Hydrologic Modeling with LIDAR

Dr. Dean Djokic, Esri Inc.

LARIAC4 Status and User Group Meeting
January 28, 2016

Stormwater Drainage System Implementation Using Arc Hydro and LARIAC LIDAR Data

What is Arc Hydro?

- Template database design and design principles
- Free toolset for advanced water resources functionality (~250 tools)
- Implementation strategy philosophy and best practices
- Available since 2002 for all desktop versions of ArcGIS (including current transition to Pro)

Basic Arc Hydro Design Concepts

- Define core feature classes for water resources analyses
- Establish relationships between core feature classes
- Use geometric network for tying pieces together
- Mobilization of standard ArcGIS functionality
- Custom tools for some of the attribute management
- Custom tools for advanced “water resources” functionality

The Arc Hydro Implementation Mantra

- Arc Hydro is a "system" of tools and data structures that work in unison to provide rich and effective experience for GIS users in water resources community.
- If you are using Arc Hydro, you will most likely be doing ANALYSES – there are important considerations for GIS implementation when doing analyses that are different than using GIS just for mapping. Respect that.
- When using the tools, you are building a "system", not just using a "bunch" of independent tools to produce a "bunch" of independent data.
  - Of course, there are plenty of Arc Hydro tools that can be used independently of the "system". Use them as such and enjoy.
- When starting an Arc Hydro project, think ahead of the system you will be building. Plan ahead. Organize, then execute.
- Keep it simple – Ockham's Razor is alive and well!
- Do not reinvent the wheel, leverage established processing workflows.
- Analytical system, analytical system, analytical system, …

Arc Hydro Storm Water Implementation (1)

- Leverage vector drainage representation for movement through drainage infrastructure (pipes, channels, inlets).
  - Use geometric networks and vector data
- Leverage raster drainage representation for overland flow until drainage infrastructure is reached.
  - Use Spatial Analyst and raster data
- Use Arc Hydro tools for preprocessing and execution.

Arc Hydro Storm Water Implementation (2)

- Drainage infrastructure – fully integrated geometric network:
  - Pipes (below surface - no direct surface contribution). Edges.
  - Channels (direct surface contribution). Edges.
  - Inlets (direct surface contribution – ties surface and pipe components). Junctions.
- Terrain model. Derivation of drainage areas contributing to inlets and channels (sinks).
- Relationship class between drainage areas and inlets and channels to connect overland areas to inlets.

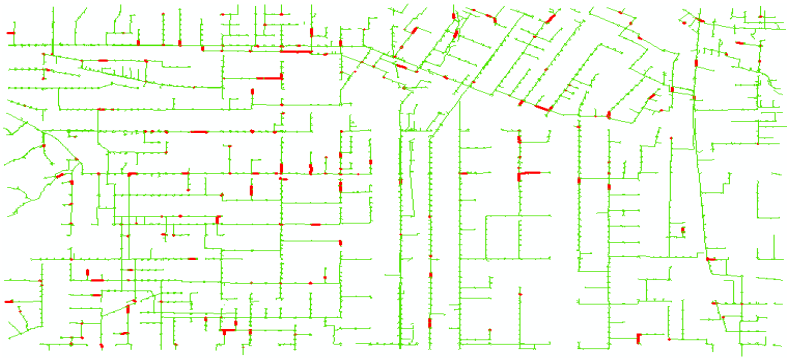
Arc Hydro, LARIAC LIDAR, and Stormwater Infrastructure Data in Action

Data Review – No Such Thing As Perfect Data

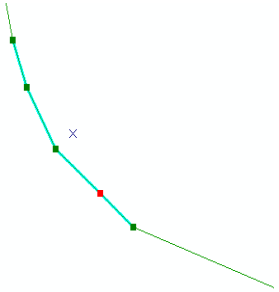
- Drainage infrastructure (lines and points):
  - Connectivity
  - Directionality (lines)
  - Attributes
  - Completeness
- LIDAR:
  - Horizontal/vertical accuracy
  - Bare terrain derivation methodology and artefacts
- DEM:
  - Point to raster conversion artefacts

