Quantum Leaps: An Initial Reflection on a Walk/Bike Audit Method using Quantum Geographic Information System, Geotagged Photography, and Cartographic Notation

Author: Mark Wetherbee Jr.

"The hope of this project is to develop a system that empowers communities beyond their traditional means of walk/bike auditing by providing a thoroughly tested, customizable, powerful turn-key method of mixed-technological surveying."

Ewing Green Team with TCNJ Bonner Society

9/29/2014

This document is a technical reflection on a pilot walk/bike audit performed by The Sustainable Ewing Green Team in collaboration with volunteers from The College of New Jersey Bonner Institute for Civic and Community Engagement (their representatives Joanne Mullowney and Michael Nordquist, respectively). With the objective to test and refine an efficient replicable method for walk/bike audits, we explore a mix of quantitative and qualitative data collection for volunteers of varying skill levels and abilities. Rationale, effectiveness, and refinements are detailed.

Key Words: Walk/Bike Audit, Bikeability, Walkability, Complete Streets, Safe Routes, Quantum GIS, Geographic Information System, Sustainability, Geotagged Photography.

Technical Documentation Page

Report Date: September 2014 **Date Audited**: Saturday, September 20th, 2014.
Type of Report: Final report on the pilot run of a walk/bike audit.
Author of the Report: Mark Wetherbee Jr.
Audit Performed by: Representative of The Ewing Green Team, Joanne Mullowney; The College of New Jersey's Michael Nordquist (Ph.D., CEL Coordinator for Environment and Community Development Division); Bonner representatives Emily LaRosa and Jack Baldwin, alongside TCNJ student volunteers; with data organizer / review author Mark Wetherbee Jr.
Neighborhood Audited: Braeburn neighborhood, directly south of TCNJ in Ewing Township, NJ; bounded by Pennington Road, Green Lane, Somerset Street, and Hollowbrook Drive.

Northwest: 40.2**63158**, -74.7**81613** Northeast: 40.2**65974**, -74.7**72000**
Southwest: 40.2**58114**, -74.7**79306** Southeast: 40.2**61545**, -74.7**66582**

Rationale for Location, Scope, and Method: The Braeburn neighborhood was chosen for reasons such as its centered location within Ewing, proximity to TCNJ and major thoroughfares, relatively symmetric layout, community assets such as churches and playground, and observed lack of sidewalks. The scope of data collected was limited in order to focus on the trial run nature. Above all, this walk/bike audit system is being crafted and tested for development due to what appeared to be a lack of readily available, efficient and customizable audit resources. The hope of this project is to develop a system that empowers communities beyond their traditional means of walk/bike auditing by providing a thoroughly tested, customizable, powerful turn-key method of mixed-technological surveying.
Supplementary Notes: Road vector files were provided by Principal Planner Matthew Lawson at the County of Mercer, NJ. Orthophotography files were downloaded from the New Jersey Geographic Information Network. All other vector and photographic information was manually constructed.
Key Words: Walk/Bike Audit, Bikeability, Walkability, Complete Streets, Safe Routes, Quantum GIS, Geographic Information System, Sustainability, Geotagged Photography.
Objective: To test an audit system of qualitative and quantitative data collection for future refinement and viability of replication.
Summary of Deliverables:
The teams of Bonners and TCNJ students identified major thoroughfares for pedestrians and cyclists, as well as a rough determination of what amenities are required for safer travel (or travel at all, in some cases). Printed maps with long-form notes accompanied the forms, as well as contextual photos were taken with volunteers' phones to pinpoint hazards and document conditions.
Data Fields:
Brush obstructions, broken tiles, an overall feeling of safety, contiguous sidewalks, lines of demarcation, demarcation icons, cycling obstructions, paint quality, marked or unmarked crosswalks, pedestrian crossing buttons (and their calibration), pedestrian icons, truncated domes, pedestrian signs, and curb cuts (naturally, more is to be included in future runs).
Software: Quantum GIS 2.4.0-Chugiak across Windows, Mac, and Linux platforms.

Map Overview

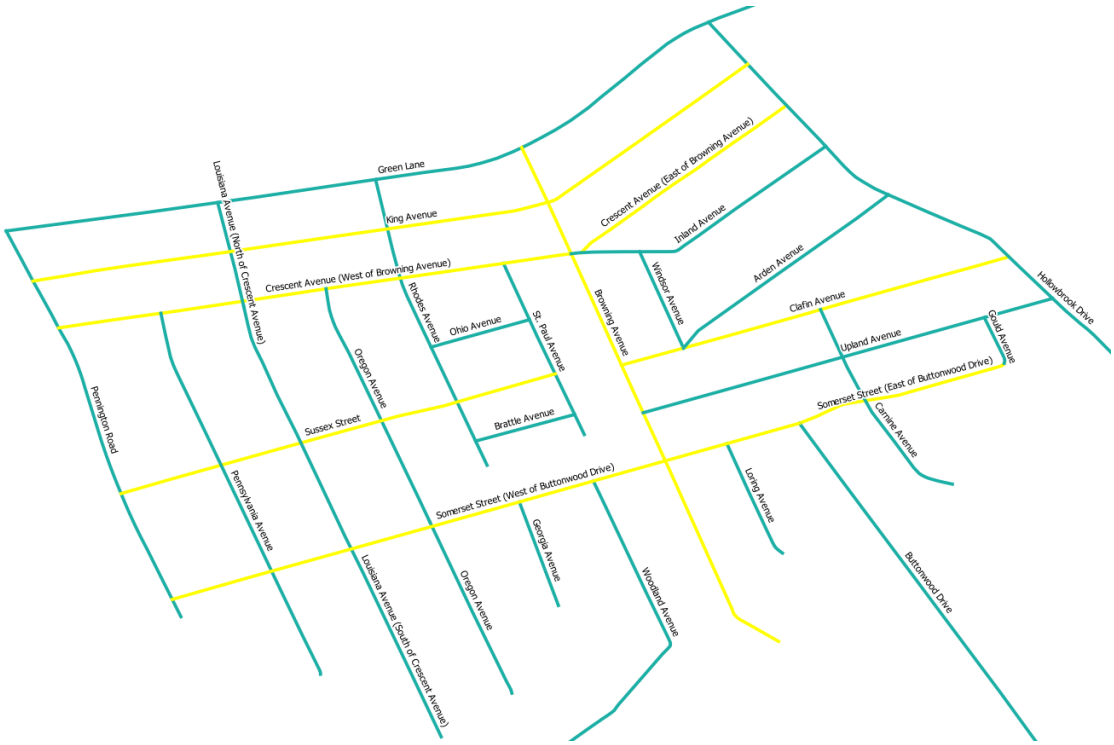
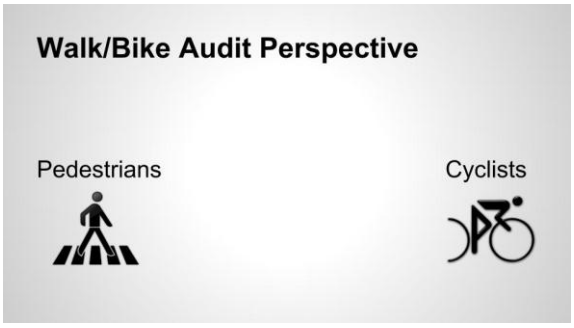


Figure 1: Roads, Intersections, and Sidewalks within the scope of the audit.

