Mobile GPS Data Collection for Infrastructure Management: A Case Study

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RoadwareDCL

ROADWARE DCL
Infrastructure Data Collection Solutions

Agenda

1. Introduction to Capabilities

2. Case Study – City of Hamilton
    - Implementation
    - Results

Introduction

- Many jurisdictions have recognized the need to implement GIS-based Asset Management Systems (AMS).
- These systems require input data for all assets.
- Existing asset inventories:
  - Usually not GIS-referenced.
  - Data not always collected in a consistent manner.
  - Data spans many years.
  - Not representative of current state of assets.

A New AMS

- When implementing a new AMS, it is often necessary to collect new GIS-referenced data across the entire road network.

Introduction

- Using a mobile vehicle to collect roadway asset data.
- Asset types include:
  - Signs
  - Guardrails (Guiderails)
  - Catch basins
  - Traffic signals
  - Bus stops/bus shelters
  - Medians
  - Fire hydrants
  - Parking meters
  - Utility poles
  - Trees

Data Collection Options

- Manual, walking surveys
  - Used when very detailed information about each asset is required.
- Semi-automated, vehicle-based collection
  - Cost-effective approach for large-scale data collection when more basic information about each asset is required.
  - **Advantage**: Relatively low cost of data collection can be further divided among several departments for optimal use of available funds.

Vehicle-based Collection

- Data that can be collected for each asset:
  - GPS Positions
  - Asset Type (e.g. MUTCD code for signs)
  - Asset Dimensions (e.g. width, height)
  - Basic Condition rating
  - Digital image of each asset
  - Any other data that can be visually determined from images captured along the roadway.

Vehicle-based Collection

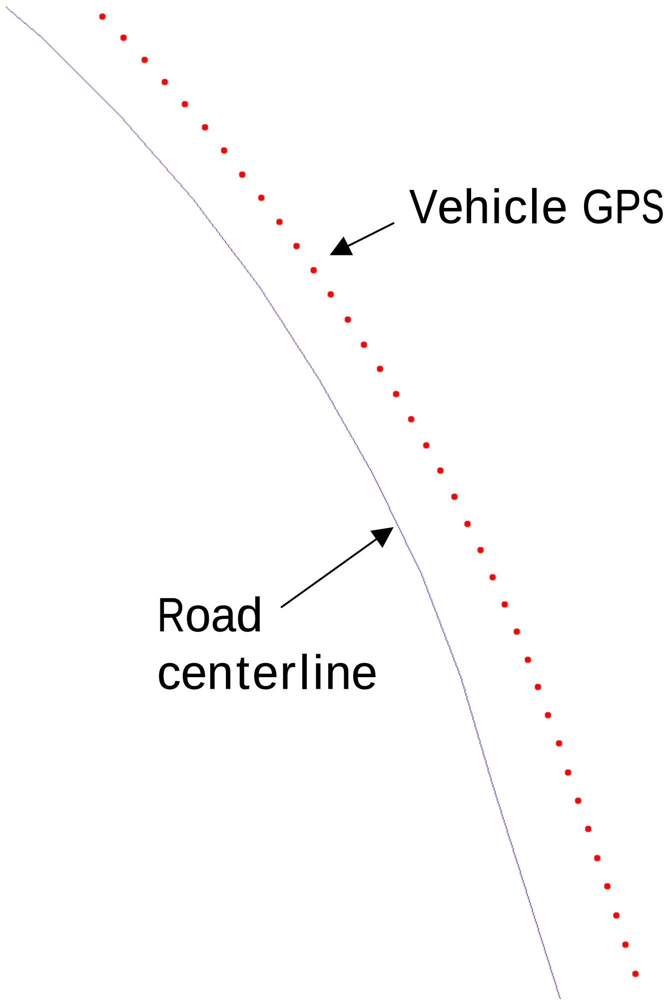
- Typical data collection vehicle will have:
  - High-resolution digital cameras
  - GPS receiver
  - Distance measuring instrument
  - Inertial sensor system

Vehicle-based Collection

- Panoramic imagery is collected at regular intervals along the roadway.
- Any assets that appear in the images can be inventoried.