Data Review – Some Examples

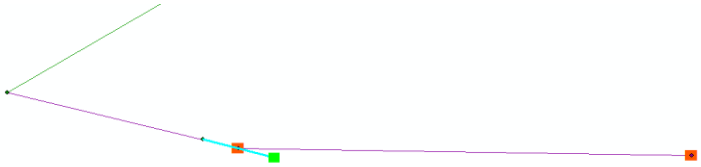
- **Overlap**



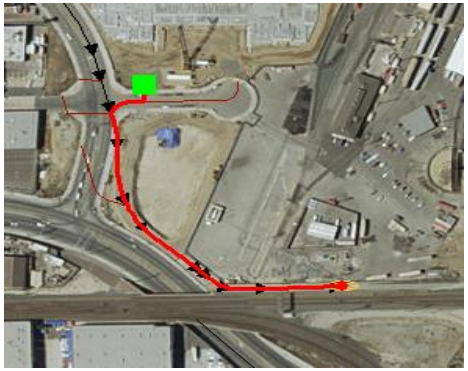
- **Internal loops**



- **Connectivity**



- **Crossing lines**

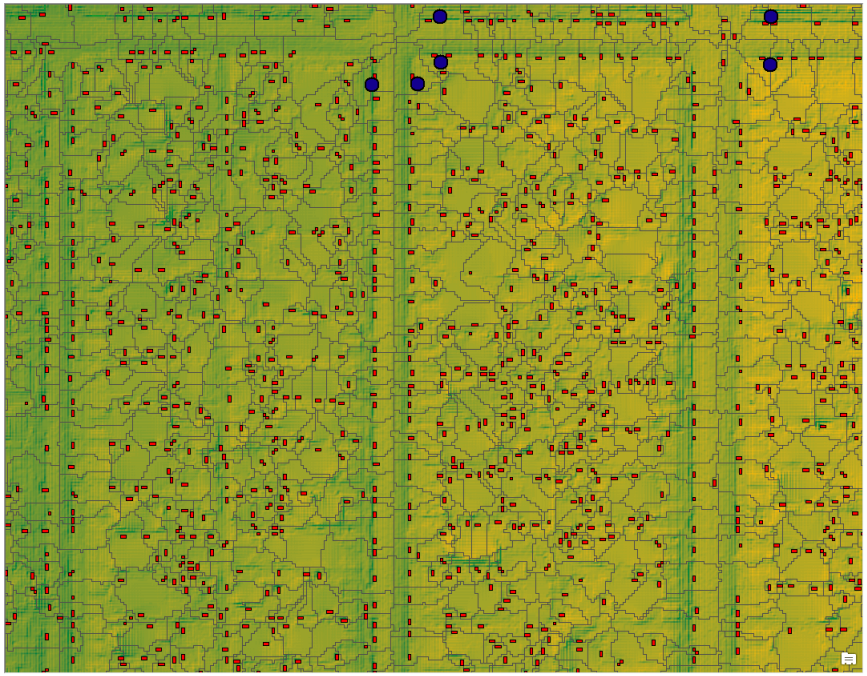


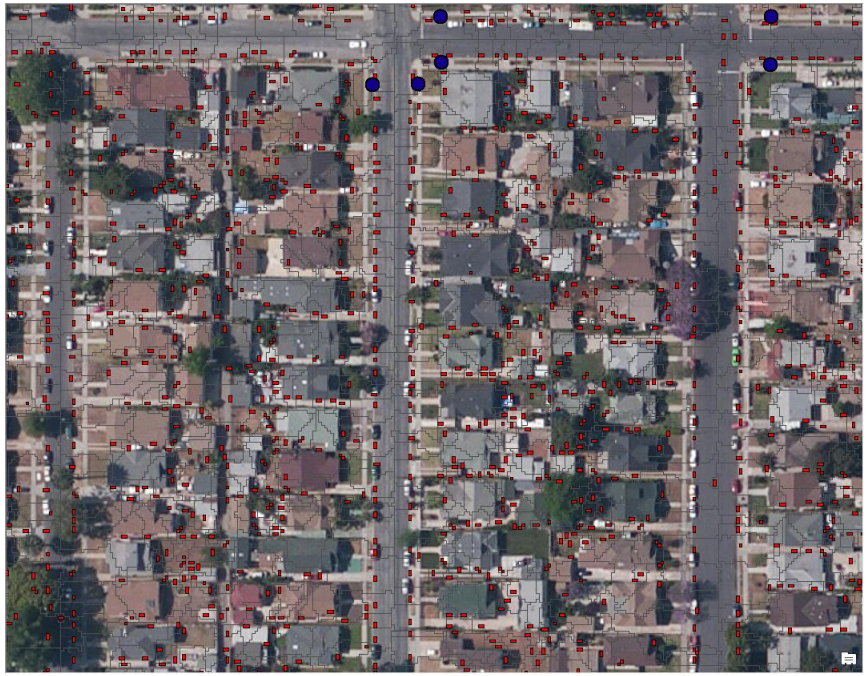
“Drainage” Role Assignment

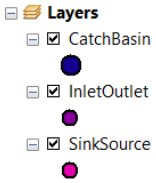
- Point water collectors – collect water and pass it to the conveyance system