King Avenue, Crescent Avenue, Sussex Street, Claflin Avenue, Somerset Street, and Browning Avenue.

Training Session:

A 15 minute training session preceded the audit. It contained item definitions and pictures of what to look for during the audit, the rationale for performing the audit, what data was to be collected, how the data was to be collected, how to enable GPS and geotagging[1] on their phones, and where the data was going to go after completion of the audit. Emphasis was placed on adopting perspectives beyond the average able-bodied pedestrian or cyclist—keeping in mind a community with multifaceted diversities.



VS.

[1] A method by which a point on a map—such as a photo—is assigned a latitudinal and longitudinal value for identification within its metadata.

Data Collected

- Groups were split by the roads and sidewalks they were to audit, King / Crescent / Sussex / Somerset.
- Sheets were then broken into three forms—*Intersections, Roads, and Sidewalks*—with several fields.
- To reduce human error while performing data entry after recording in the field, each group received the same complete list for consistency but only entered data applicable to their respective route.

Quantitative: Object counts and spatial measurements.
Qualitative: Long form notes with observations, script and sketches; GPS tagged photos; Map written pinpoints; Ratings 1 poor to 3 good.

	Is this a marked (painted) crosswalk?	Does this intersection need a pedestrian crossing button?	Calibration. If there is a PedX button, does it work AND give enough time to cross?	Does the intersection have a pedestrian-crossing icon?	Does this intersection need any curb cuts that may be missing?	Does this intersection need any truncated domes?	Are there signs for pedestrian crossings?
INTERSECTIONS	Y/N	Y/N	Y/N	Y/N	#	#	Y/N
NAME	**CROSS_TYPE**	**PEDX_BUTTN**	**PEDX_CALIB**	**PEDX_DM_IC**	**NEED_CUT**	**NEED_TRCDM**	**PEDX_SIGNS**
Arden Avenue & Hollowbrook Drive							
Brattle Avenue & Rhodes Avenue							
Brattle Avenue & St. Paul Avenue							
Claflin Avenue & Arden Avenue & Windsor Avenue							
Claflin Avenue & Browning Avenue							
Claflin Avenue & Camine Avenue							
Claflin Avenue & Hollowbrook Drive							
Crescent Avenue & Browning Avenue & Inland Avenue							
Crescent Avenue & Hollowbrook Drive							

		Width in feet		Average width	Missing lines?	Ped/Cycl icons	Obstructions	none-faded-good
ROADS	#	#	#	Inches	SHDR, CNTR	Y/N	#	1 -- 2 -- 3
NAME	**LANES**	**PAV_WID**	**SPD**	**SHLDR_WDTH**	**DMRC_LINES**	**DMRC_ICONS**	**BIKE_OBSTC**	**PAINT**
Arden Avenue	2	30	25					
Brattle Avenue	2	30	25					
Browning Avenue	2	24	25					
Buttonwood Drive	2	30	25					
Camine Avenue	2	30	25					
Clafin Avenue	2	30	25					
Crescent Avenue (East of Browning Avenue)	2	30	25					
Crescent Avenue (West of Browning Avenue)	2	30	25					
Georgia Avenue	2	30	25					
Gould Avenue	2	24	25					

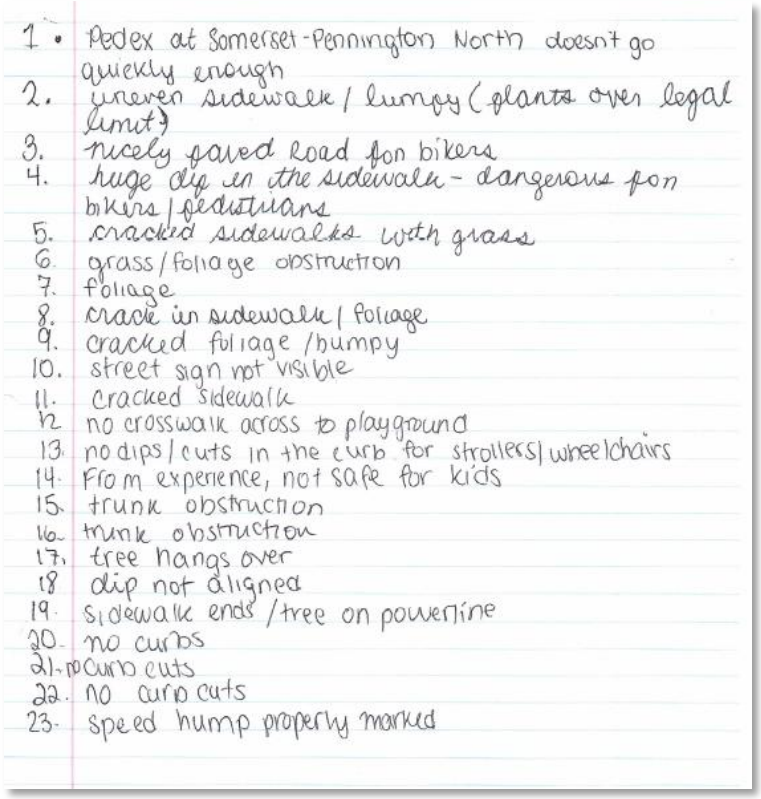
	How many significant brush obstructions are there?	How many significantly broken tiles are there?	1 avoid, 2 unsafe, 3 safe	Is the sidewalk contiguous without missing stretches?
SIDEWALKS	#	#	1 -- 2 -- 3	Y/N
NAME	**BRUSH_OBST**	**BRKN_TILES**	**FEEL_SAFE?**	**COMPLETE?**
Claflin Avenue & Browning Avenue to Upland Avenue & Browning Avenue (east side)				
Crescent Avenue & Browning Avenue to Claflin Avenue & Browning Avenue (east side)				
Crescent Avenue & Browning Avenue to Inland Avenue & Windsor Avenue (south side)				
Crescent Avenue & Browning Avenue to Somerset Street & Browning Avenue (west side)				
Crescent Avenue & Louisiana Avenue to Crescent Avenue & Oregon Avenue (south side)				
Crescent Avenue & Louisiana Avenue to Crescent Avenue & Rhodes Avenue (north side)				
Crescent Avenue & Oregon Avenue to Crescent Avenue & Rhodes Avenue (south side)				
Crescent Avenue & Pennington Road to Crescent Avenue & Louisiana Avenue (north side)				

Long Form Cartographic Notation

A simple yet effective supplement to the spreadsheets, cartographic notation allowed long form notes to be written and tagged numerically on a properly scaled map that came from the QGIS shape files.

These notes and sketches allow fluidity and work with the more binary "yes/no" queries to develop a differentiated system of data collection.

Critical is the sensitivity and understanding that not all community members wishing to aid an audit have phones or are comfortable with GPS technology.



1. Pedex at Somerset-Pennington North doesn't go quickly enough
2. uneven sidewalk / lumpy (plants over legal limit)
3. nicely paved road for bikers
4. huge dip in the sidewalk - dangerous for bikers / pedestrians
5. cracked sidewalks with grass
6. grass / foliage obstruction
7. foliage
8. crack in sidewalk / foliage
9. cracked foliage / bumpy
10. street sign not visible
11. cracked sidewalk
12. no crosswalk across to playground
13. no dips / cuts in the curb for strollers / wheelchairs
14. From experience, not safe for kids
15. trunk obstruction
16. trunk obstruction
17. tree hangs over
18. dip not aligned
19. sidewalk ends / tree on powerline
20. no curbs
21. no curb cuts
22. no curb cuts
23. speed hump properly marked

Figure 2 (above): Notes matching the map in figure 3.