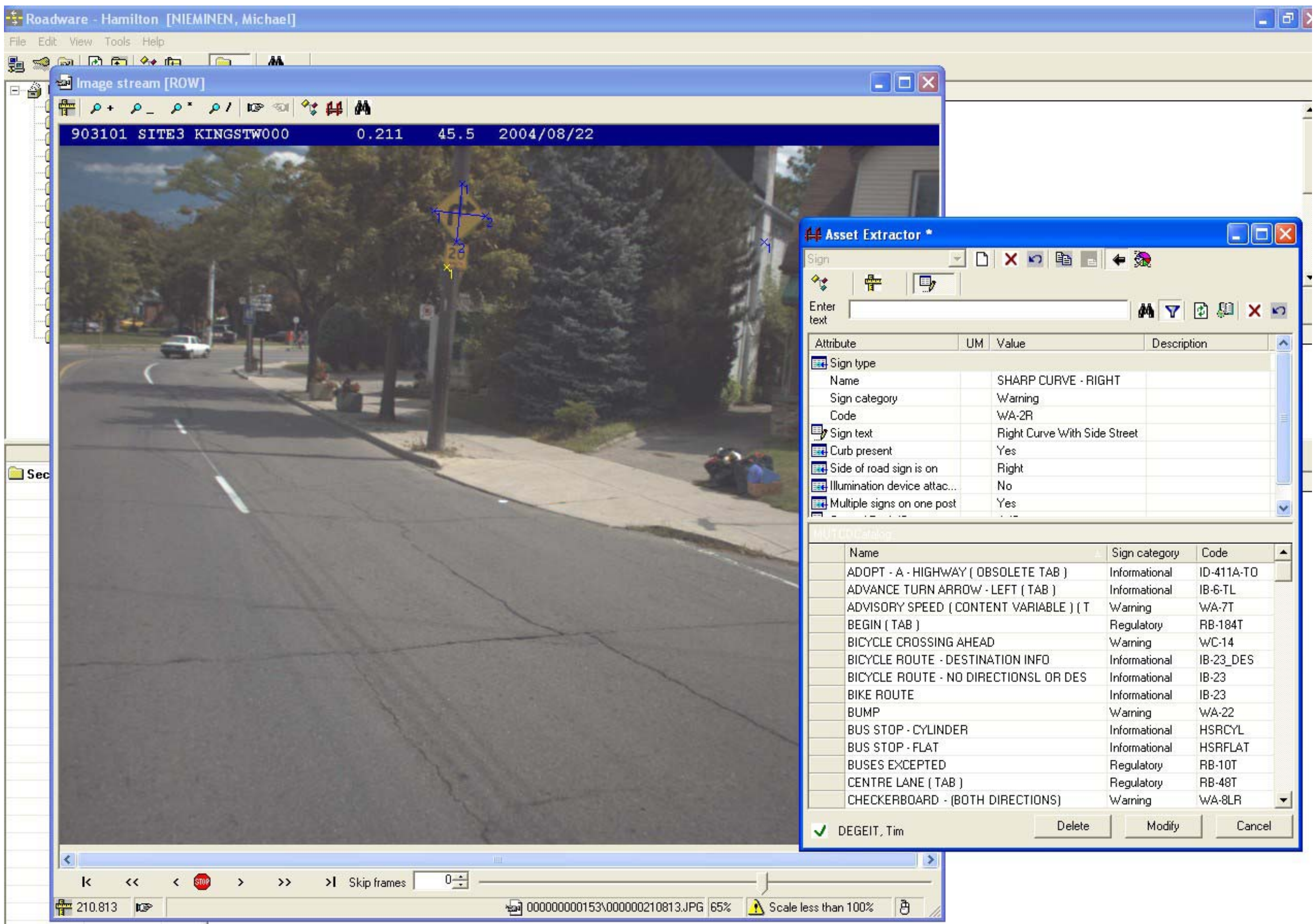
How It Works

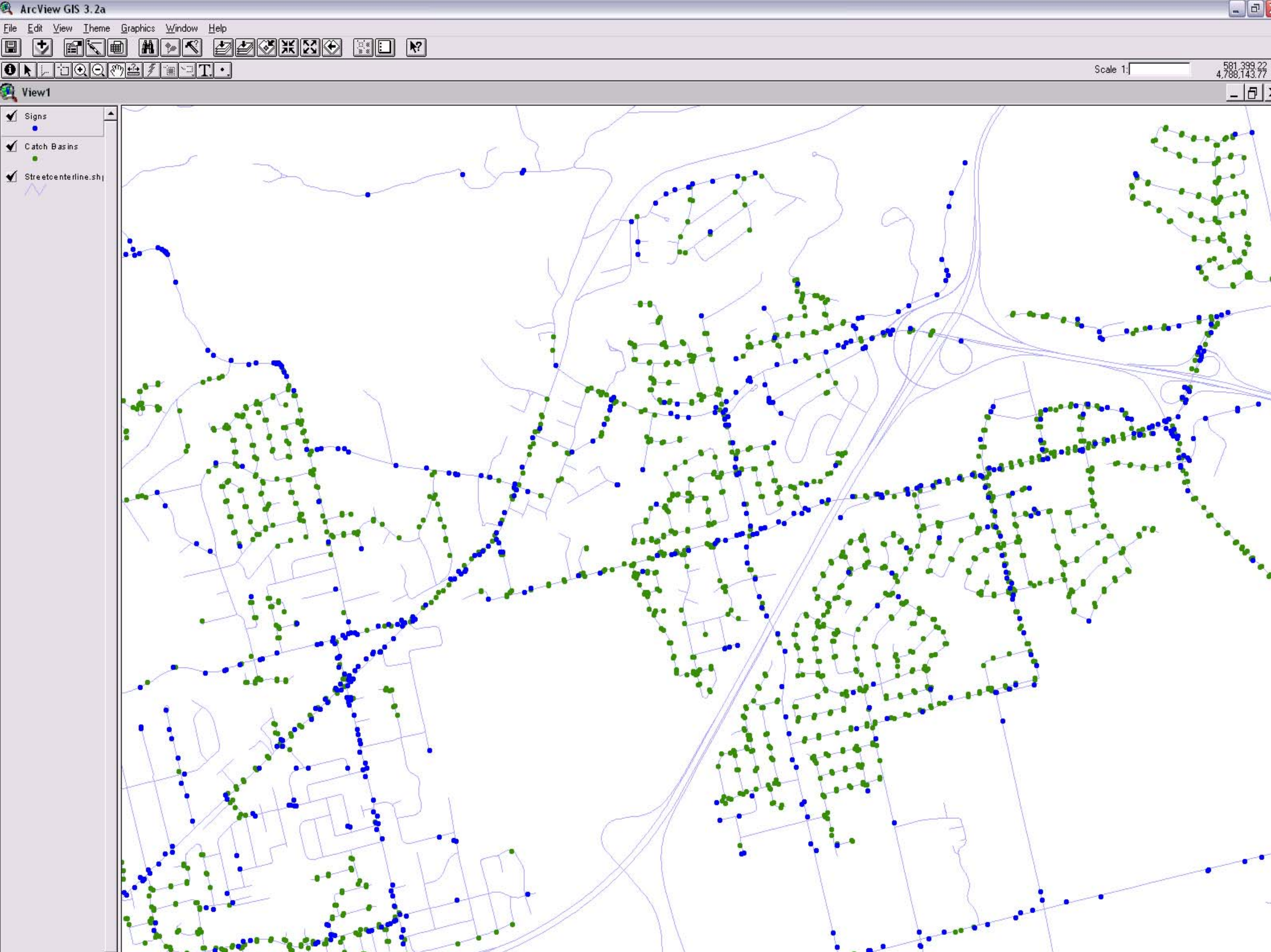
- The vehicle tracks its own GPS position as it drives along the road.
- Back at the office:
  - Asset positions are “marked” using the Surveyor software.
  - The software then “triangulates” the position of the asset.



Surveyor Software

Surveyor Software




ArcView GIS 3.2a
File Edit View Theme Graphics Window Help
Scale 1:
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View1
Signs
Catch Basins
Streetcenterline.shp

GPS Positional Accuracies

- What are the GPS positional accuracies of assets inventoried this way?
- Answer: There are several options. It depends on the accuracy of the *vehicle GPS*.
- The software used to mark the assets (Surveyor) adds only a small error component (20 to 50 cm).

