A Socioeconomic Analysis of the Spatial Distribution of Fire Hydrants

By
Dylan Carmody
Robert Chappell
Jana Tracy

Allan McMillian 2003

History of Portland Fire Hydrants

- The first fire hydrant was installed in Portland in 1885
- There are 2000 miles of pipe and 13,000 fire hydrants in Portland
- Portland has an unusual and varied fire hydrant population
- Many of the old hydrants are still used today
- Question: Are these hydrants evenly distributed?

1886-1894

1912-1913

1930's

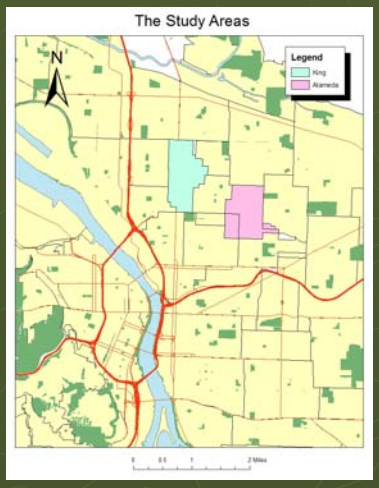
1930's

Allan McMillian 2003

Choice of Neighborhoods

Hypothesis:

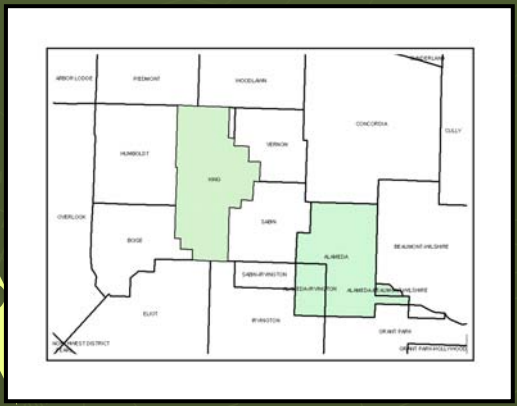
- Are Fire Hydrants Spatially Biased Towards Geographic Locations With Affluent Populations?



Criteria for Conducting Portland Neighborhood Fire Hydrant Analysis

- Land acreage similar in size
- Established Neighborhoods developed in the same time period
- Neighborhoods with similar population
- Neighborhoods with differing demographics

Acreage of King and Alameda Neighborhoods

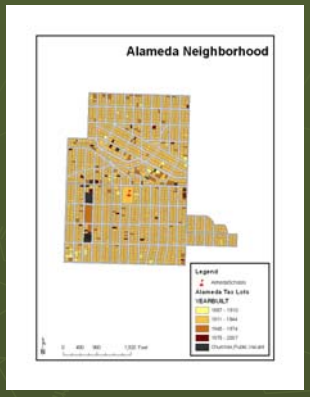


KING NEIGHBORHOOD
Polygon feature
Perimeter: 20,433 Feet
Area: 397 Acres

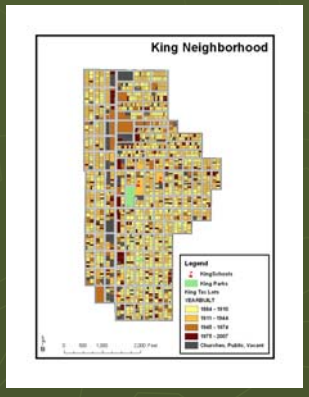
ALAMEDA NEIGHBORHOOD
3 Polygon features
Total Perimeter: 29893 Feet
Total Area: 393 Acres

Development of Neighborhoods

By use of Commercial and Residential Buildings

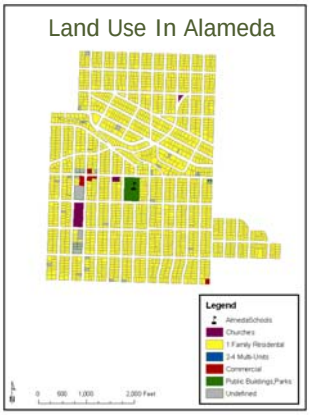


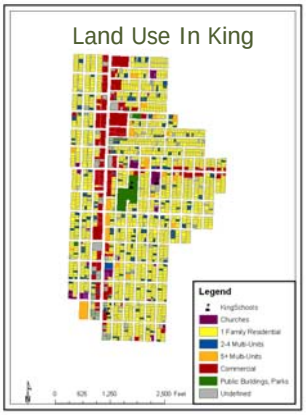
Number of Buildings: 2036
Minimum age: 1890
Maximum age: 2006
Mean age of buildings: 1927
Standard Deviation:12