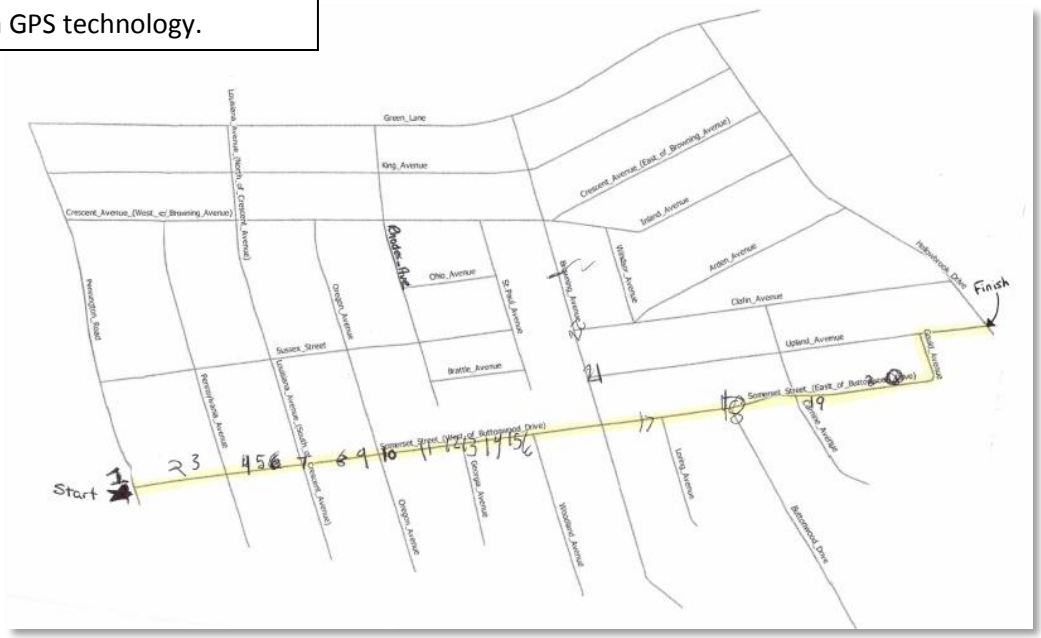


Figure 3 (above): The map for group "Somerset," matching notes in figure 2.

Rationale for using QGIS

Above all else, QGIS[2] (Quantum Geographic Information System) was chosen due to the fact that its principle file type (.shp)[3] is the industry standard and can be most useful to professional planners. Therefore, the efforts of those within a municipality are maximized, in fact exponentially amplified beyond traditional long-form notation and written map making. QGIS is a cross-platform, free, open source desktop geographic information system application that provides data viewing, editing, and analysis. It is written in C++, Python, and Qt but utilizes a learnable and adaptable graphical user interface. Maps and attribute tables created within QGIS can be used in concert with Google Maps and Google Earth's KML[4] file type, but it provides a level of customization and tweaking for a honed purpose that free versions of Google utilities and others does not provide.

The Purpose of Filtering:

Once collected, the data was entered directly into the QGIS project for observation and filtering. Filtering is certainly one of the most visually pleasant and useful reasons to use QGIS. Simple queries can be built to isolate and display data. Choosing from Fields, Operators, and Values, maps can be constructed (like the one shown below) to display *only* the intersections that require curb cuts.

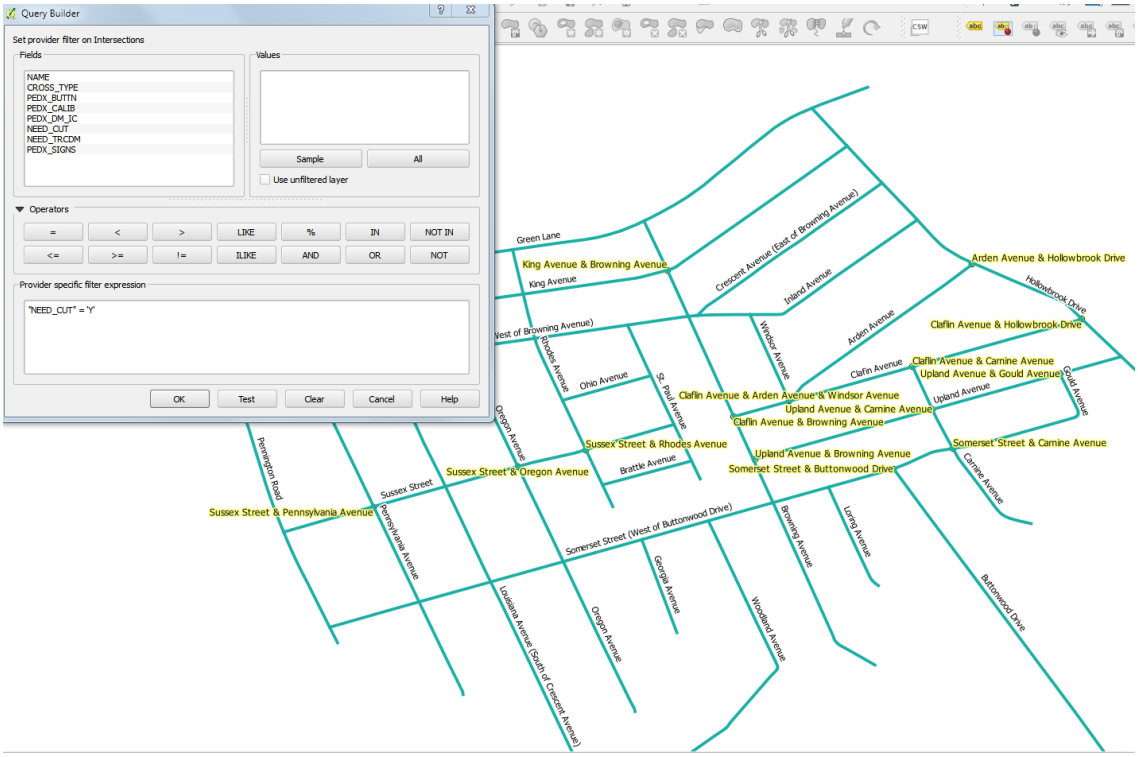


Figure 4 (above): The query "NEED_CUT" = 'Y' returns 16 intersections (in yellow) that need curb cuts.

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[2] http://www.qgis.org/en/site/index.html

[3] The Esri shapefile, or simply a shapefile, is a popular geospatial vector data format for GIS software. Several file types accompany .shp files in order to make it a completely readable and usable package within GIS software.

[4] Keyhole Markup Language is an XML notation for expressing geographic annotation and visualization within internet-based, two-dimensional maps and three-dimensional browsers.