GPS Positional Accuracies

- Four GPS options on the vehicle:
  - Real-time GPS
    - 5 - 20 meter accuracy → not useful for asset inventory
  - Real-time Differential GPS (RT DGPS)
    - 1 - 3 meter accuracy
  - Inertially-aided Real-time DGPS
    - 1.0 - 1.5 meter accuracy
  - Inertially-aided Post-processed DGPS
    - 0.4 – 1.0 meter accuracy

Real-time DGPS

- Real-time Differential GPS
  - Reasonable accuracy
  - Moderate coordinate availability
  - Low price
- Uses a differential correction signal broadcast from a service like OmniSTAR to adjust its position in real-time.
- Weaknesses:
  - Loss of GPS data during poor satellite visibility
  - Can have a jittery signal

Inertially-aided RT DGPS

- Inertially-aided real-time DGPS:
  - High accuracy
  - Excellent coordinate availability
  - Higher data collection costs
- Integrating GPS and inertial systems (e.g. POS/LV) improves data availability dramatically.
- Inertial systems use vehicle dynamics to provide coordinate fill-in during periods of GPS outage.
- Without the use of inertial technology, situations occur where it is not possible to obtain a GPS position for the roving receiver.

Inertially-aided Post-processed DGPS

- Inertially-aided post-processed DGPS:
  - Highest accuracy
  - Excellent coordinate availability
  - Higher data collection costs
- For data applications requiring the highest possible positional accuracy and coordinate availability, GPS data is collected using inertially-aided GPS receivers (on the data collection vehicle) and short base-line reference stations.
- This configuration provides both excellent coordinate availability through inertial fill-in, and accuracy through post-processing.

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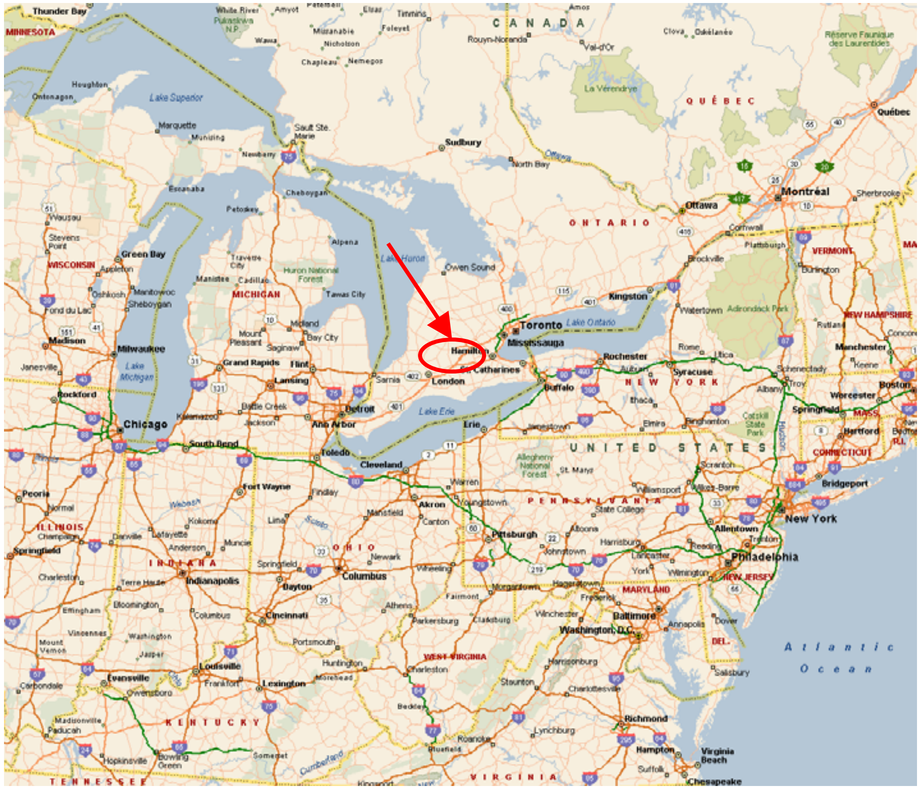
Case Study: City of Hamilton

- The City of Hamilton in Ontario, Canada implemented a Hansen AMS.
- The system required an initial input of accurate asset data.
- Roadware was selected to collect digital videolog and asset inventory on the City’s 6,500 lane-km network.
- Hamilton required that GPS positional accuracy would be +/- 1.5 m.



Asset Attributes Collected

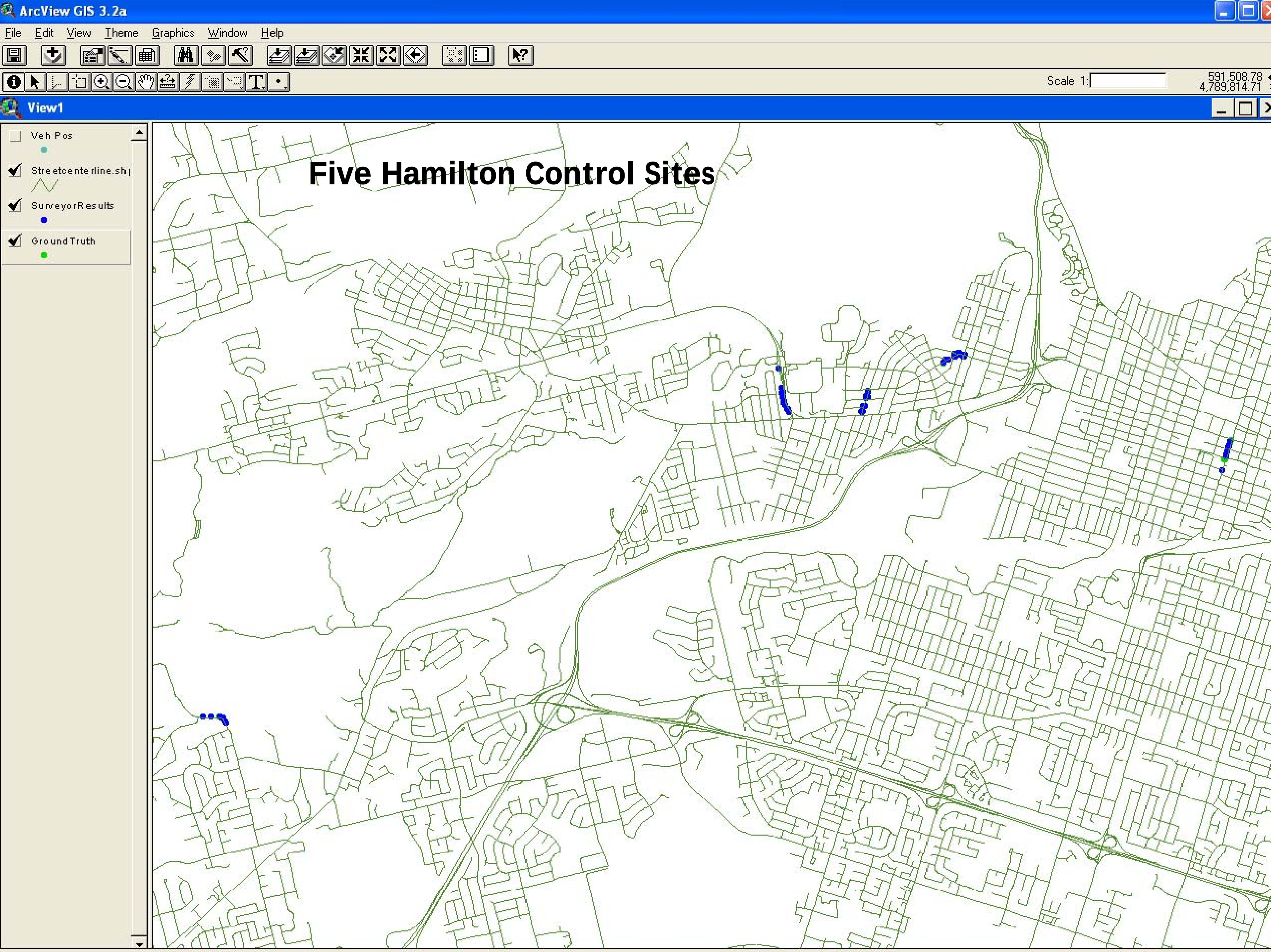
- Signs
  - GPS position
  - Sign dimensions (width, height)
  - Digital image of each sign
  - MUTCD code, sign category, sign text
  - Curb present? (Y, N)
  - Side of road sign is on (Left, Right, Overhead)
  - Illumination device attached? (Y, N)
  - Multiple signs on same post? (Y, N)
- Catch basins
  - GPS position
  - Digital image of each catch basin
  - Catch basin type (Single, Double)
  - Grate type (selection from City list)

