Building Resilience:
Before, During and After the Event

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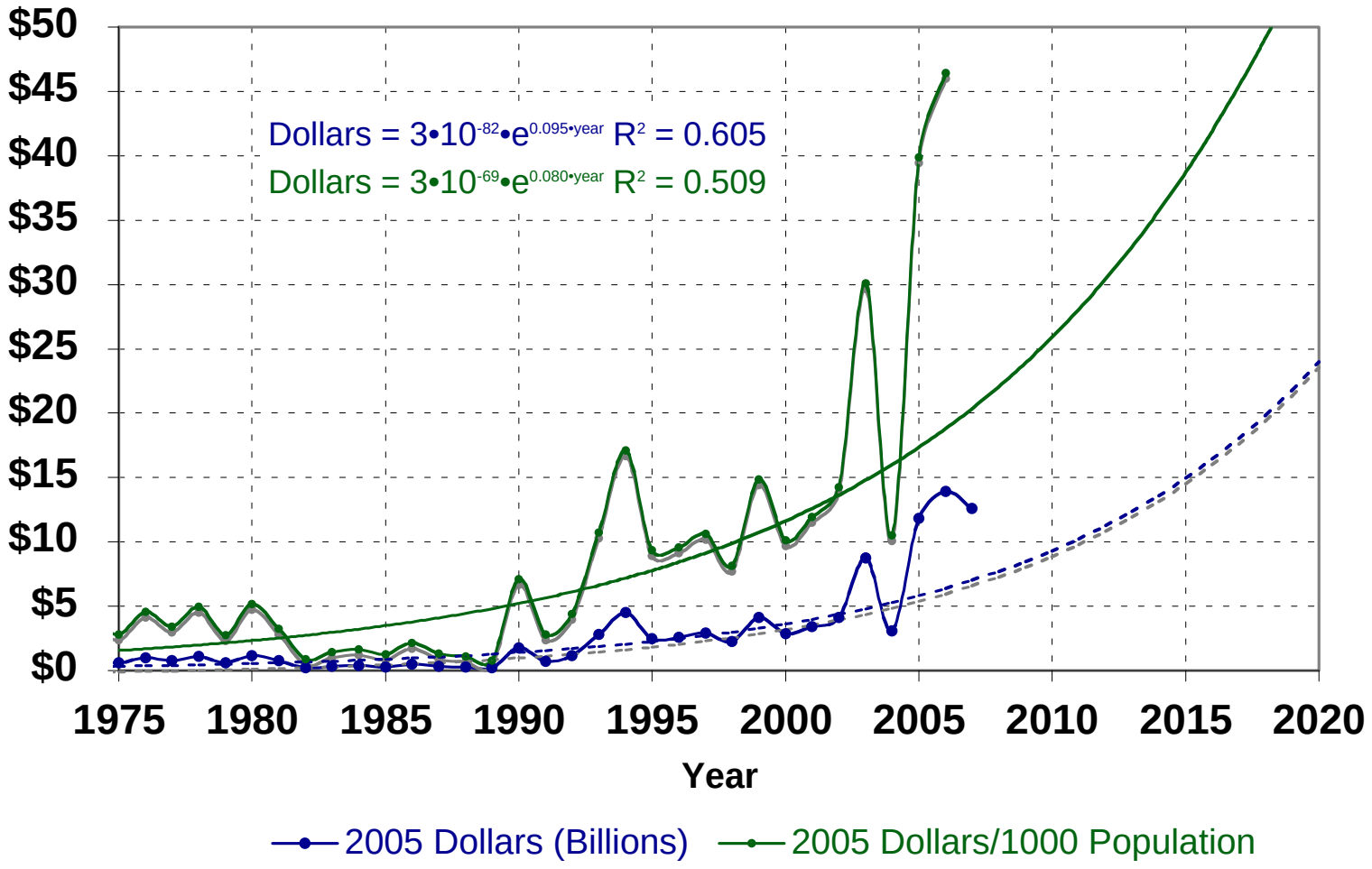
Resilience

- Resilience is the ability to deflect, avoid or absorb the impact of hazards.