Geotagging and GPS Enabled Photography

By enabling the geotagging feature on GPS capable phones, photographs were able to be shot with proper context and then imported with an average accuracy of 10 meters. Again, taking multiple shots—at least one directly of the object/obstruction and one with surrounding contextual clues—helped the post-import arrangement. The question here is raised, "Why not use Google Earth or Google Maps' street view function?" The answer is that Google Earth's and Google Maps' "street view"—to the surprise of many—do not cover all areas, roads, and certainly not walking paths. The importance of calibrated phones with tagged dates and precise longitude and latitude cannot be overstated for survey purposes.

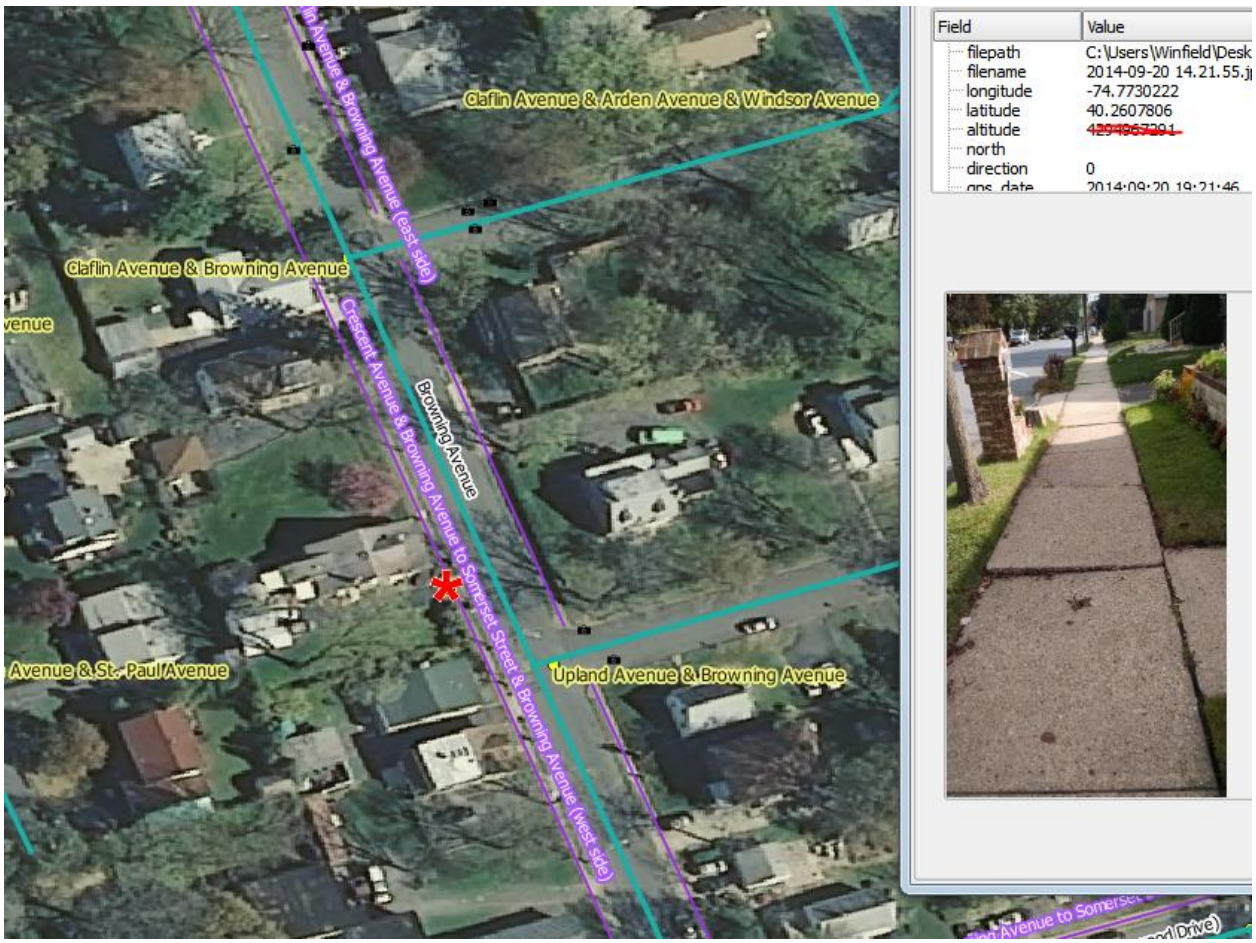


Figure 5 (above): A sidewalk obstruction for wheelchairs and strollers--uneven tiles--photographed and tagged by latitude and longitude within QGIS. The red asterisk displays the location of the photo.

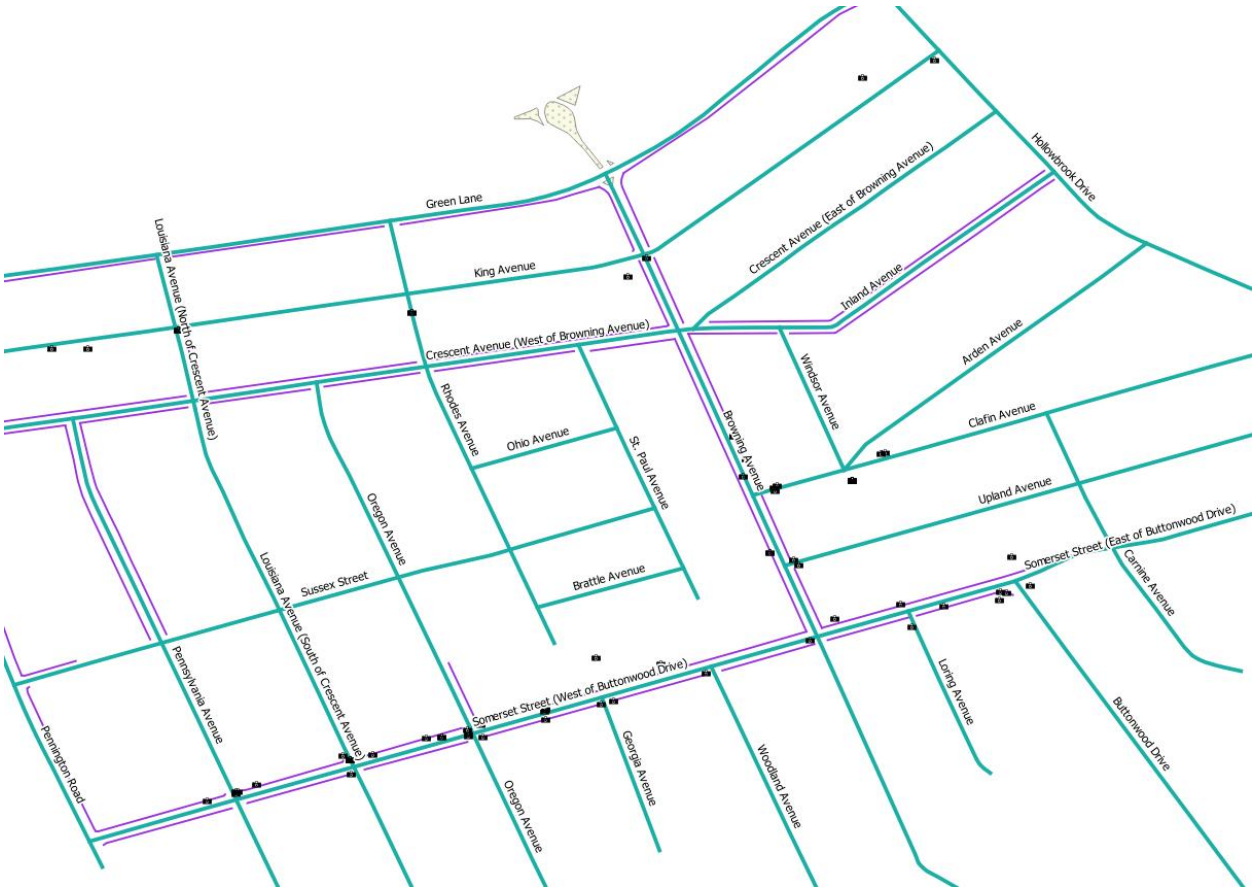


Figure 6 (above): The black camera icons represent where the photos populated after collecting them from group members' phones and uploading via the Photo2Shape plug-in within QGIS, which then uses the eVis plug-in to view the photos.