Routing

- Hamilton sent Roadware a database listing all City-owned streets that were to be collected.
- Roadware determined the most efficient way to collect the City's road network.
- Right-of-way cameras were set up according to City specs.
- An integrated GPS and POS/LV system was chosen to meet the accuracy requirements.

Control Sites

- 5 control sites were set up within the City of Hamilton.
- An independent survey company collected very accurate (+/- 2 cm) GPS positions for 78 assets on the control sites.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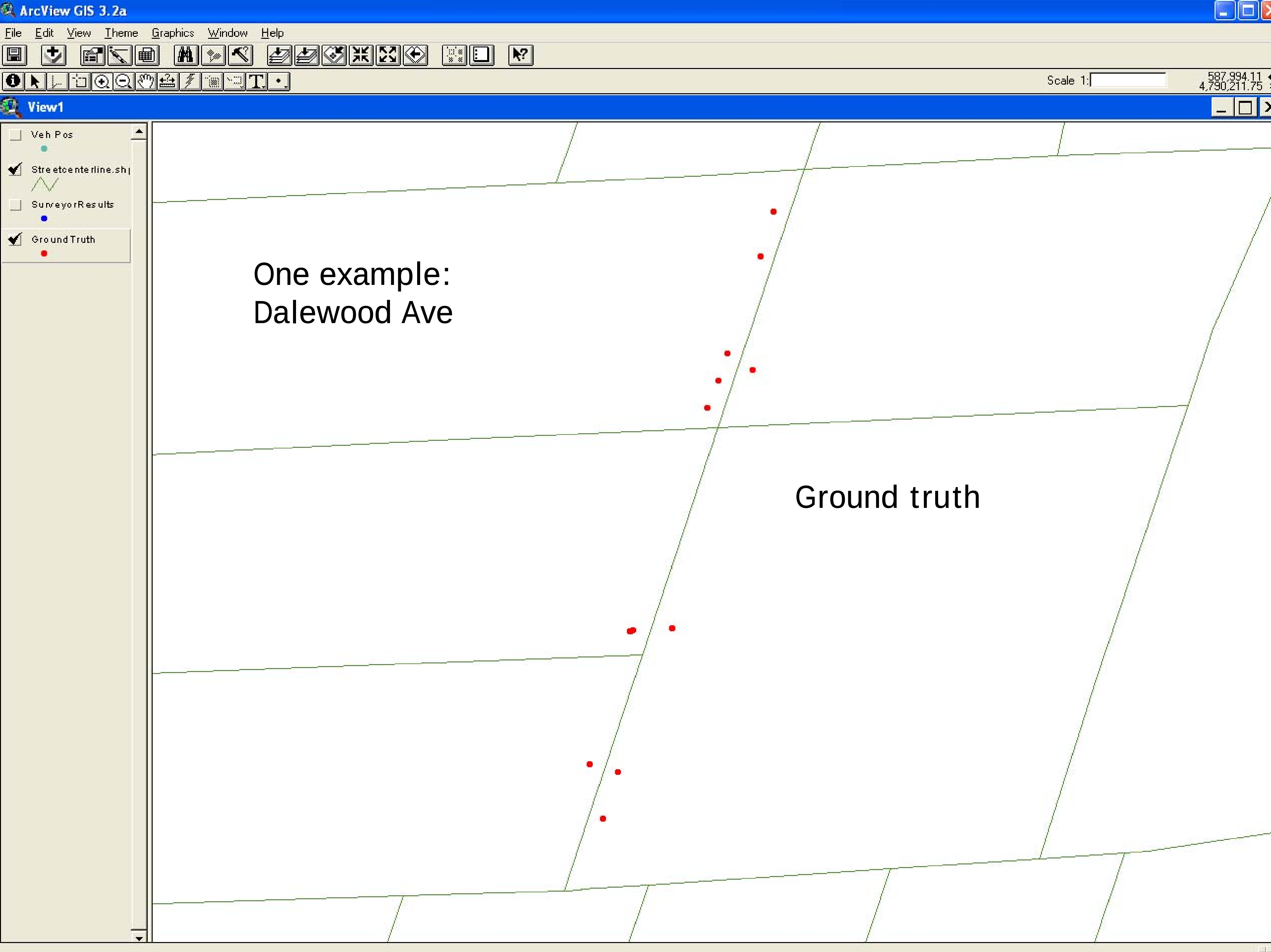
Veh Pos
Streetcenterline.sh
SurveyorResults
GroundTruth
Five Hamilton Control Sites