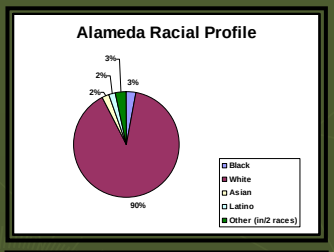
Number of Buildings: 2069
Minimum age: 1884
Maximum age: 2007
Mean: 1926
Standard Deviation:31

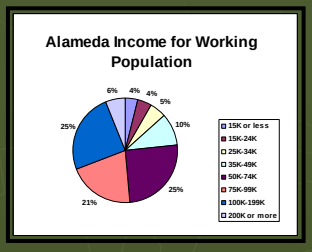
Land Use of Alameda and King Neighborhoods

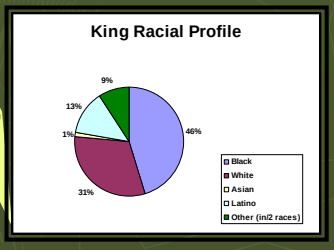


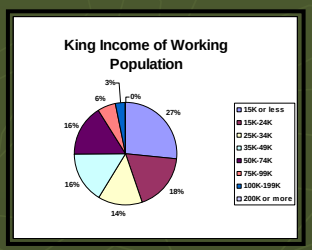


Population Demographic Differences









Determining Distance From Taxlots To Hydrants

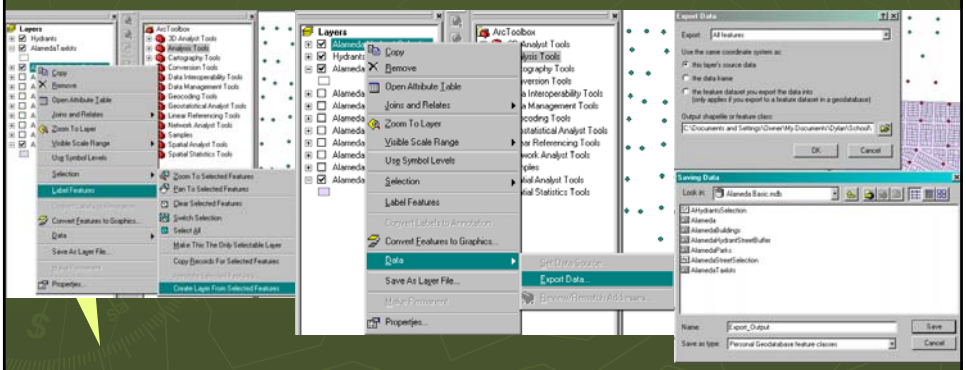
- Centroid Method
- Buffer Method
- Combined Method

Centroid Method Process

1. Select hydrants to be used and clip (create layer from selected features, export data as feature class into geodatabase)
2. Clip taxlots to neighborhoods (clip tool)
3. Create Centroids (feature to point tool)
4. Calculate distance from taxlot centroid to closest hydrant (near tool)
5. Join centroid data to taxlot data (Spatial Join tool)
6. Display results in a graphically pleasing way

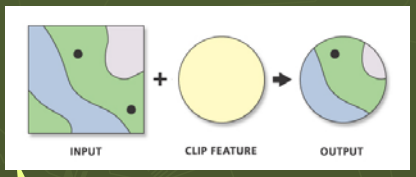
Selecting Which Hydrants To Use

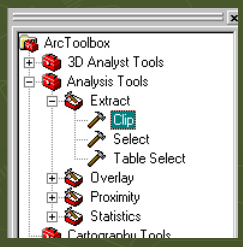
- Hand chosen and selected to cover the entire neighborhood.
  (create layer from selected features, export data as feature class into geodatabase)

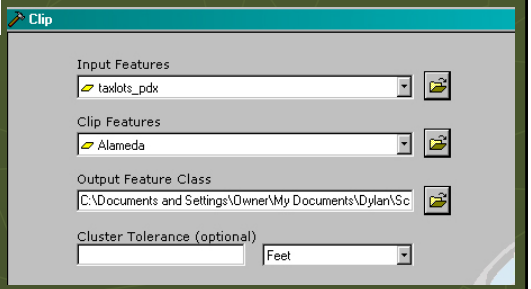


Clipping taxlots to neighborhoods

- Clip tool (under Analysis Tools, Extract)