10 of 71 usable images did not import with proper geotags. This could have been due to low batteries, obstructions, or poorly configured/calibrated phones. Considering time constraints and not going through each phone as a group to confirm proper setup, this was adequate for a trial run.

Major Outcomes

One of the goals in a resource-strapped community is to locate and audit the roads and sidewalks that provide the most potential for redevelopment. Somerset Street proves to be one of them, second to Browning Avenue. Hollowbrook Drive was not fully audited, but I feel certain it would also benefit from redevelopment as it has few sidewalks along the majority of the roadway yet provides critical arterial connections along the north/south axis of the easternmost portion of the neighborhood.

The below skeletal view of purely the sidewalks (*this is for the entire neighborhood*) we saw illustrates the need for optimization and upkeep of sidewalks and the nodes[5] that connect them. Sidewalks were drawn into the QGIS system manually as vector data[6], over top of raster files[7] downloaded from the New Jersey Geographic Information Network in the form of orthophotography for the years 2012-2013.[8] Sidewalks were then confirmed for accuracy of location and completeness / termination during the walking audit.

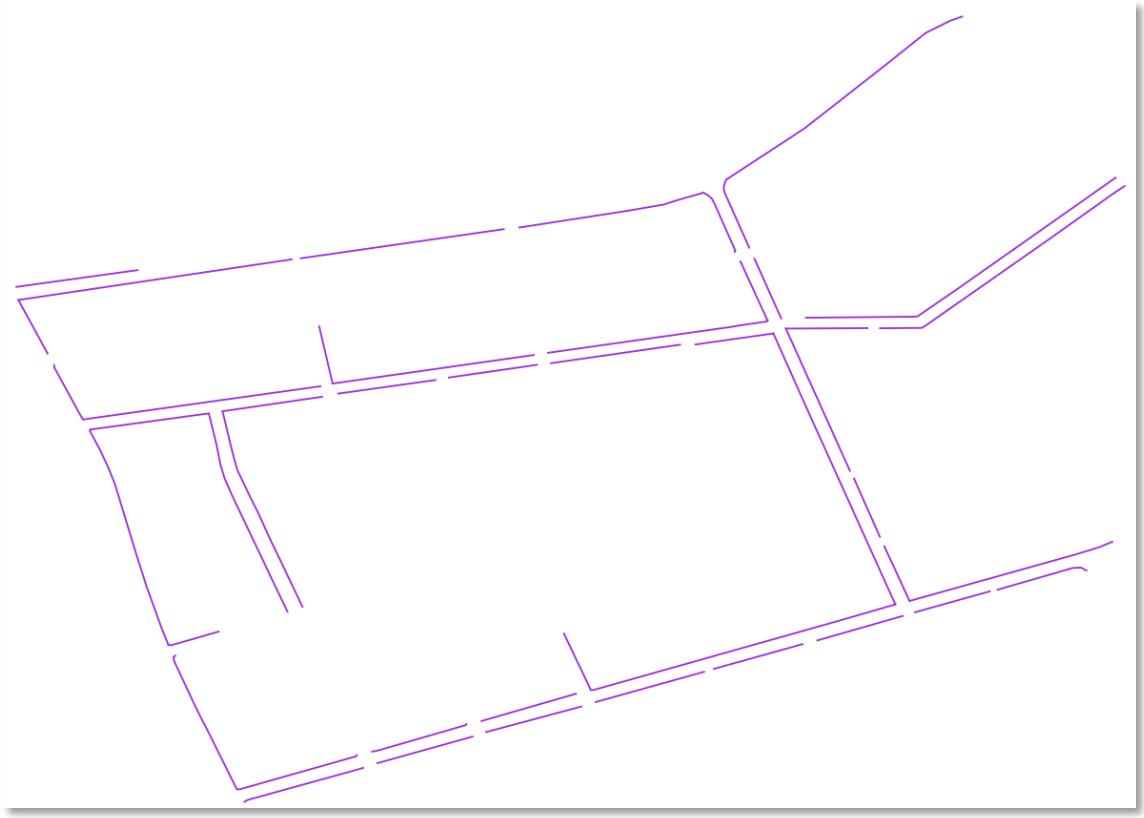


Figure 7 (above): skeletal view of sidewalks. We see at least four sidewalks that terminate before making a node connection. We also see entire blocks with neither sidewalks nor walking paths.

[5] A "node" is defined as a beginning or end point for transportation across a geographic network.
[6] Vector data uses geometrical primitives such as points, lines, and polygons within GIS.
[7] A dot matrix data structure representing a generally rectangular grid of pixels, or points of color.
[8] https://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp