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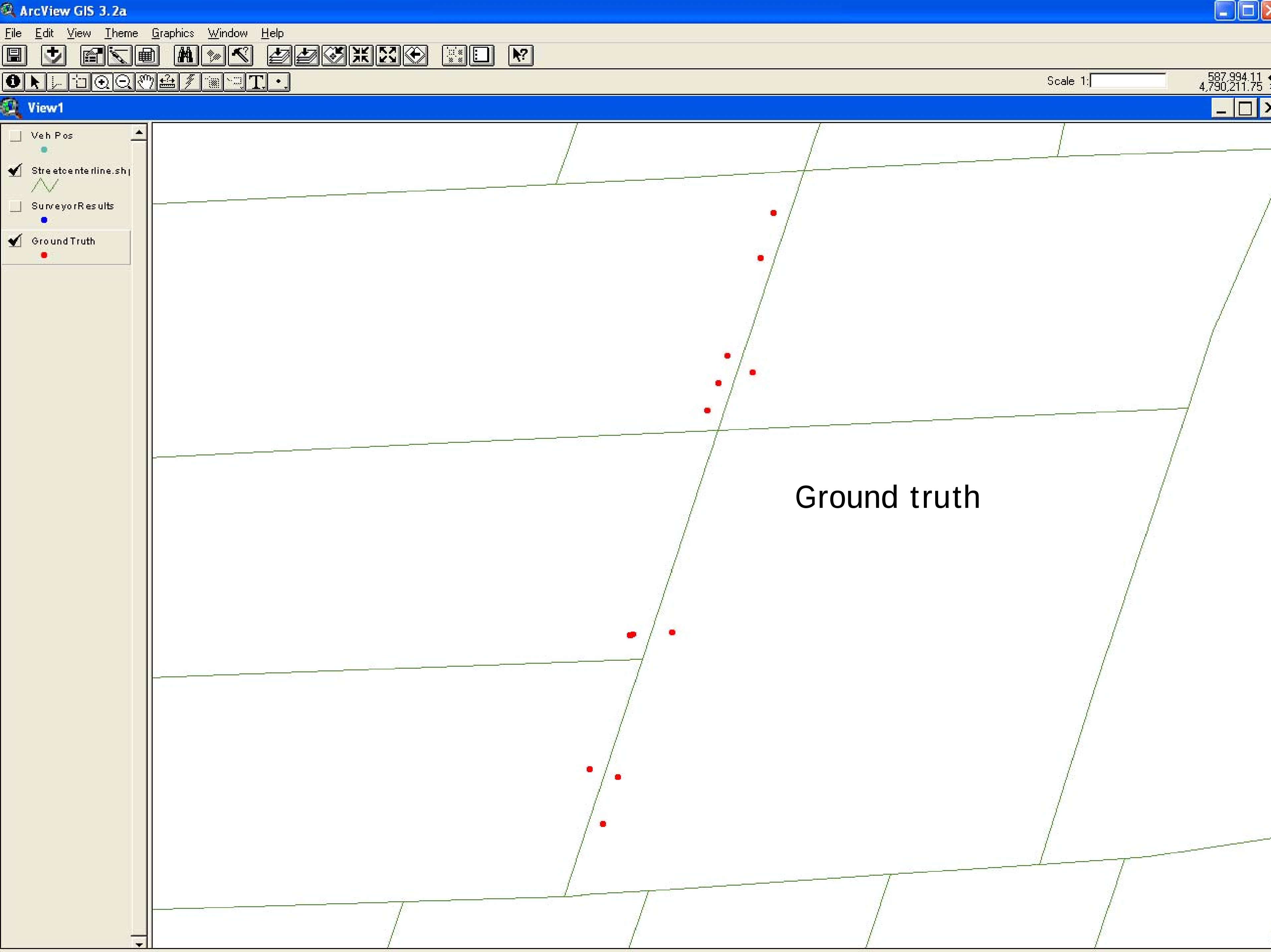
File Edit View Theme Graphics Window Help
Scale 1:
587,994.11
4,790,211.75
View1
Veh Pos
Streetcenterline.shp
SurveyorResults
Ground Truth
One example:
Dalewood Ave
Ground truth