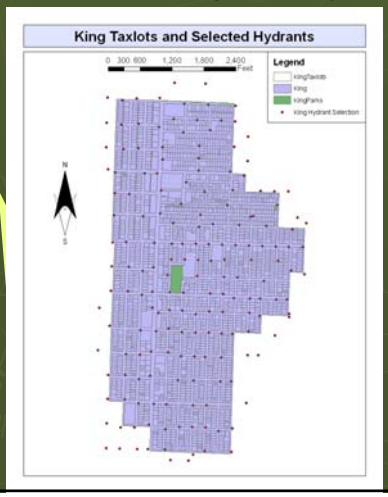


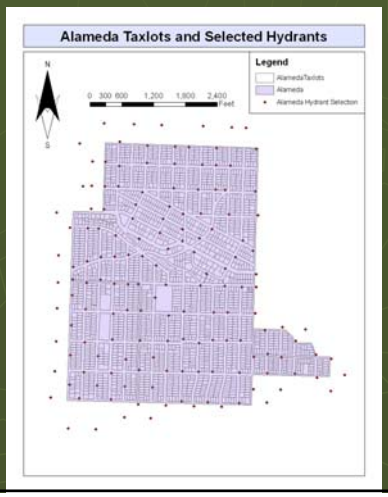




Preproduction Data For Both Neighborhoods

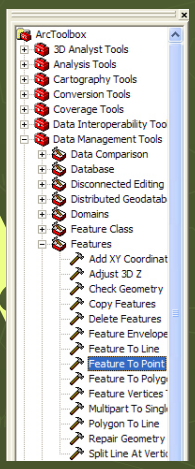
- Select hydrants to be used and clip (hand selected and create layer from selected features, export data as feature class into geodatabase)
- Clip taxlots to neighborhoods (clip tool)

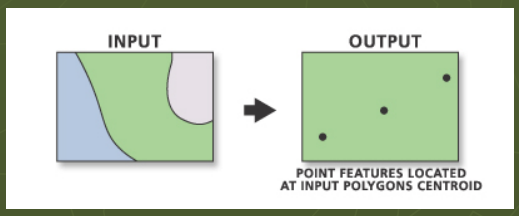


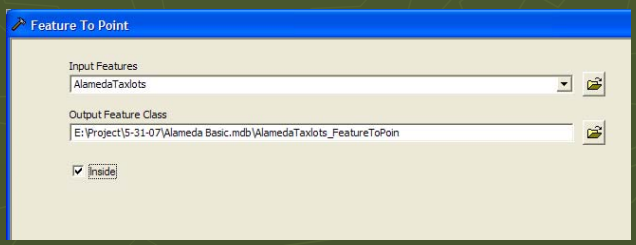


Creating Centroids

- Feature to point tool (under Data Management Tools, Features)



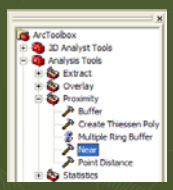


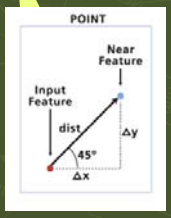


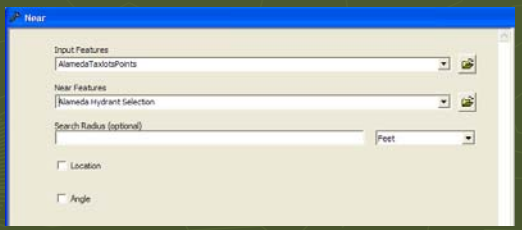
Taxlot Centroids

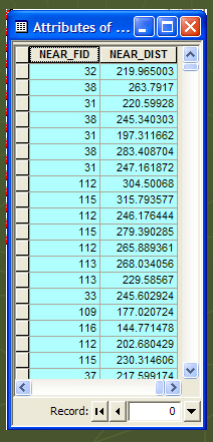
Calculate distance from taxlot centroid to closest hydrant

- Near tool (Analysis Tools, Proximity)



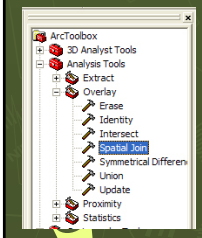


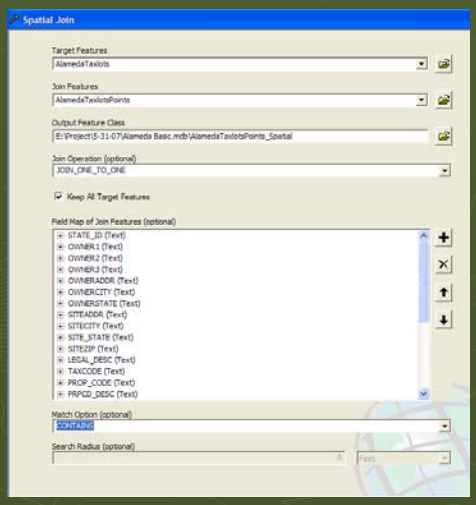


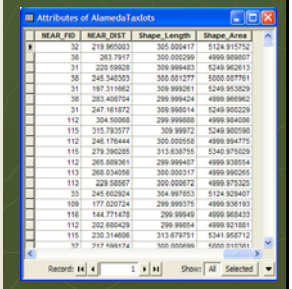


Join centroid data to taxlot data

- Spatial Join tool (Analysis Tools, Overlay)