  - CatchBasin, InletOutlet, SinkSource (ancillary role of Sink/None)
- Open linear structure – collect and convey water
  - NaturalDrainage, PseudoLine, OpenChannel
- Closed linear structure – only convey water
  - GravityMain, PermittedConnection, LateralLine

“Raw” Terrain Processing

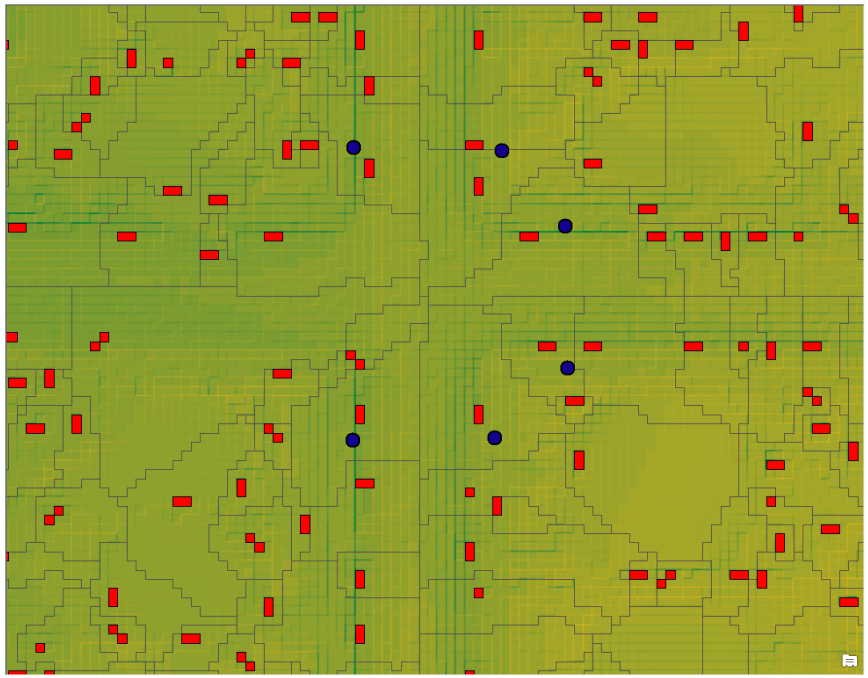
- Use “raw” LIDAR derived 3ft DEM as is and identify depressions.

