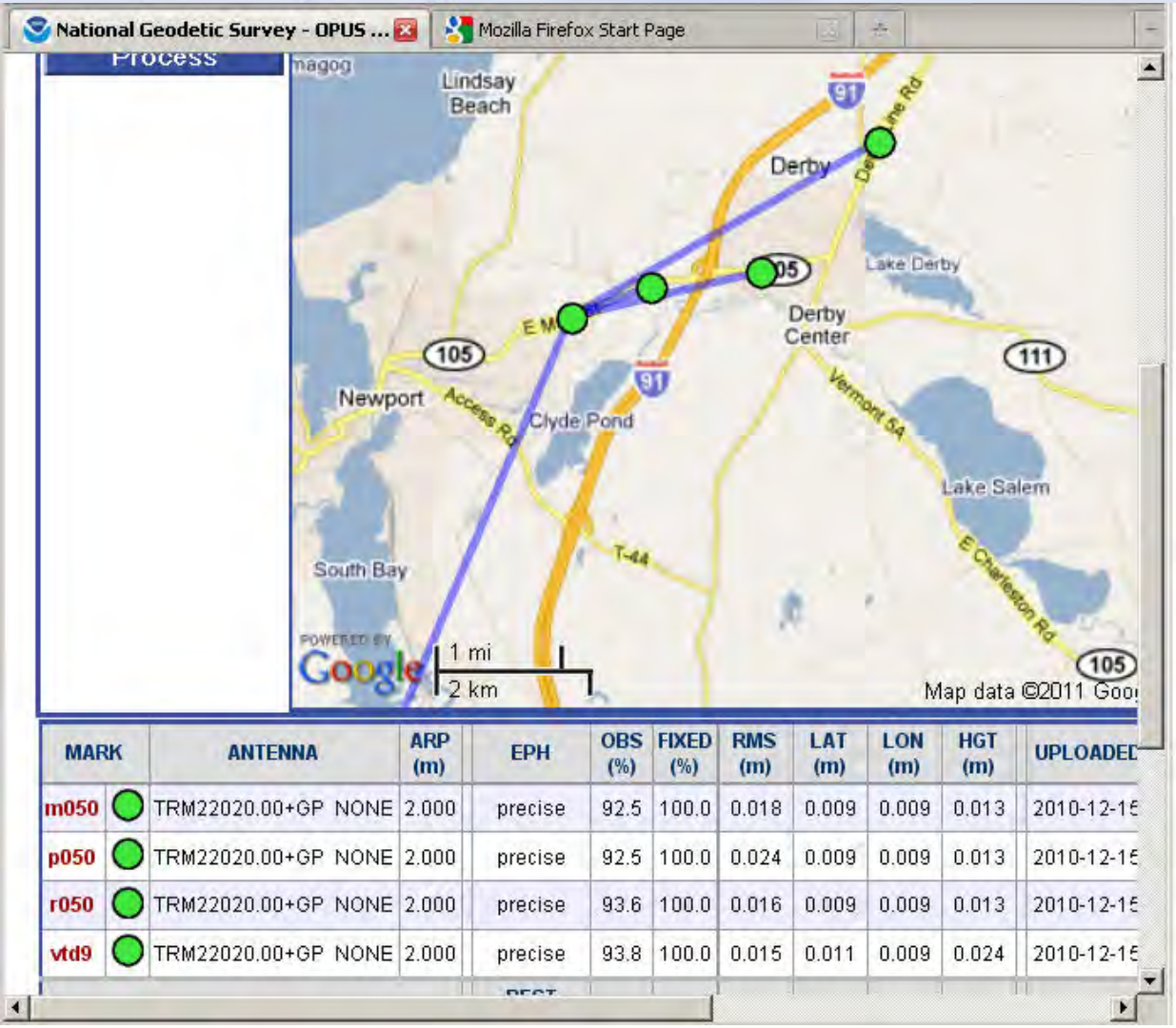


	OPUS_DB	RTK	OPUS_RS	UFCORS	OPUS_S	VT FTP	VTDL	Total
2008	$24,000	$177,100	$280,200	$359,600	$411,600	$416,450	$605,100	$2,274,050
2009	$38,800	$161,440	$338,400	$472,800	$489,600	$404,900	$588,000	$2,493,940
2010	$44,800	$143,230	$454,800	$550,600	$589,800	$449,350	$430,800	$2,663,380

Future Trends for Accessing the NSRS

- OPUS-Projects
  - Observers (crew members) submit data
  - Process between local stations
  - Manage project
- OPUS-Net
  - New OPUS processing engine
  - Ties to ITRS
- Submit data, let OPUS choose processor
  - Optimized based on your data

OPUS-Projects



MARK		ANTENNA	ARP (m)	EPH	OBS (%)	FIXED (%)	RMS (m)	LAT (m)	LON (m)	HGT (m)	UPLOADED
m050		TRM22020.00+GP NONE	2.000	precise	92.5	100.0	0.018	0.009	0.009	0.013	2010-12-15
p050		TRM22020.00+GP NONE	2.000	precise	92.5	100.0	0.024	0.009	0.009	0.013	2010-12-15
r050		TRM22020.00+GP NONE	2.000	precise	93.6	100.0	0.016	0.009	0.009	0.013	2010-12-15
vtd9		TRM22020.00+GP NONE	2.000	precise	93.8	100.0	0.015	0.011	0.009	0.024	2010-12-15

MARK		HUB	CONSTRAINT	HE
m050			NONE	EL HGT
p050			NONE	EL HGT
r050			NONE	EL HGT
vtd9			NONE	EL HGT
CORS		**HUB**	**CONSTRAINT**	**HE**
nyet			3-D	EL HGT
nypb			3-D	EL HGT
vcap			3-D	EL HGT
vtuv			3-D	EL HGT

Processing Options	
Output Ref Frame:	NAD_83(CORS96)
Geoid Model:	USGG2009
GNSS:	G (GPS-only)
Tropo Model:	Piece-wise, Linear
Tropo Interval (s):	7200
Elevation Cutoff (deg):	15.0
Constraints:	Loose Normal Tig
Network Design:	USER CORS MS

VT CORS Summary

- The VT CORS Network has provided significant benefit to VTrans and the taxpayers of VT
- It supports a wide variety of different applications from a diverse user community
- It provides a direct tie to the NSRS

Recommendations

- Continue with expansion of network to provide state-wide coverage
- Work to get as many stations into the National Network as possible
- Work to increase the use of the network inside VTrans
- Continue to promote the network outside of VTrans