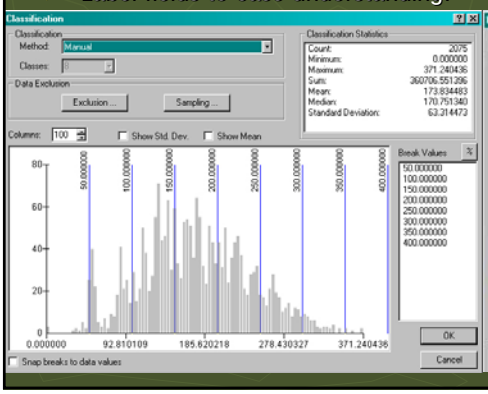


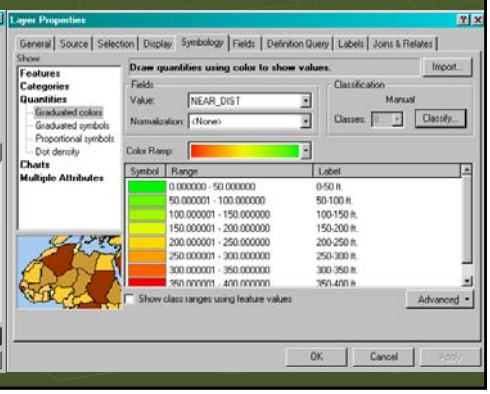




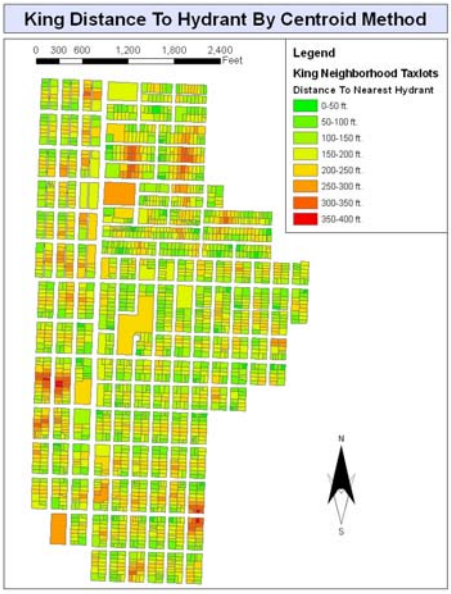
Display results in a graphically pleasing way

- Manual Classification into groups of 50 ft. intervals. (50 ft. is the length of a typical fire hose.)
- Choose color ramp that displays coverage in an easily interpretable way.
- Label fields to ease understanding.





Distance From Taxlots To Hydrants By Centroid Method

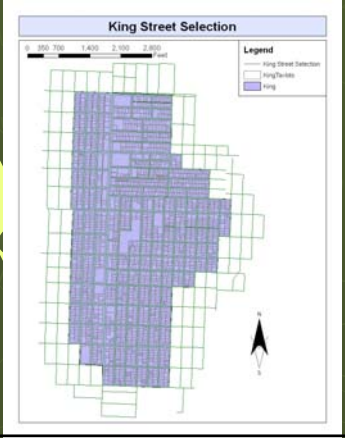


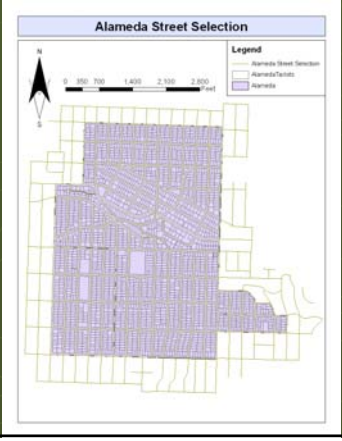
Buffer Method Process

1. Select hydrants to be used (create layer from selected features, export data as feature class into geodatabase)
2. Select streets to be used (create layer from selected features, export data as feature class into geodatabase)
3. Buffer selected hydrants at 50 ft. intervals starting at 50 and ending at 500 (multiple ring buffer script)
4. Buffer neighborhood streets at 30 ft. to either side of the line (buffer tool)
5. Combine hydrant and street buffers to create Neighborhood hydrant street buffer (Intersect tool)
6. Use clipped neighborhood taxlots and hand enter highest value of Neighborhood hydrant street buffer that touches each taxlot, add field to taxlot attribute and call HYD_DIST (Editor toolbar)
7. Display results in a graphically pleasing way

Selecting Streets To Use

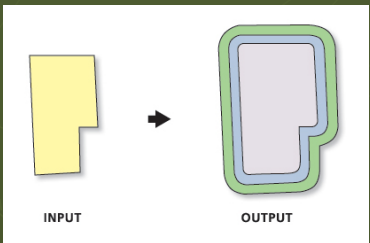
- Hand chosen and selected to cover the entire neighborhood.
  (create layer from selected features, export data as feature class into geodatabase)
- This was done because when I tried clipping the streets to the neighborhood the process kept resulting in a triangular network that resembled a TIN coverage. (Later in the term I tried the clipping process again and it worked fine)