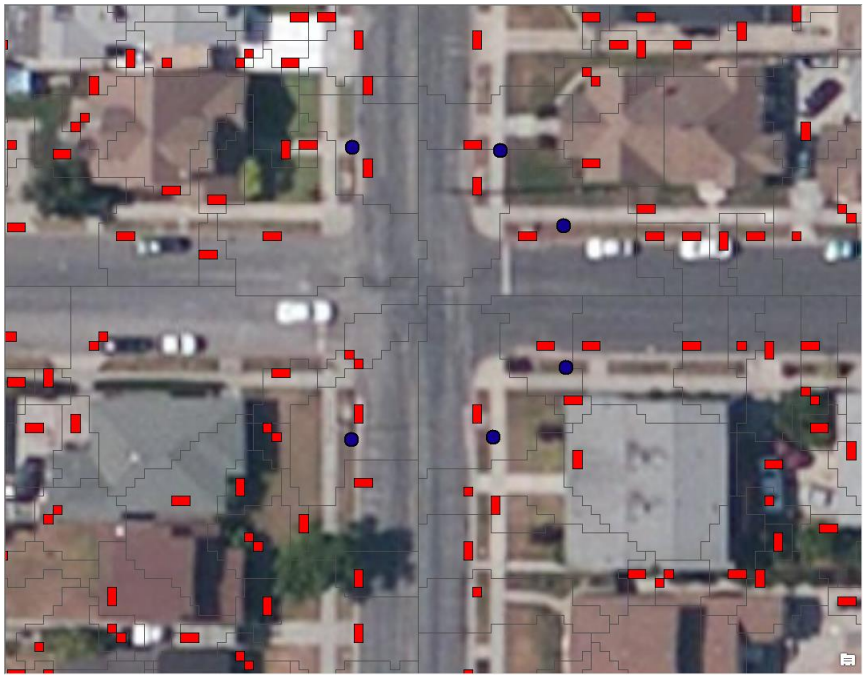


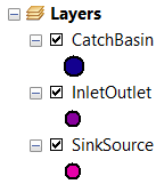




“Raw” Terrain Processing







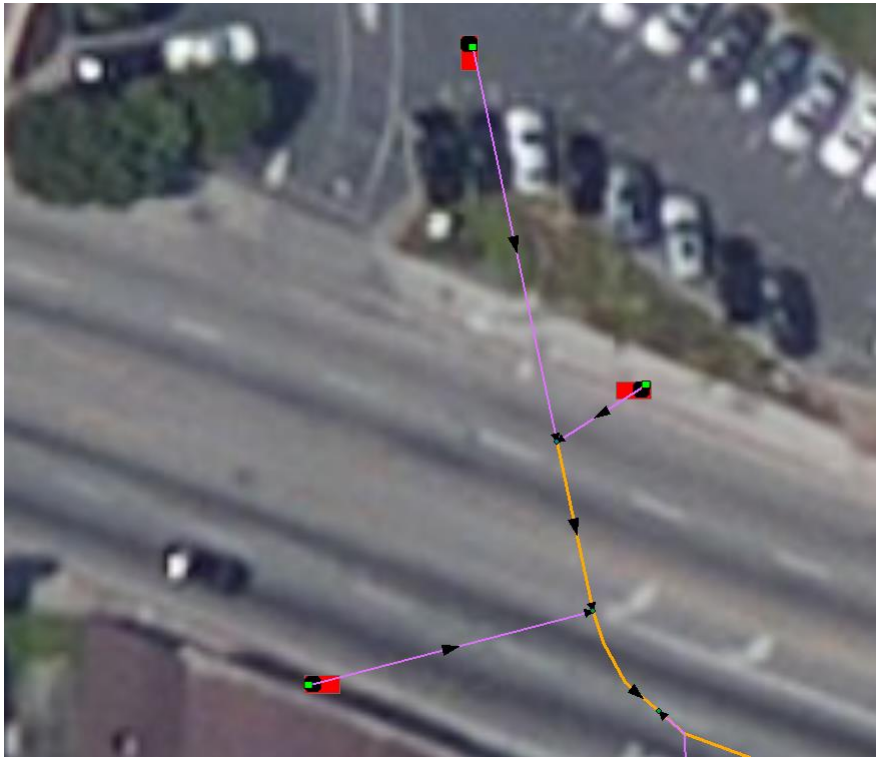
- Need help in “raw” DEM flow pattern interpretation.