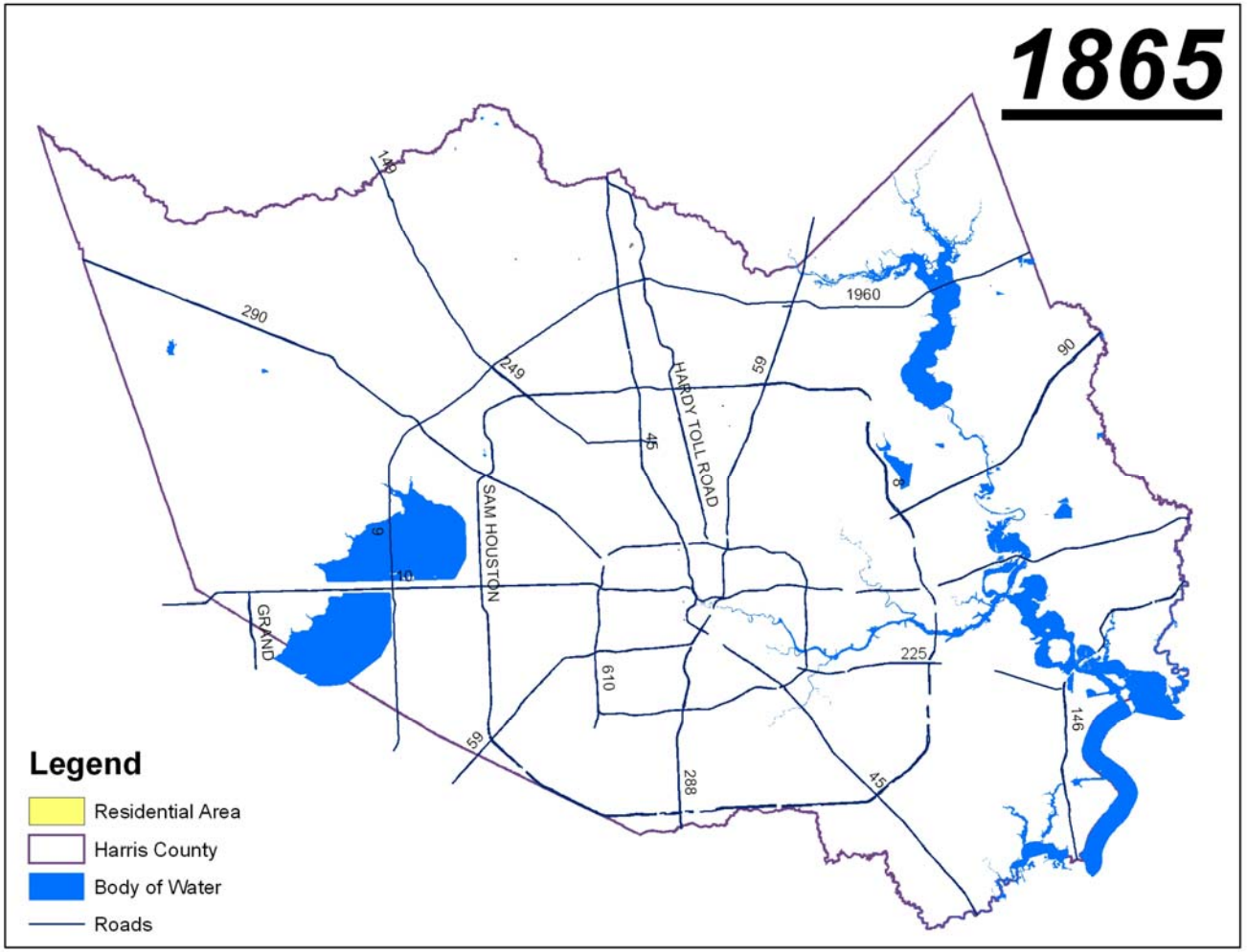
Challenges

- Population Growth
- Population Distribution
- Infastructure
- Global Warming

Figure 1 Disaster assistance funds by year.
(Dollars, Congressional Research Service, 2005; Population, U. S. Census Bureau, 2007)