Control Site Methodology

- At the beginning of data collection, all 5 sites were collected by Roadware's vehicles.
- The asset positions were determined using Surveyor and these positions were compared to the ground truth data collected by the survey company.
- Every week thereafter, one site was collected and the results were again compared to the known asset positions.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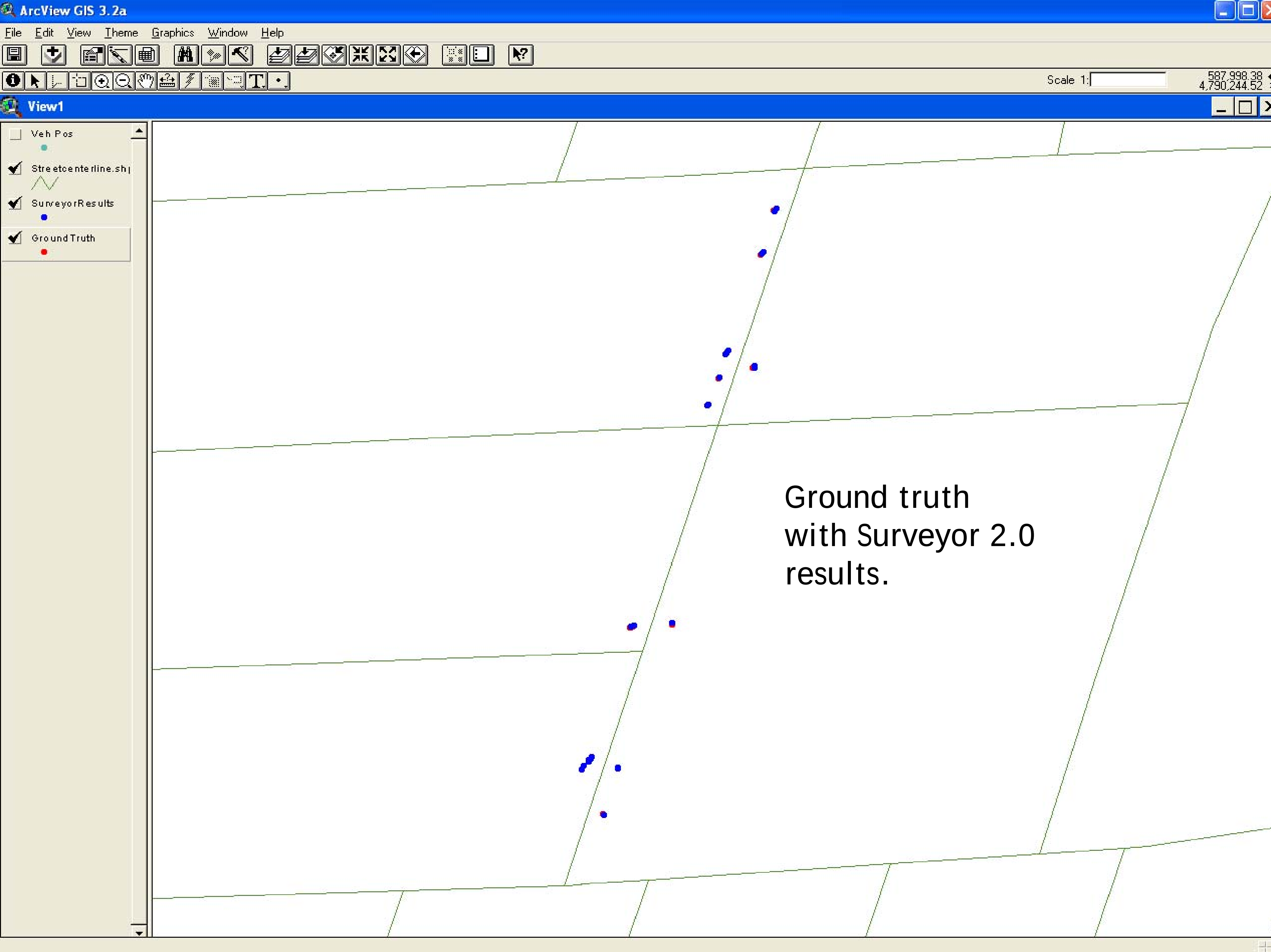
View1
Veh Pos
Streetcenterline.shp
SurveyorResults
Ground Truth
Ground truth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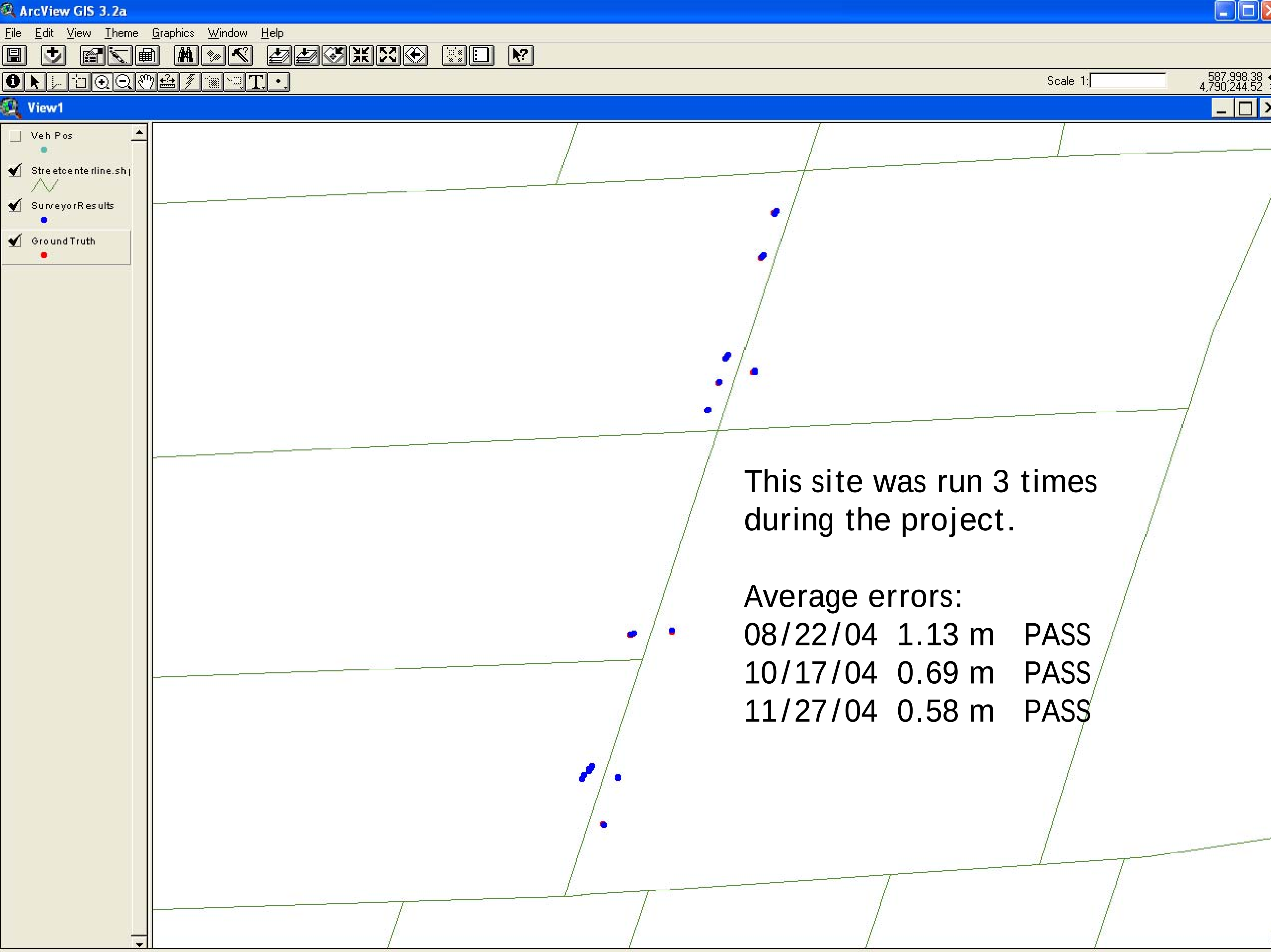
View1
Veh Pos
Streetcenterline.shp
SurveyorResults
Ground Truth
Ground truth with Surveyor 2.0 results.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File Edit View Theme Graphics Window Help
Scale 1:
587,998.38
4,790,244.52
View1
Veh Pos
Streetcenterline.shp
SurveyorResults
GroundTruth
This site was run 3 times during the project.
Average errors:
08/22/04 1.13 m PASS
10/17/04 0.69 m PASS
11/27/04 0.58 m PASS