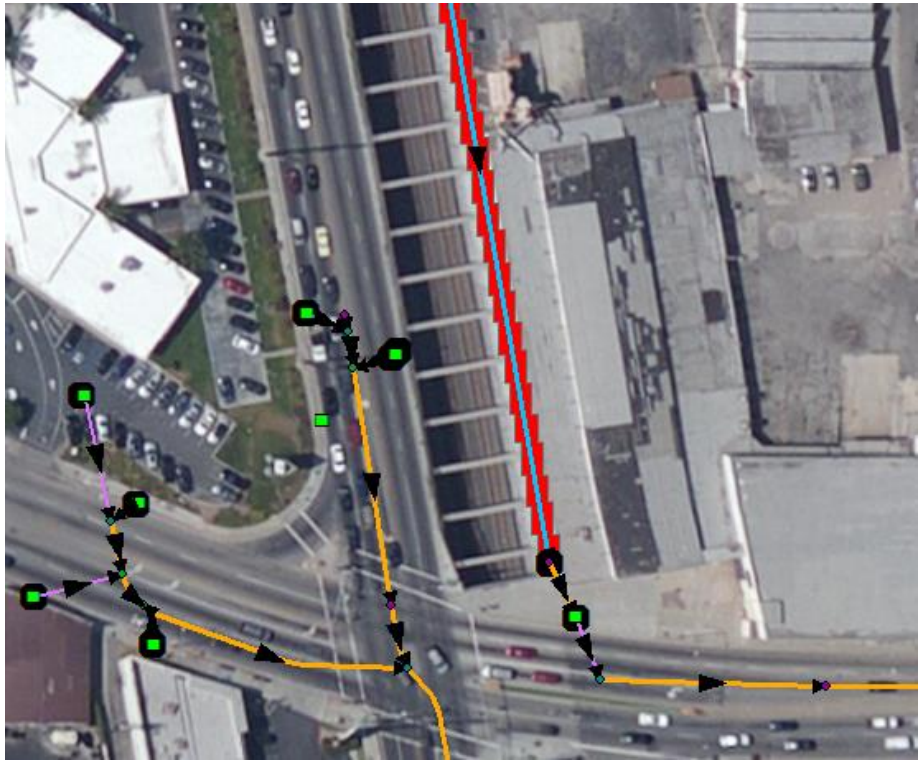
Terrain Reconditioning

- "Help" the data with processing methodology
  - Enforce the role – define "collector" elements as sinks to attract water (buffer around to get sink polygons or use alternative sink poly definition techniques).
  - Ignore imperfections in the DEM by filling depressions in the DEM outside of the sink polygons.

Terrain Reconditioning – Technique 1

- Burn point features by 2 cells in the direction of underlying pipe
- Buffer line collectors by 6 ft





Terrain Processing

1. Define sink and sink point
2. Create Sink Structures (raster representation)
3. Level DEM (using offset)
4. Fill Sinks (except in sink polygon)
5. Flow Direction
6. Adjust Flow Direction in Sinks (to force water to flow towards the sink point)
7. Sink Watershed Delineation (create watersheds associated with the structures)
8. Add to structure in DrainID the HydroID of associated SinkWatershed
9. Create relationship between the structures and SinkWatershed

(#8 and #9 only implemented on CatchBasin for now)