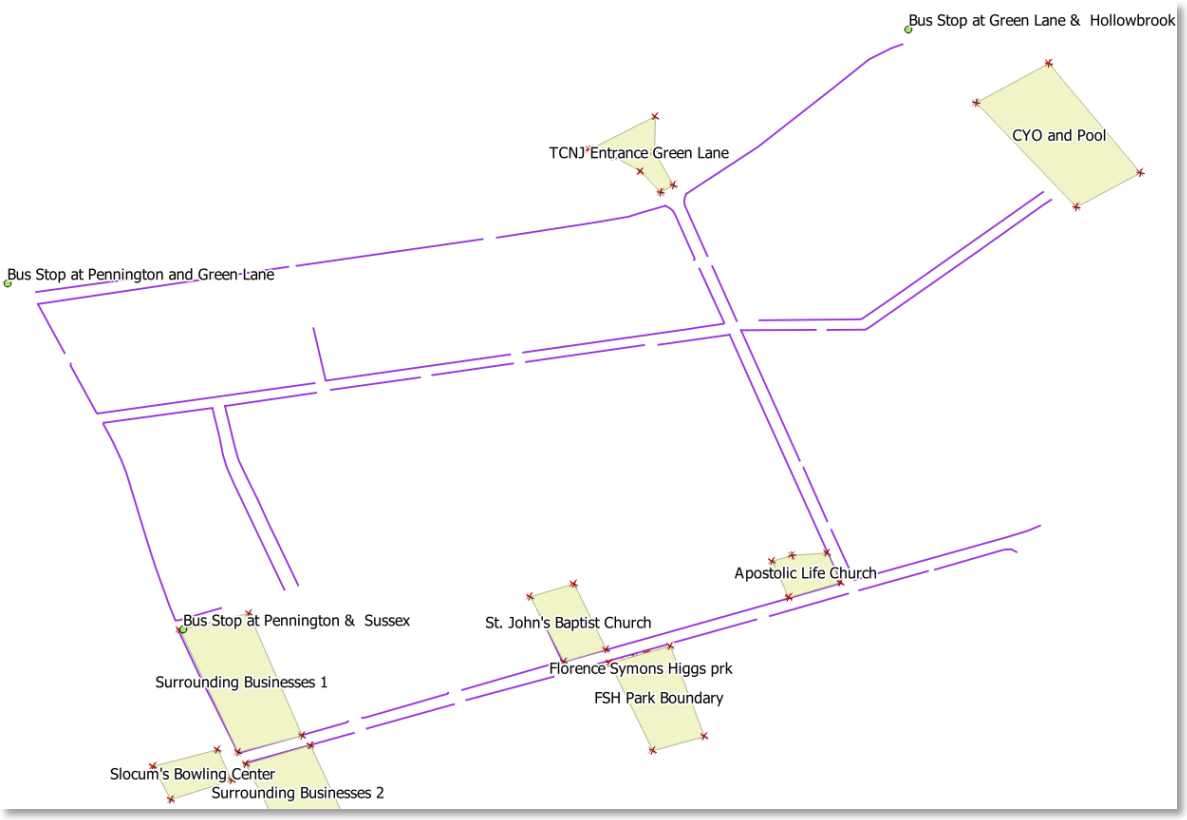


Figure 8 (above): When we pair a map of just a few nearby basic existing community assets with just the sidewalk skeleton, it becomes immediately clear how the average person might travel among destinations.

Biking

Cyclists often cannot be as versatile as pedestrians in selecting paths. Cyclists need to remain on consistent pavings, largely stay off of the sidewalks for safety of both pedestrians and themselves, as well as minimize the length of a detour around a stressful node. While the smaller avenues offer lower speed limits than larger roads, total connectivity must be taken into consideration while redevelopments overlap in order to conserve money spent and maximize their effective output.

Hollowbrook Drive's 25mph speed limit and clean north/south alignment makes it attractive to cycling and all the more attractive northbound due to few intersections on the right side of the road. If a well marked right of way can be established at the TCNJ entrance on Green Lane and Browning Avenue (which is desperately needed for pedestrians as well), that crossing can utilize TCNJ's central node to allow passage for cyclists who need north/south alternatives to Pennington/Rt. 31. With a safe connection to Browning (centermost vertical yellow line), Somerset street (southernmost horizontal yellow line) offers wide roads and major node connections to and from TCNJ (as well as across Ewing neighborhoods east to west). Cycling turn lanes and marked crossings at Green Lane and Browning, Green Lane and Hollowbrook, Somerset and Browning, and Somerset and Buttonwood would offer stronger connectivity with reduced stress of travel.

The Best Roads for Redevelopment: Somerset and Browning

Somerset Street Assets:

- Contains the Apostolic Life Church and St. John's Baptist Church.
- Contains the Florence Symons Higgs community park on the corner of Somerset and Georgia.
- Has a high "safety" feeling rating that is decently lit, and of 1-3 it had threes across the board.
- Boasts a wide, attractive tree line with solid connections to the north side and south side of the neighborhood (via Browning N/S and Buttonwood N/S).
- Has existing contiguous sidewalks.
- Connects to commerce on the west side with the sidewalk on Pennington Road towards Olden Avenue. The intersection poses potential, if rezoned and cleaned up, for more corner stores to supply this and nearby neighborhoods.
- Has no major physical bike obstructions, and is wide enough to support a bike lane.

Somerset Street Needs:

- Bike lines, no doubt about it, or at the very least clean lines of demarcation for the shoulder and a bike icon with signs designating it as a bicycle boulevard.
- Marked pedestrian crossings in the very least at busy connections like Browning Avenue and Buttonwood Drive. Those might also benefit from pedestrian lights.
- Another sweep to clean up brush obstructions and low hanging limbs that would pose trouble this year in upcoming storms, in addition to just being troublesome for strollers and wheelchairs. For example:
    - **14** brush obstructions need clearing along sidewalks.
    - **37** broken tiles, of varying degrees, could be patched. More specificity is needed for the worst of the worst that would cause a stroller or wheelchair to not pass.
- Replaced street signs that are clear of foliage and readable.

Figure 9(below) signage that requires replacing.

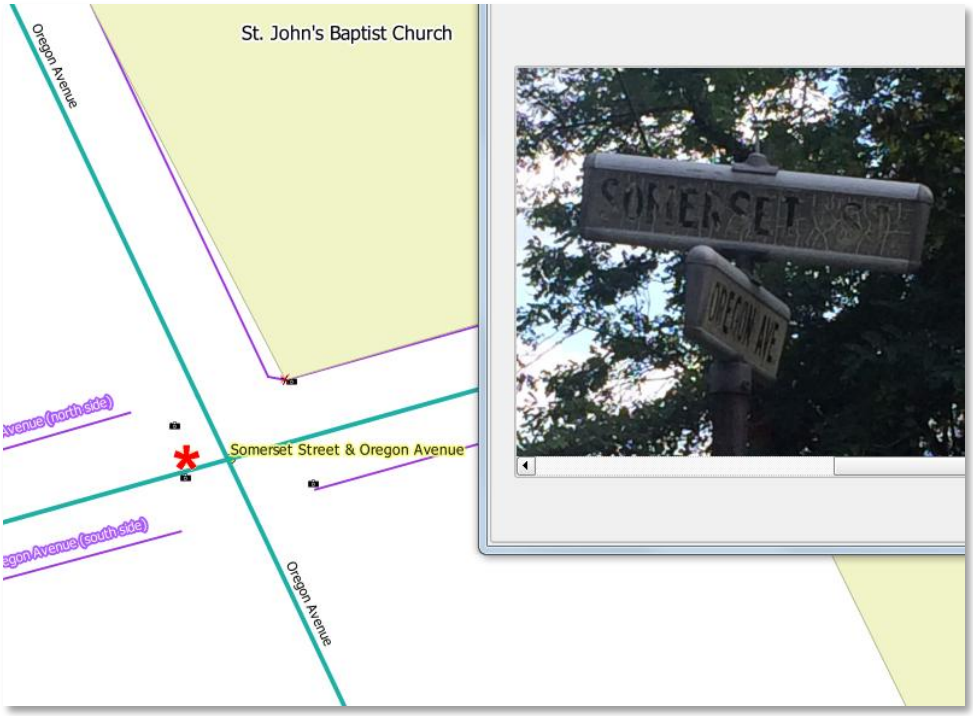


Figure 10 (below) a mid-street crossing would help children cross to the playground.