Control Site Results

Site	RT DGPS	IA RT DGPS	PP IA DGPS
Cootes Drive - rural, open skies	1.55	0.62	0.41
Dalewood Ave. - subdivision, tree cover	13.2	0.88	0.80
King St. - urban, few obstruct.	1.84	1.10	0.72
James St. - urban canyon	N/A	1.84	1.09
Sulphur Springs - rural, high tree cover	51.8	1.05	0.80

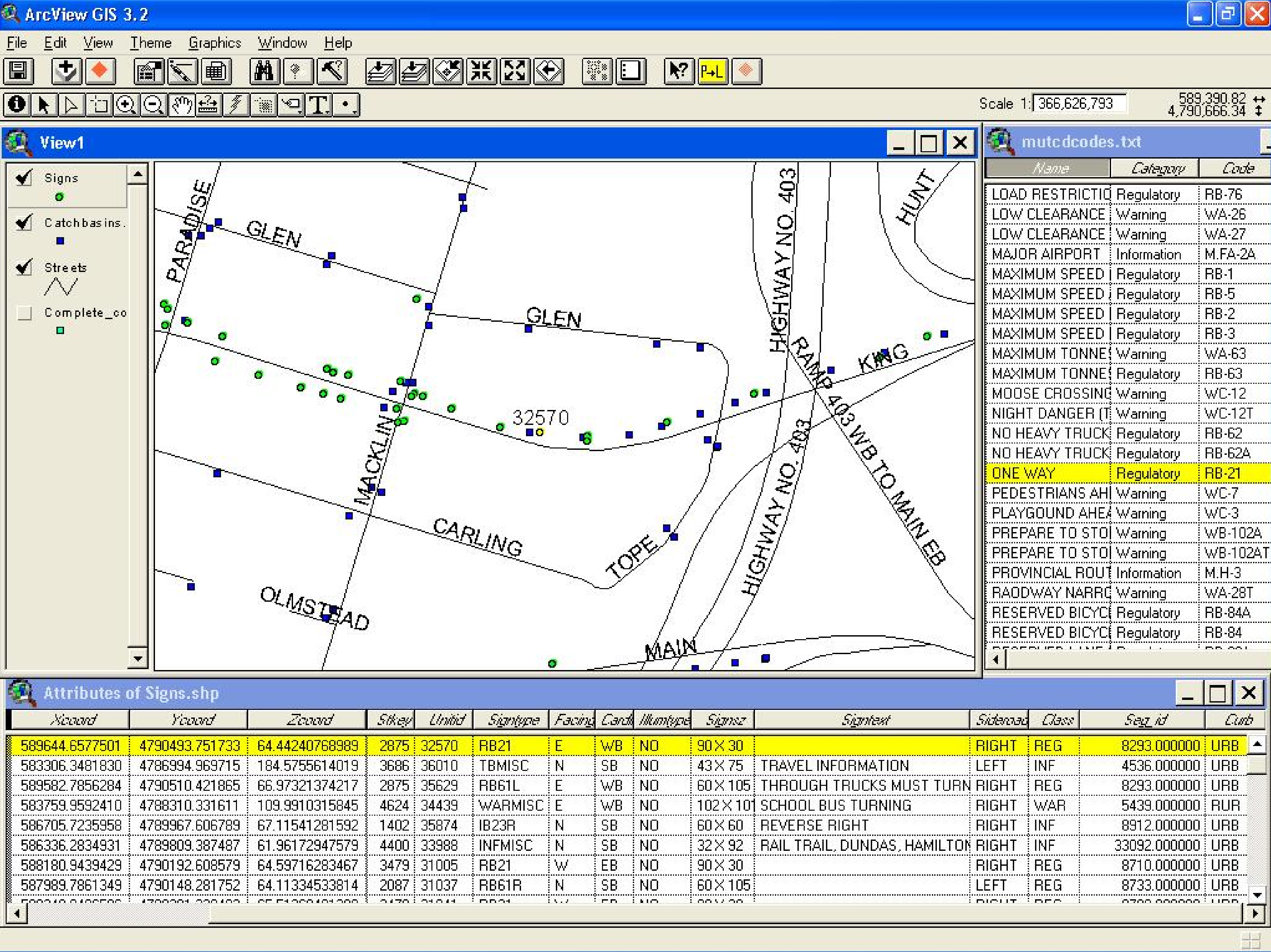
Average error magnitudes, measured in metres (m)

Discussion of Results

- RT DGPS is not a good option for urban environments. It can be adequate for rural areas and major highways.
- With an inertial system, data availability is good even in urban environments.
- Post-processing provides even better GPS accuracy.
- It is possible to obtain excellent accuracy on a network level vehicle-based survey.