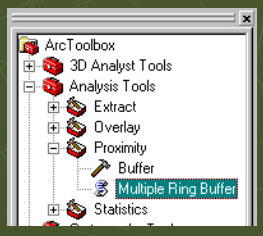


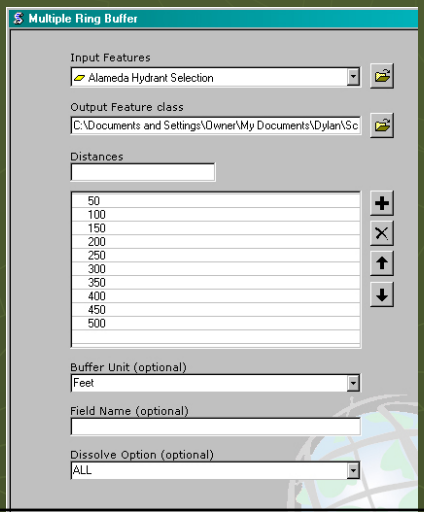


Buffering The Selected Hydrants

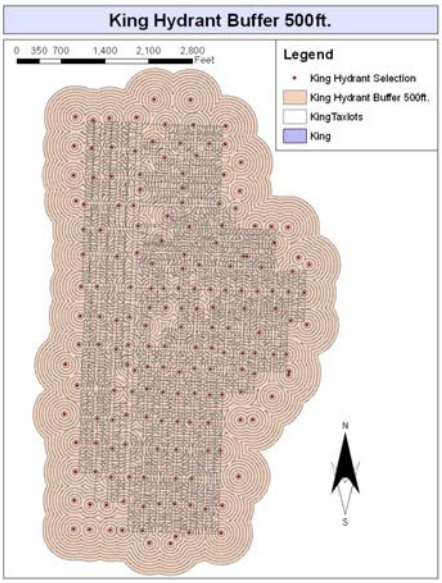
- Multiple Ring Buffer Script (under Analysis Tools, Proximity)

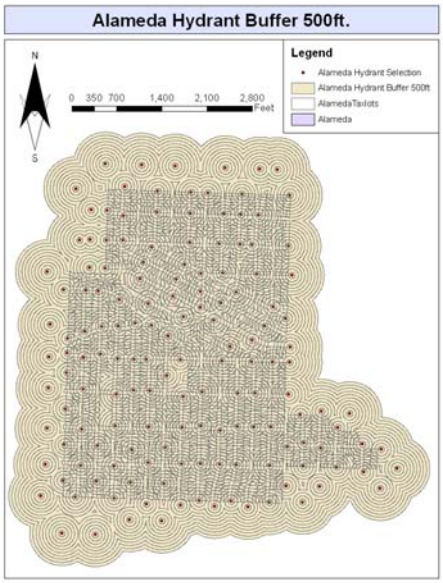






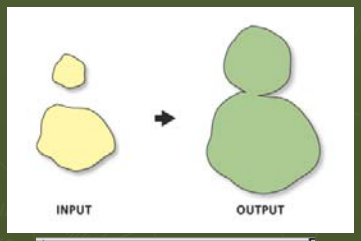
500 ft. Buffer Rings Around Hydrants

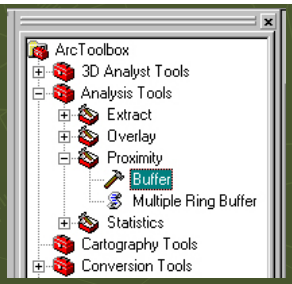


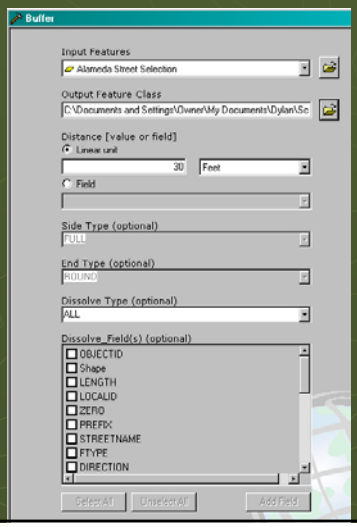


Buffering The Neighborhood Streets

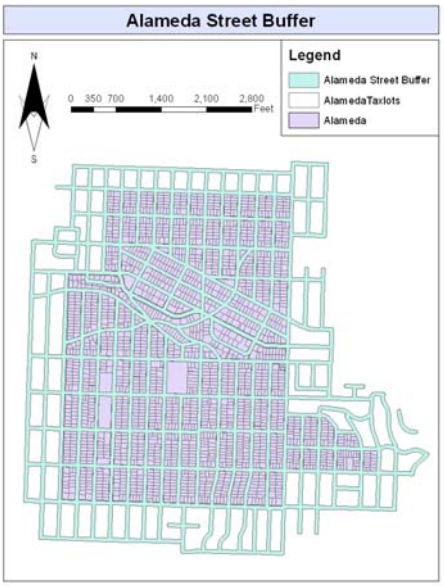
- Buffer Tool (under Analysis Tools, Proximity)