Sidewalk Termination

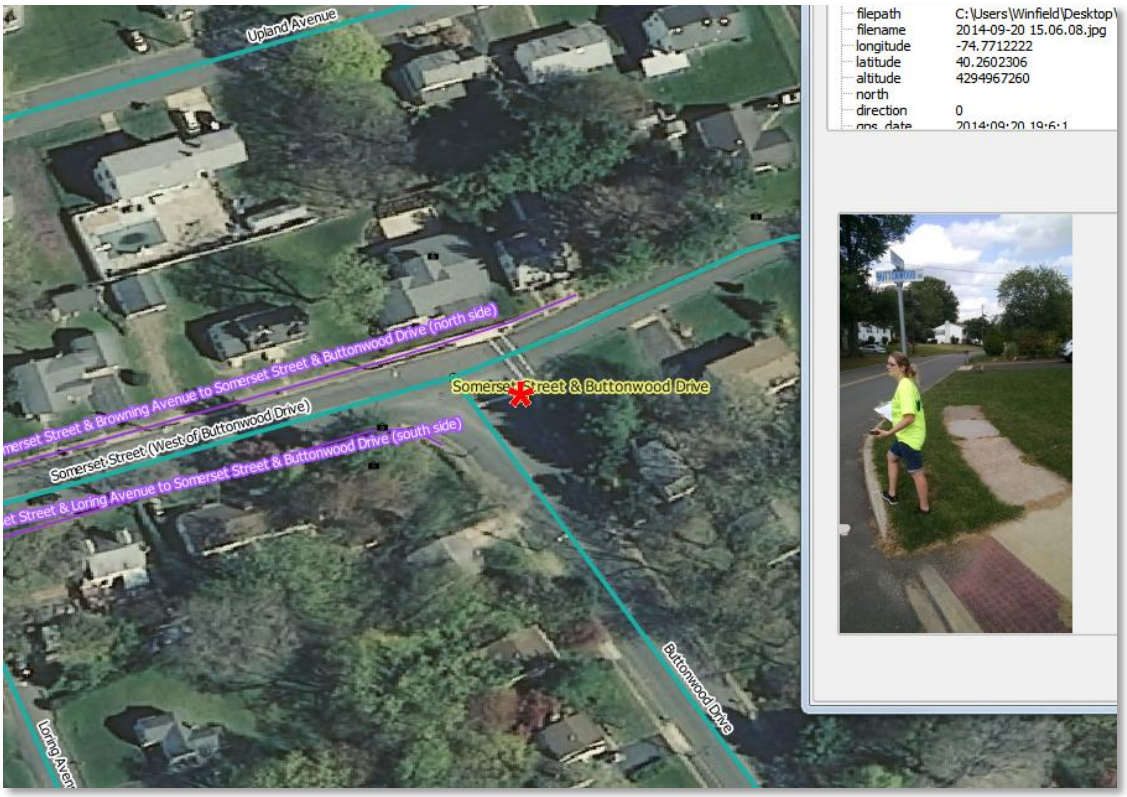
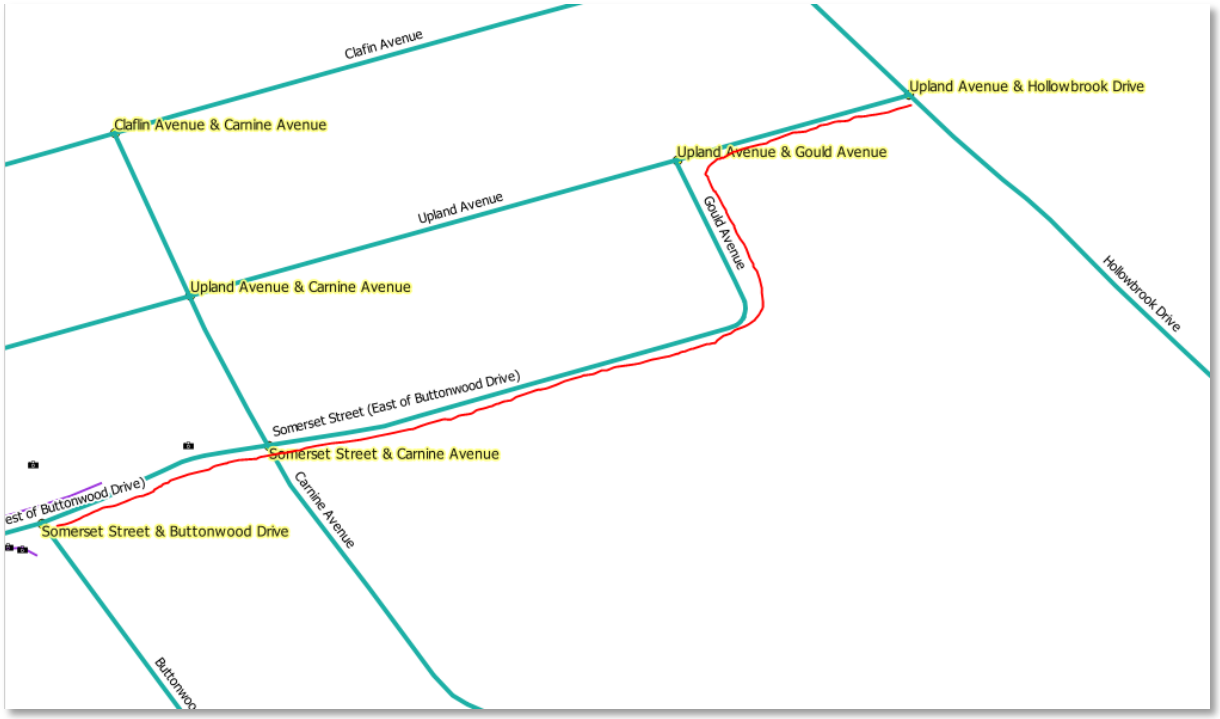


Figure 11 (above and below): At the corner of Somerset and Buttonwood, the sidewalks terminate. To make this a truly usable pedestrian thoroughfare, connecting that last stretch of Gould Avenue to Hollowbrook would be best.

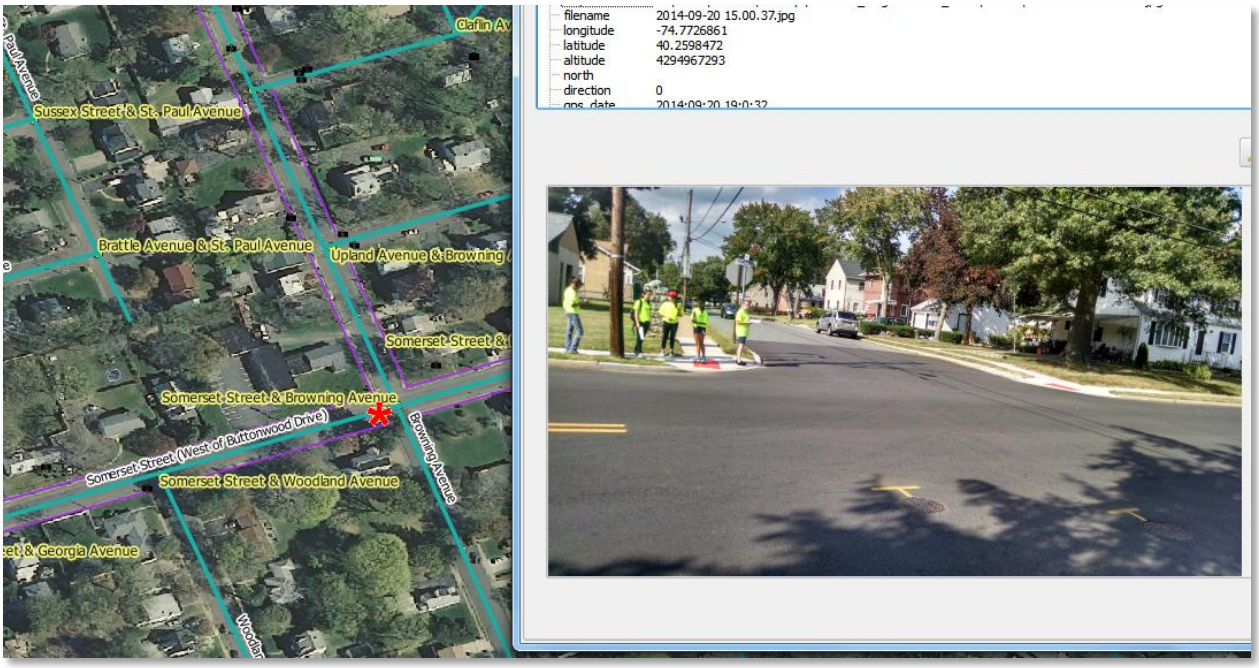


Browning Avenue Assets:

- Browning leads directly to the Green Lane entrance to TCNJ.
- It is the north to south "spine" of Braeburn.
- It has sidewalks, traffic calming speed bumps, and a pleasant aesthetic, but it needs completion.