Limitations of Vehicle-based Collection

- Some assets may not be visible in the camera views.
  - Obstructed by traffic or parked vehicles
  - Covered by leaves or other debris
- Detailed data (like serial number of assets) cannot be determined.
- Asset condition cannot be assessed in detail.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View1
Signs
Catchbasins
Streets
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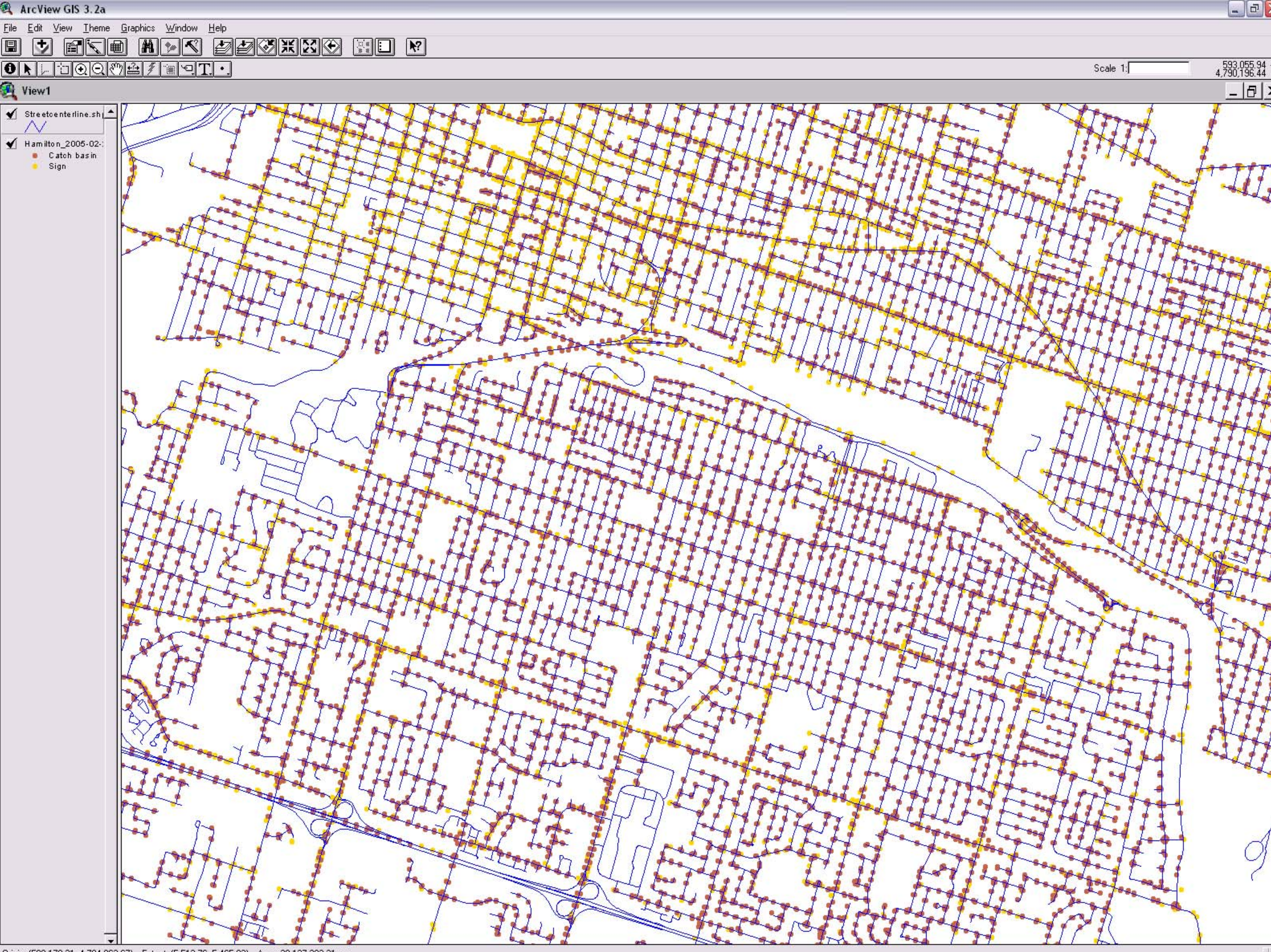
PARADISE
GLEN
GLEN
MACKLIN
CARLING
OLMSTEAD
TOPE
MAIN
KING
HUNT
HIGHWAY NO. 403
HIGHWAY NO. 403
HIGHWAY NO. 403
RAMP 403 WB TO MAIN EB
32570
mutcdcodes.txt
Name | Category | Code
LOAD RESTRICTIO | Regulatory | RB-76
LOW CLEARANCE | Warning | WA-26
LOW CLEARANCE | Warning | WA-27
MAJOR AIRPORT | Information | M.FA-2A
MAXIMUM SPEED | Regulatory | RB-1
MAXIMUM SPEED | Regulatory | RB-5
MAXIMUM SPEED | Regulatory | RB-2
MAXIMUM SPEED | Regulatory | RB-3
MAXIMUM TONNE | Warning | WA-63
MAXIMUM TONNE | Regulatory | RB-63
MOOSE CROSSING | Warning | WC-12
NIGHT DANGER (T | Warning | WC-12T
NO HEAVY TRUCK | Regulatory | RB-62
NO HEAVY TRUCK | Regulatory | RB-62A
ONE WAY | Regulatory | RB-21
PEDESTRIANS AH | Warning | WC-7
PLAYGOUND AHE | Warning | WC-3
PREPARE TO STO | Warning | WB-102A
PREPARE TO STO | Warning | WB-102AT
PROVINCIAL ROUT | Information | M.H-3
RAODWAY NARRO | Warning | WA-28T
RESERVED BICYC | Regulatory | RB-84A
RESERVED BICYC | Regulatory | RB-84
Attributes of Signs.shp
Xcoord | Ycoord | Zcoord | Stkey | Unitid | Signtype | Facing | Card | Illumtype | Signsz | Signtext | Sideroad | Class | Seg_id | Curb
589644.6577501 | 4790493.751733 | 64.44240768989 | 2875 | 32570 | RB21 | E | WB | NO | 90 X 30 | | RIGHT | REG | 8293.000000 | URB
583306.3481830 | 4786994.969715 | 184.5755614019 | 3686 | 36010 | TBMISC | N | SB | NO | 43 X 75 | TRAVEL INFORMATION | LEFT | INF | 4536.000000 | URB
589582.7856284 | 4790510.421865 | 66.97321374217 | 2875 | 35629 | RB61L | E | WB | NO | 60 X 105 | THROUGH TRUCKS MUST TURN | RIGHT | REG | 8293.000000 | URB
583759.9592410 | 4788310.331611 | 109.9910315845 | 4624 | 34439 | WARMISC | E | WB | NO | 102 X 101 | SCHOOL BUS TURNING | RIGHT | WAR | 5439.000000 | RUR
586705.7235958 | 4789967.606789 | 67.11541281592 | 1402 | 35874 | IB23R | N | SB | NO | 60 X 60 | REVERSE RIGHT | RIGHT | INF | 8912.000000 | URB
586336.2834931 | 4789809.387487 | 61.96172947579 | 4400 | 33988 | INFMISC | N | SB | NO | 32 X 92 | RAIL TRAIL, DUNDAS, HAMILTON | RIGHT | INF | 33092.000000 | URB
588180.9439429 | 4790192.608579 | 64.59716283467 | 3479 | 31005 | RB21 | W | EB | NO | 90 X 30 | | RIGHT | REG | 8710.000000 | URB
587989.7861349 | 4790148.281752 | 64.11334533814 | 2087 | 31037 | RB61R | N | SB | NO | 60 X 105 | | LEFT | REG | 8733.000000 | URB


ArcView GIS 3.2a
File Edit View Theme Graphics Window Help
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4,790,196.44
View1
Streetcenterline.sh
Hamilton_2005-02-
Catch basin
Sign

Conclusions

- Vehicle-based data collection is a cost-effective way to gather accurate information about roadway assets.
- Various GPS accuracies are available depending on the project requirements.
- Vehicle-based collection cannot completely replace manual methods.

Questions?