Watershed Delineation

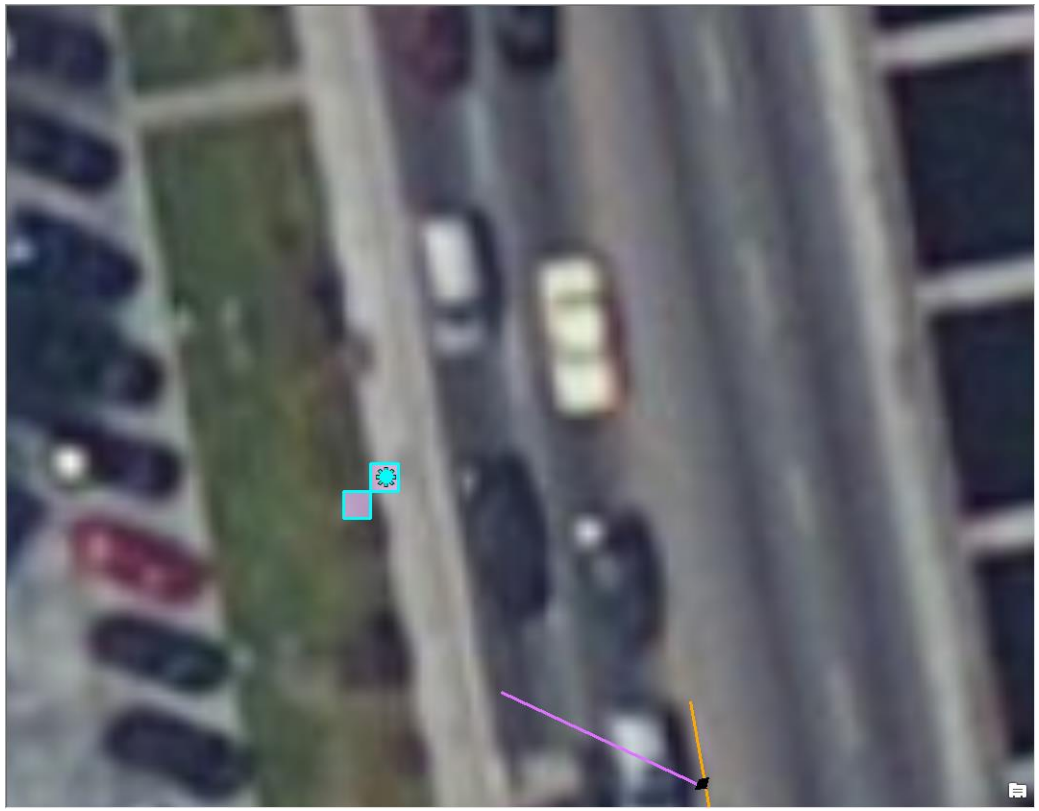
- Four “types” of delineation (different outcomes)
  - On CatchBasin feature (sink)
  - On land
  - On open channel
  - On closed pipe

Watershed Delineation

- Four “types” of delineation (different outcomes)
  - On CatchBasin feature (sink)