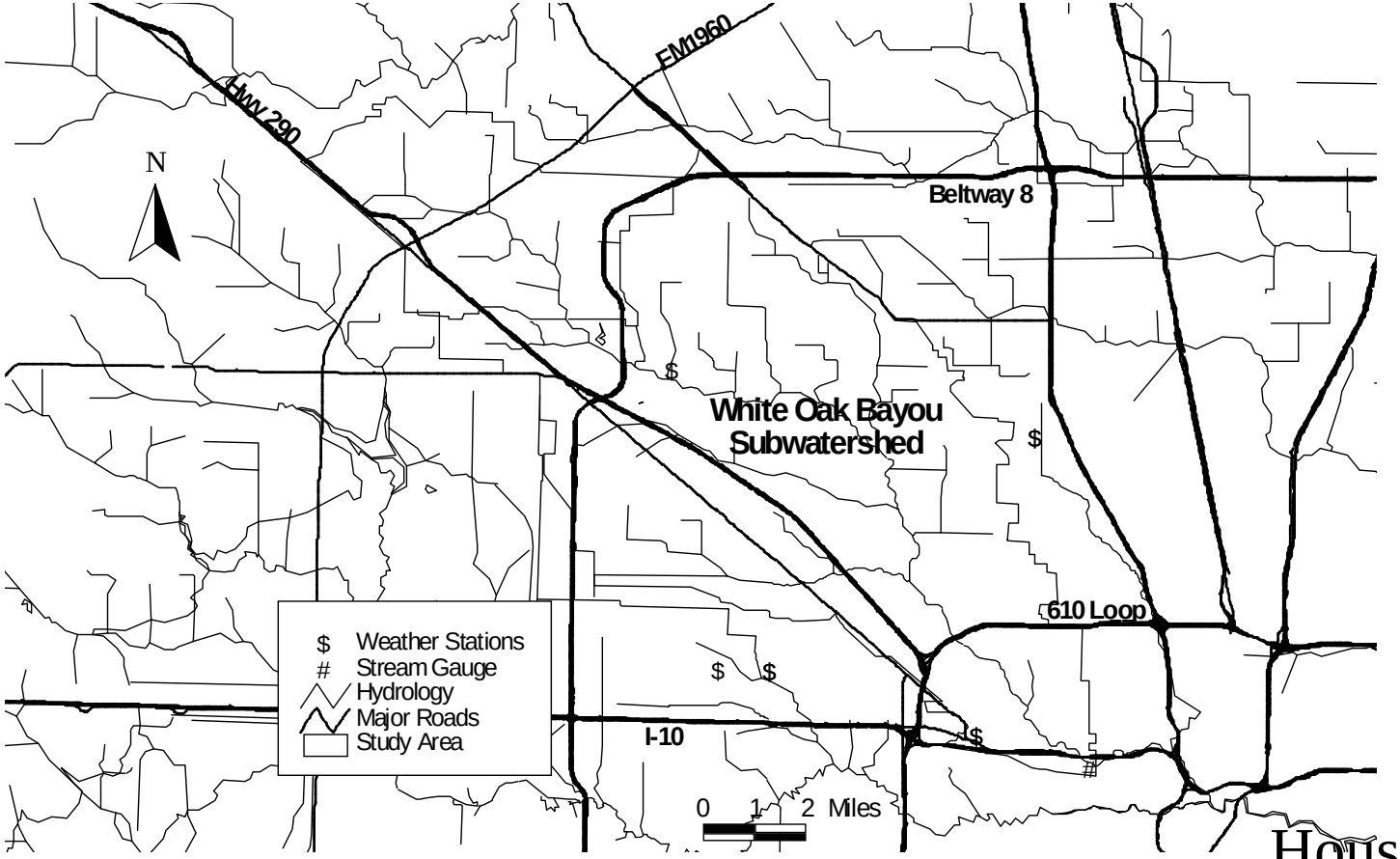
Harris County Development

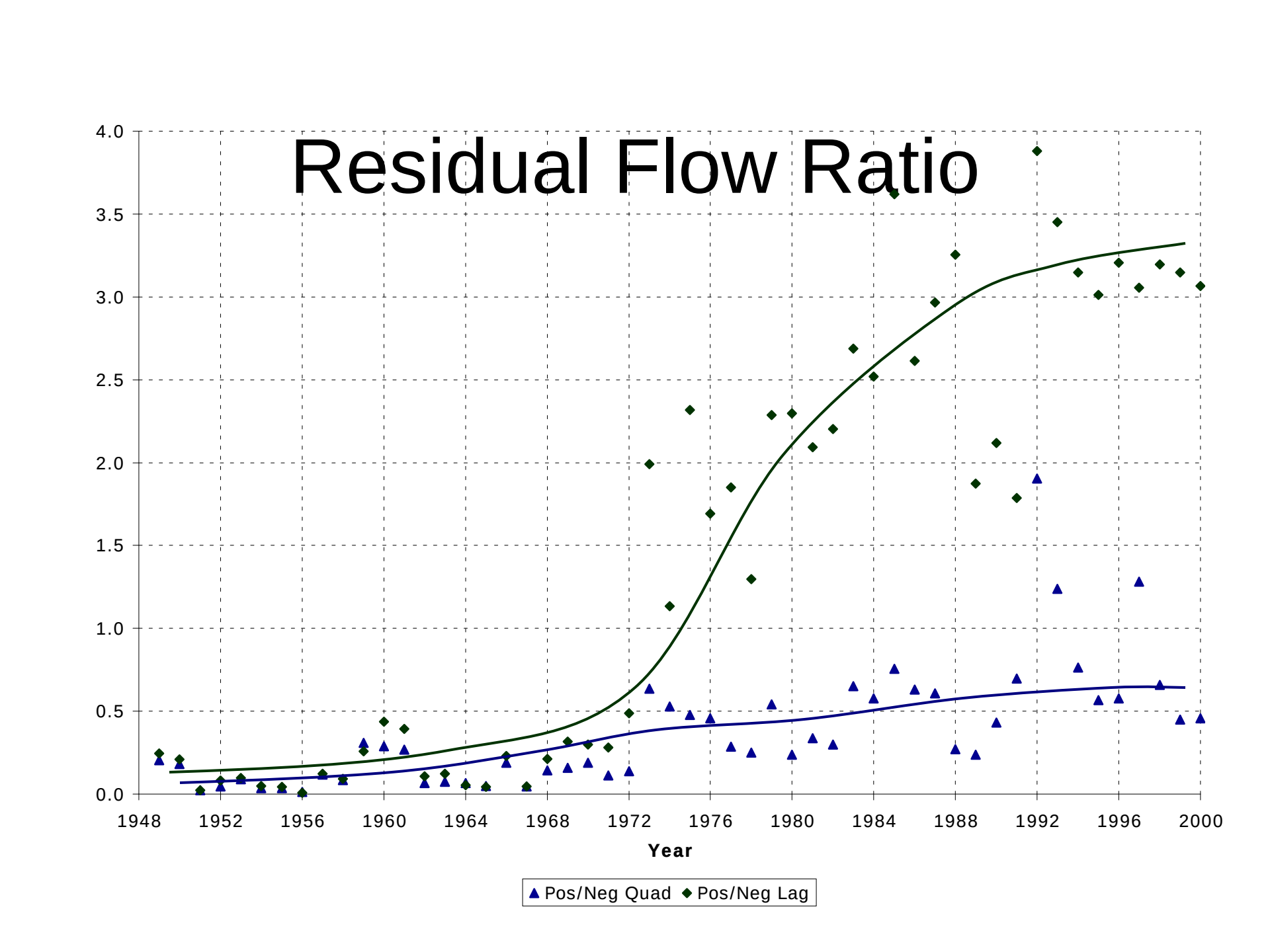


Flooding History

- 16 major floods between 1836 and 1936
- Losses of $1.5 and $3.0 million in 1929 and 1935 floods respectively
- 1937 Harris County Flood Control District
- 1940s Barker and Addicks reservoirs constructed
- 1972 next flood to exceed 1935 levels
  - But with only six inches of rain not 16