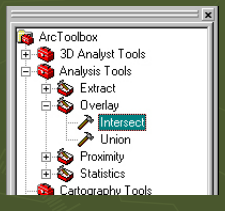


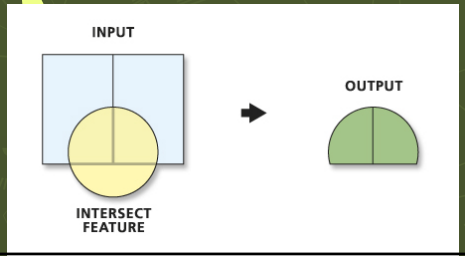
30 ft. Buffer To Either Side of Neighborhood Streets

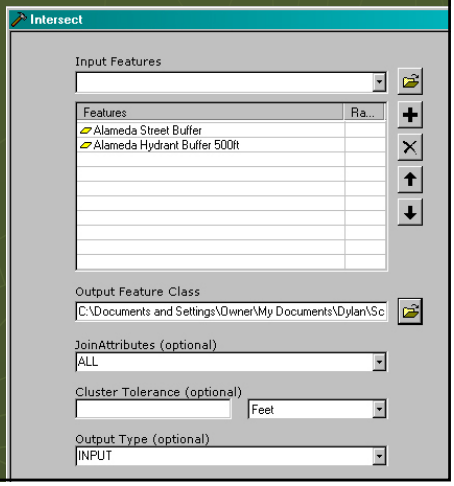


Combining The Hydrant And Street Buffers

- Intersect Tool (under Analysis Tools, Overlay)

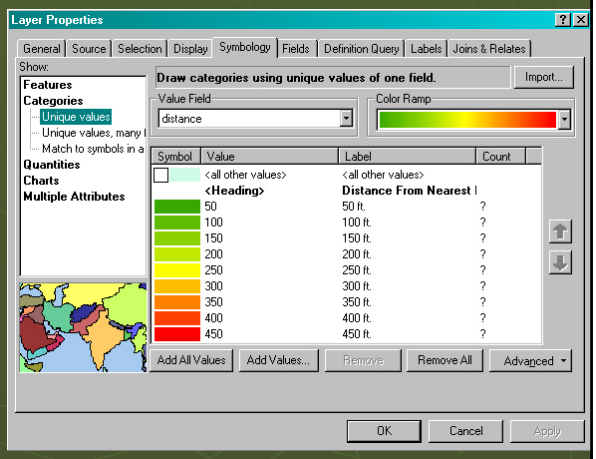




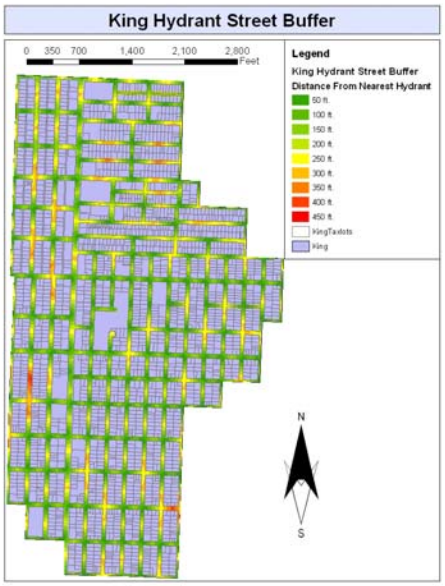


Displaying The Combined Hydrant Street Buffer

- Display as unique values 50 ft. intervals from 50 to 450 ft.
- Clip the Combined Hydrant Street Buffer to the Neighborhood.
- Choose color ramp that displays coverage in an easily interpretable way.
- Label fields to ease understanding.