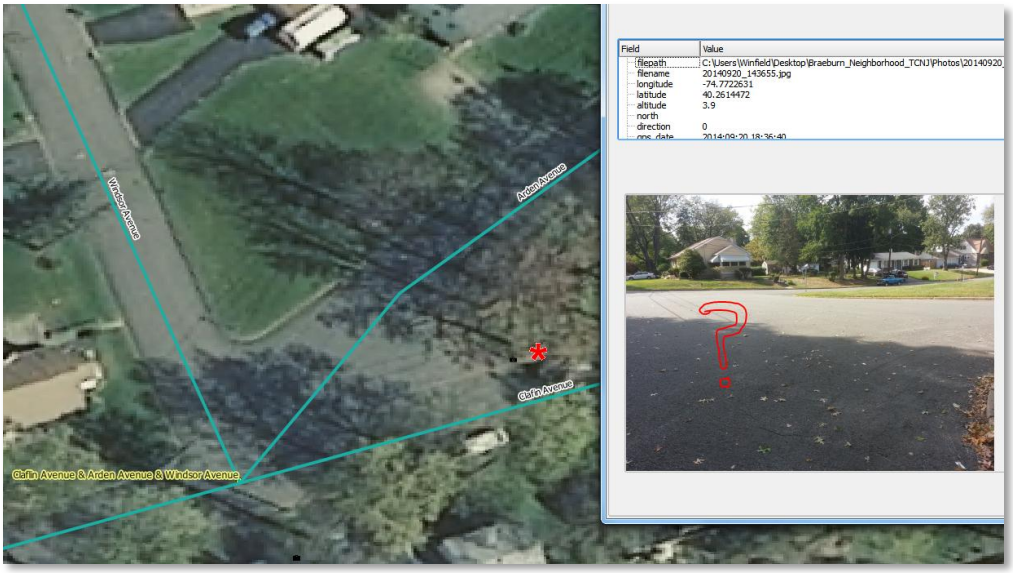
Browning Avenue Needs:

- Curb cuts at the intersections of Clafin, Upland, and King.
- Truncated domes and marked pedestrian crossings at the major tri-intersection of Browning, Crescent, and Inland. This is two blocks south of the TCNJ entrance.
- A pedestrian crosswalk with lights at the Green Lane/Browning Avenue entrance. This is a high pedestrian traffic area.



Claflin, Arden, Windsor Notes:

This intersection (a tributary off of the "spine" Browning) currently has no demarcations, crossings, or sidewalks/curb cuts. Taking this intersection by bicycle is dicey at best and, even with demarcations, will still present a need for extra caution for cyclists and pedestrians alike.



Hollowbrook Drive Notes:

Hollowbrook drive would benefit from sidewalks, of which is has about none, but even more so from a line of demarcation for cycling. This makes Browning the most legitimate North/South road for pedestrians—but not for cyclists, due to tight lanes and parked cars. Hollowbrook contains the CYO and the corner to Green Lane and yet that corner is the *most* dangerous intersection—by far—of the surveyed areas due to the steep hill and blind turn on the higher speed Green lane. This is a high need spot for cheap, basic redevelopments, also considering the frequented bus stop that is a danger to access.

Figure 12 (above) Hollowbrook Drive north-south and Green Lane east-west meet at a bus stop.

Thoughts on Refining the System

Google Maps: As mentioned earlier, Google Maps (and other GPS file creation systems) can be used with Quantum GIS relatively seamlessly. A map made with Google Maps can be exported to KML (Keyhole Markup Language) and imported into QGIS (as well as the reverse).
Reference Sheets: Auditors will benefit from reusable sheets and online digital lists that detail definitions and types of obstructions, assets, and features—as well as provide a quick F.A.Q. for reference in the field.
"Good GPS Practices": Spending more time on ensuring phones are properly enabled and training users to take contextual photos with measurement devices like meter sticks and road signs or points of reference is always a good investment.
Readable Data Sheets: A middle ground between clean data entry and user-friendly labeling is needed, but some standard rules should apply (such as consistent listings of streets in x,y format).
Cloud Collaboration: As the auditing grows, so too should the collaboration among community members. GIS data should be saved in an online repository with copied master files—non editable—so that individuals can work nondestructively on layer data while they learn the system and stitch together record information.
Template Expansion and "Starter Files": The goal is to create "starter files" of maps, data fields, and other project related documents to help community members commence and collect data in a uniformed fashion. The templates need to be expanded but also fluid enough for customization. A modular design is thus critical for success. Being that the QGIS files are arranged in spreadsheets with database file types, it makes this modular block-on-block building possible.
Modeling Best Practices: A truly unified "on the same page" audit team should reinforce the training session with a whole group demo audit of a stretch of road once they arrive in the field, but before they split up. Like any solid lesson, this whole group audit offers reinforcement, opportunities for questions, and opportunities for differentiated learning. Training group leaders ahead of time combined with roaming check-ins makes an audit consistent.

Feedback

From the community – The students received positive feedback from at least three neighbors in the community while walking the streets. A local cyclist stopped and approached the group to not only commend their efforts but also inquire about how to become involved in the efforts. Between both pedestrians and cyclists, community feedback in the field was voiced and positive.

From the students – As the group of students pointed out, freedom of choice within structure is important for keeping participants engaged and levels of frustration low. Consistent methods of data entry need to be balanced better with user-friendly sheets. Ample training time and supplemental informational pages are worthy investments. Pertaining to the need for redevelopment, one student mentioned in the project reflection a moment of visceral understanding when a young boy ran across the street at an unmarked intersection on Somerset Street, between moving cars. "We gasped," she said. Participant feedback was invaluable and many thanks are given to their efforts.

References

New Jersey 2012 - 2013 High Resolution Orthophotography, NAD83 NJ State Plane Feet, MrSID Tiles
https://njgin.state.nj.us/NJ_NJGINExplorer/ShowMetadata.jsp?docId={DF49386A-73AC-4A1A-B6DC-13B769E176A4}

The College of New Jersey Bonner Institute for Civic and Community Engagement:
http://bonner.pages.tcnj.edu/

Sustainable Ewing Green team:
http://ewinggreenteam.org/

Quantum GIS:
http://www.qgis.org/en/site/

Quantum GIS documentation:
http://www.qgis.org/en/docs/index.html