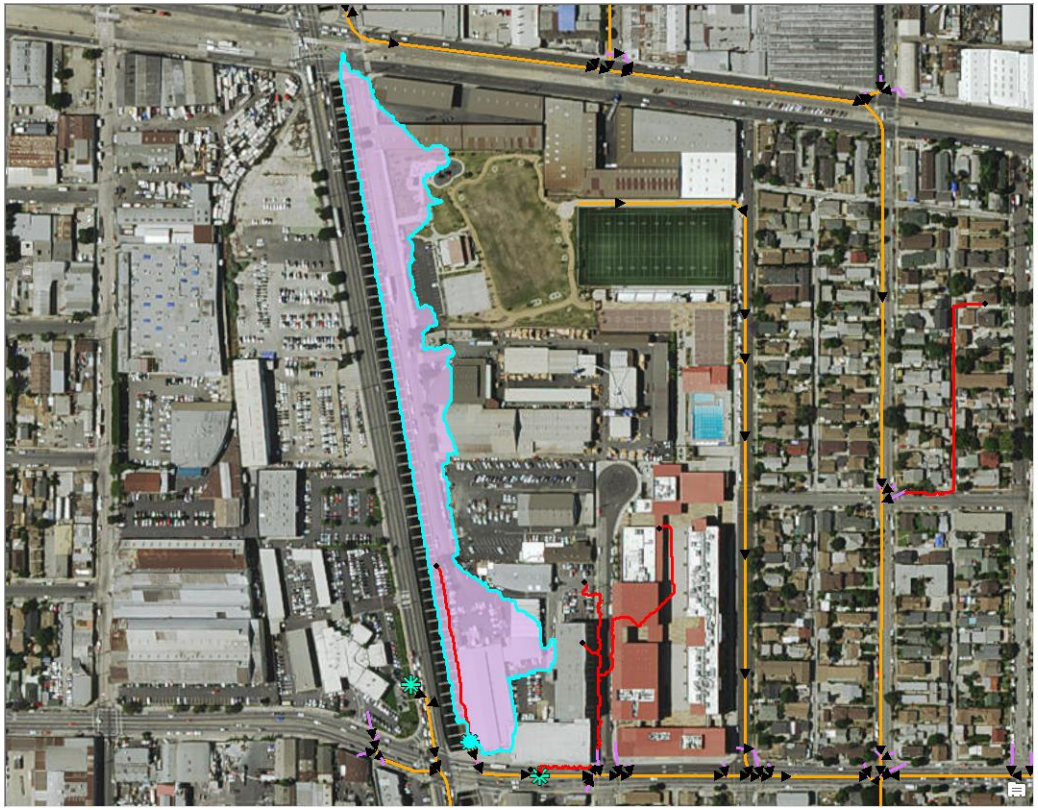
Watershed Delineation

- Four “types” of delineation (different outcomes)
  - On land



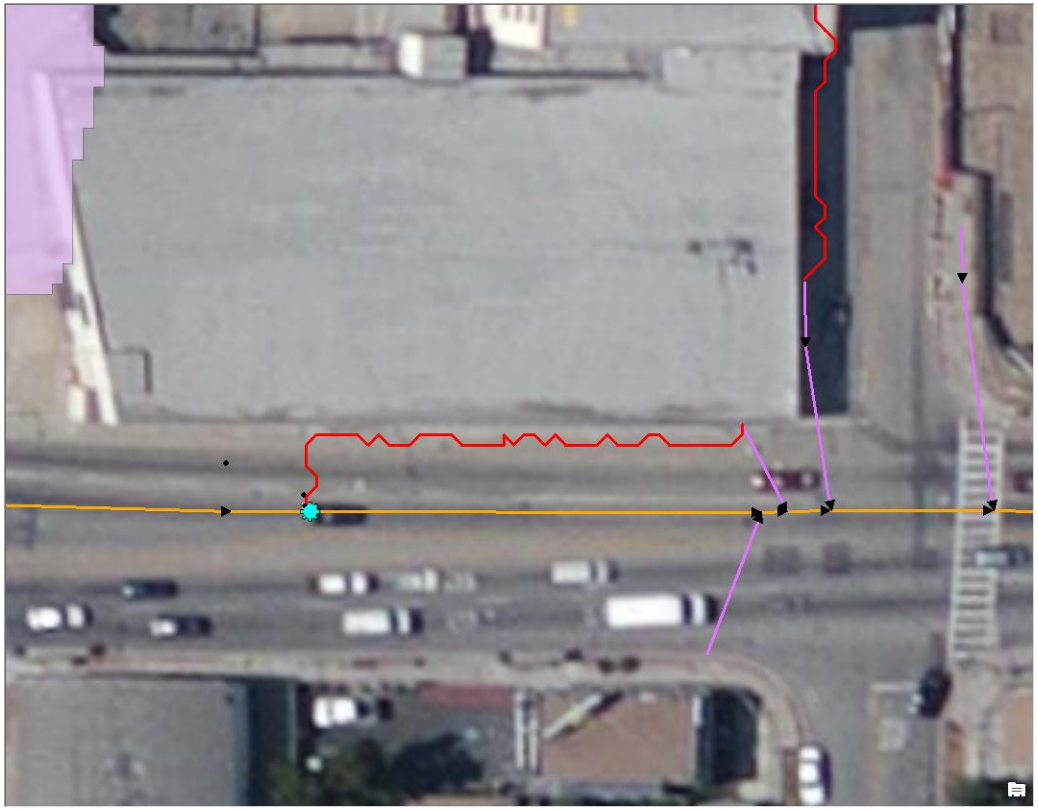
Watershed Delineation

- Four “types” of delineation (different outcomes)
  - On open channel



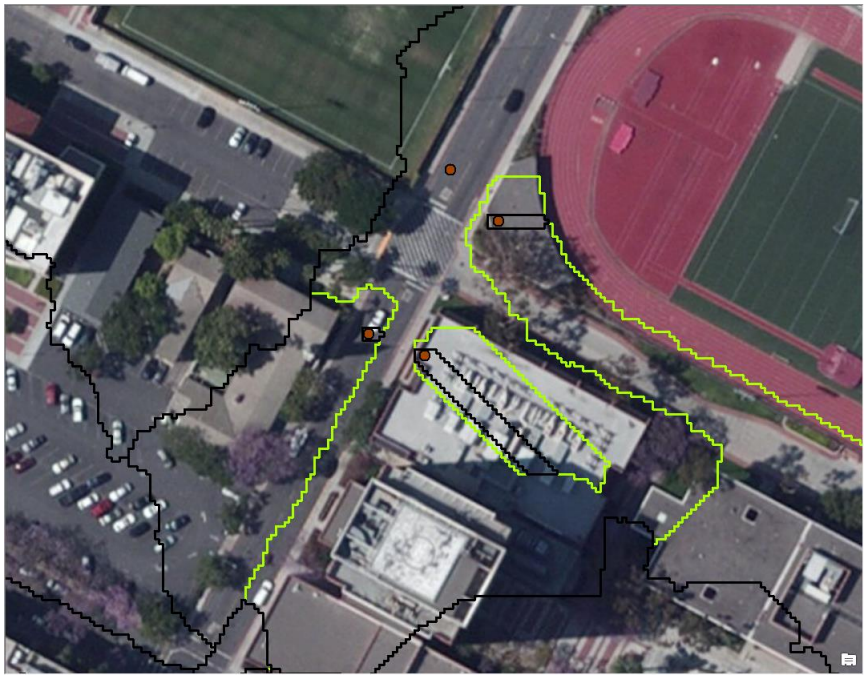
Watershed Delineation

- Four “types” of delineation (different outcomes)
  - On closed pipe



Terrain Reconditioning – Technique 2

- **Burn point features by 6 ft** (focus on local comparison, so pipes were not burned)



Hydrology and Hydraulics Discussion

H&H Discussion

- Fully developed stormwater infrastructure and DEM based watershed delineation and characterization functionality provide foundation for hydrologic and hydraulic modeling.
- For design modeling (e.g. 25-year capacities) using standard design techniques (e.g. Rational or SCS methods) most of the work can be done within GIS.
- Additional spatial data like impervious cover, land use, precipitation, can be easily mobilized using existing tools.
- For dynamic modeling, an external numerical model linked to GIS database would be required.

Conclusions

Conclusions

- LARIAC DEM can be quickly mobilized for watershed delineation purposes that make foundation for hydrologic and hydraulic modeling.
- Even the 3ft resolution DEM needs “help” in properly identifying drainage patterns.
- Availability of good stormwater infrastructure is critical for proper results.
- Exiting Arc Hydro tools and processing workflows provide most of required functionality.
- Final results are sensitive to techniques and parameters used in terrain processing.

Questions