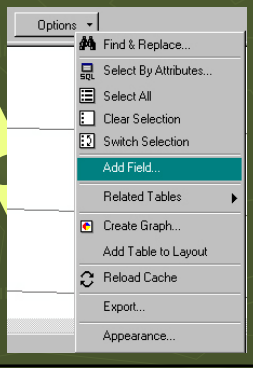


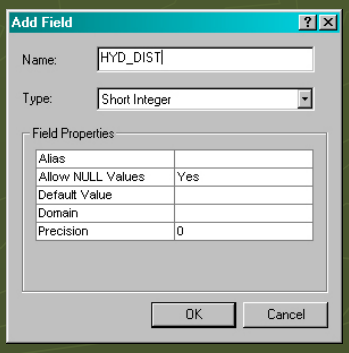
Combined Hydrant Street Buffer



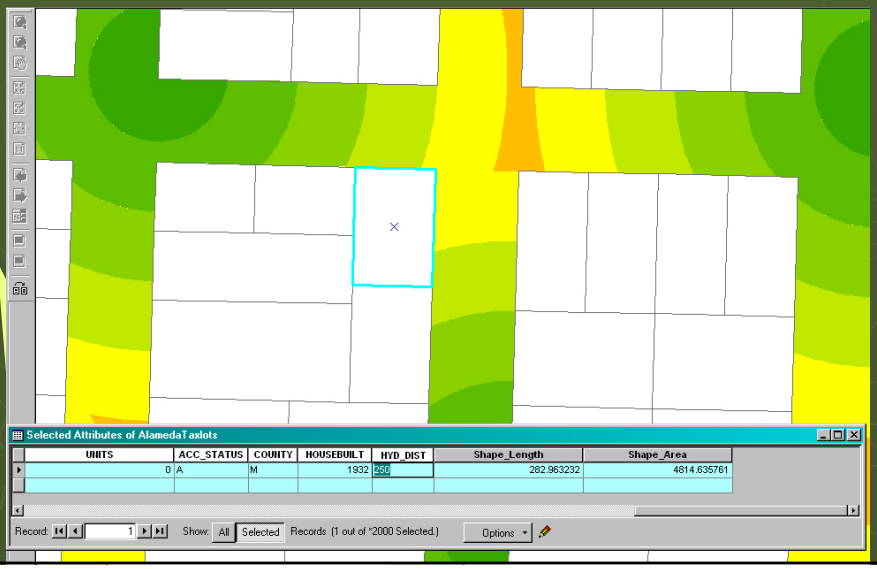
Entering Hydrant Street Buffer Into Taxlot Attribute Tables

- Add field to taxlot attribute and name HYD_DIST
- Use clipped neighborhood taxlots and hand enter highest value of Neighborhood hydrant street buffer that touches each taxlot.

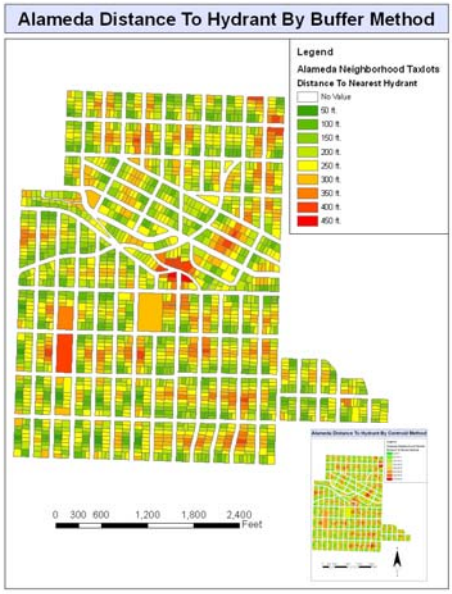




Entering Hydrant Street Buffer Into Taxlot Attribute Tables

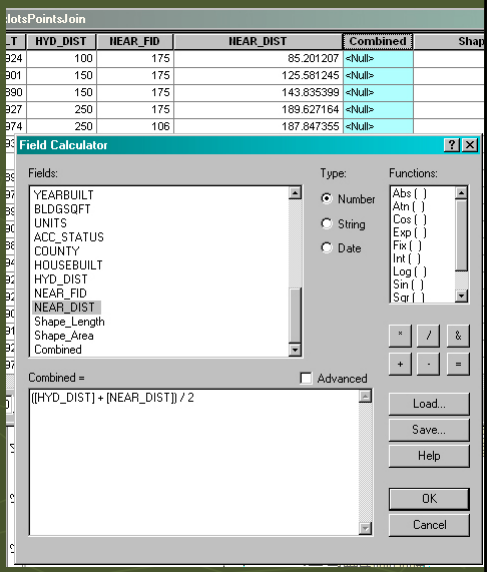


Distance From Taxlots To Hydrants By Buffer Method



Combined Method Process

1. Add field to taxlot attribute table and call COMBINED
2. Calculate values using ([HYD_DIST] + [NEAR_DIST]) / 2
3. Display data as done previously



Distance From Taxlots To Hydrants By Combined Method

Comparing Methods

Centroid Method

Alameda Stats NEAR_DIST

Count:	2075
Minimum:	
Maximum:	371.24
Sum:	360706.55
Mean:	173.83
Median:	170.75
Standard Dev.:	63.31

King Stats NEAR_DIST

Count:	2215
Minimum:	
Maximum:	390.01
Sum:	355384.24
Mean:	160.44
Median:	156.22
Standard Dev.:	61.06

Buffer Method

Alameda Stats HYD_DIST

Count:	2073
Minimum:	50
Maximum:	450
Sum:	450800
Mean:	217
Median:	200
Standard Dev.:	73

King Stats HYD_DIST

Count:	2209
Minimum:	50
Maximum:	450
Sum:	455050
Mean:	206
Median:	200
Standard Dev.:	65

Combined Method

Alameda Stats Combined

Count:	**2073**
Minimum:	**42**
Maximum:	**396**
Sum:	**405663**
Mean:	**196**
Median:	**190**
Standard Dev.:	**67**

King Stats Combined

Count:	**2209**
Minimum:	**38**
Maximum:	**420**
Sum:	**404700**
Mean:	**183**
Median:	**179**
Standard Dev.:	**61**

Comparing Methods

Centroid Method

Cons

- Underestimates distance because a straight line distance is not the route a fire hose is going to be able to take to house.

Pros

- Very quick and easy process.

Buffer Method

Cons

- Prone to error because the hydrant buffer can go through taxlots and show up on the other side, resulting in a distance that may be shorter than a straight line distance.
- Overestimates some distances because the furthest distance touching the taxlot is used as the distance.
- Takes a lot of time.

Pros

- More accurate than the straight line distance because it runs along the road.
- Averages errors within itself.

Combined Method

Cons

- It does not take into account the shortening of the distance to the nearest hydrant when a straight line distance is averaged with a taxlot in which the buffer method distance resulted from the buffer going through a taxlot.
- Takes a lot of time.

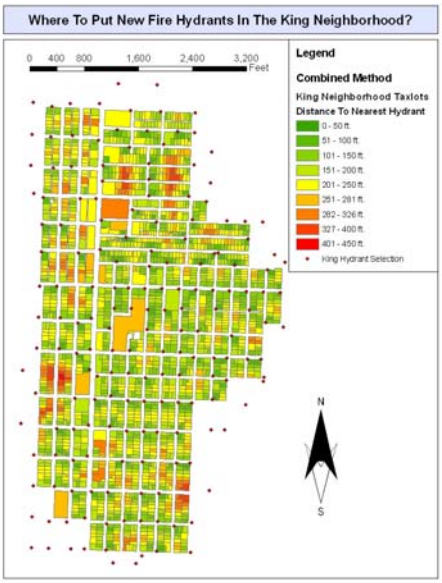
Pros

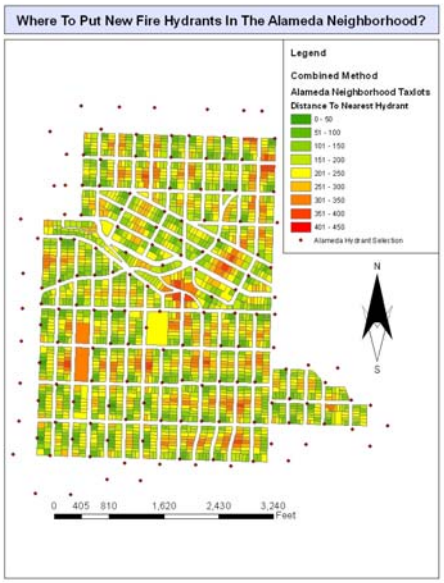
- Provides an average of the other two methods.
- Eases effects due to overestimation by the buffer method and underestimation by centroid method in some cases.

Conclusions

- The King neighborhood ended up having a smaller average distance to each home then the Alameda neighborhood for all methods used.
- The difference between the average distances wasn't very much and the standard deviations were both large so there isn't anything to suggest that the King neighborhood has much better coverage than the Alameda neighborhood.
- Although these maps did not show that there was a significant difference between the two neighborhoods it may have provided maps to show where future fire hydrants could be placed to insure better coverage.

Where Should New Hydrants Go?





Further Study

- Susceptibility of each neighborhood to fire.
- Do a Network Analysis of transit times from the nearest fire station.
- Factor in the age of water distribution infrastructure.
- Reanalyze with new census data.
- Different ways to determine distance from hydrants to taxlots.

References

- McMillan, Allen. 2003. Portland Fire Hydrants (Text and Images). Retrieved on May 4, 2007 on website: FireHydrant.org
- City of Portland, Office of Neighborhood Involvement. 2007. 2000 Portland Neighborhood Demographic Data. Retrieved on May 23, 2007 on website: http://www.portlandonline.com/shared/cfm/image.cfm?id=151629
- Hydrant data came from the Portland Water Bureau
- All other data came from RLIS