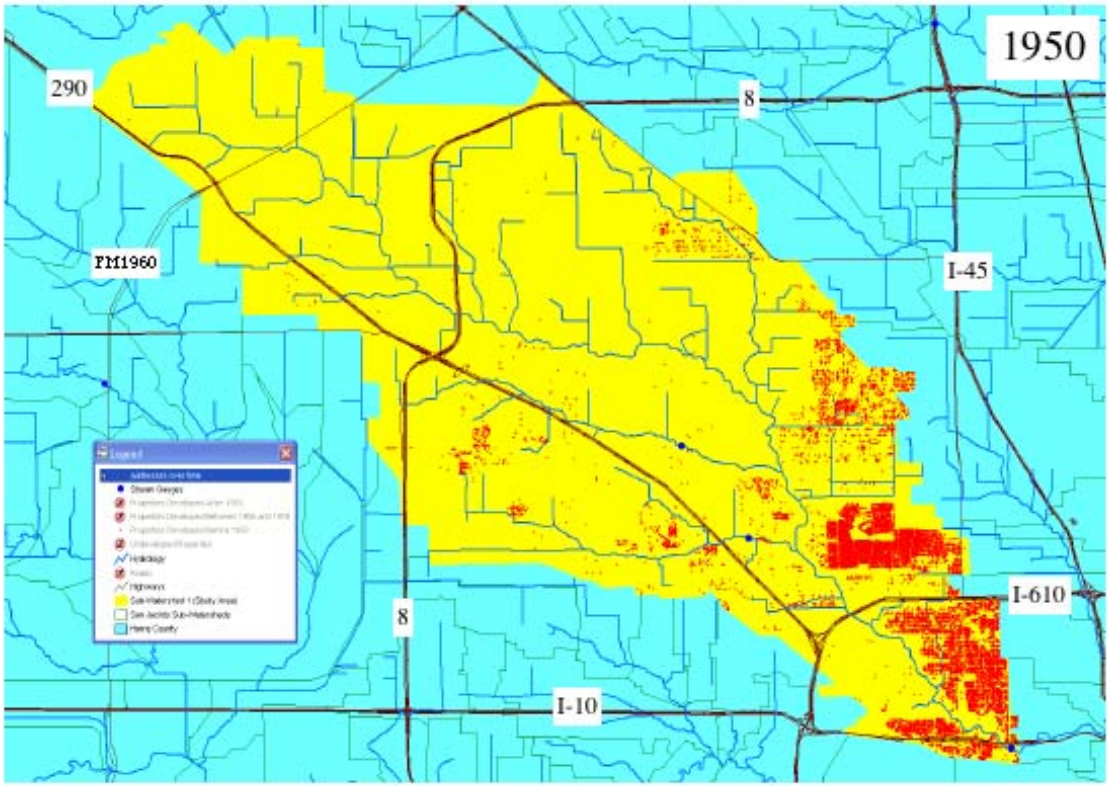
Study Area


FM1960
HWY 290
N
Beltway 8
White Oak Bayou
Subwatershed
610 Loop
I-10
$ Weather Stations
# Stream Gauge
Hydrology
Major Roads
Study Area
0 1 2 Miles
Houston


Residual Flow Ratio
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
Year
Pos/Neg Quad
Pos/Neg Lag

Land Development by Year

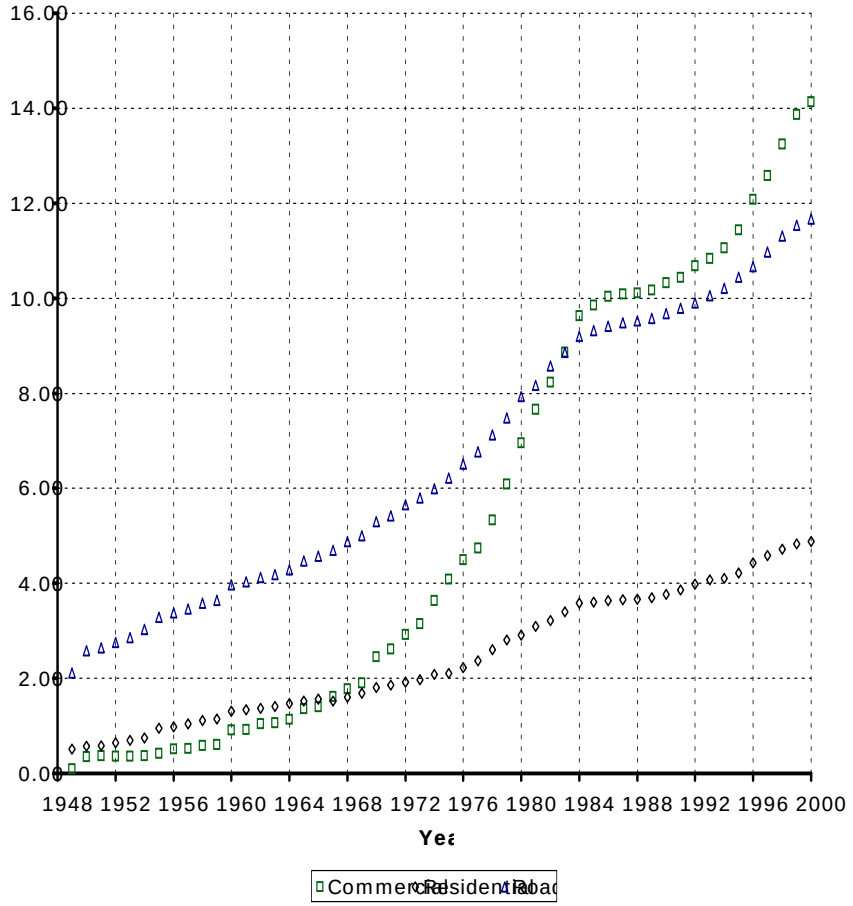
- Develops from SE to NW
- Begins Down stream
- Continues up Watershed
- Follows Riparian Zone



Impervious Cover

$\sum(c_t)$/total watershed area * 100

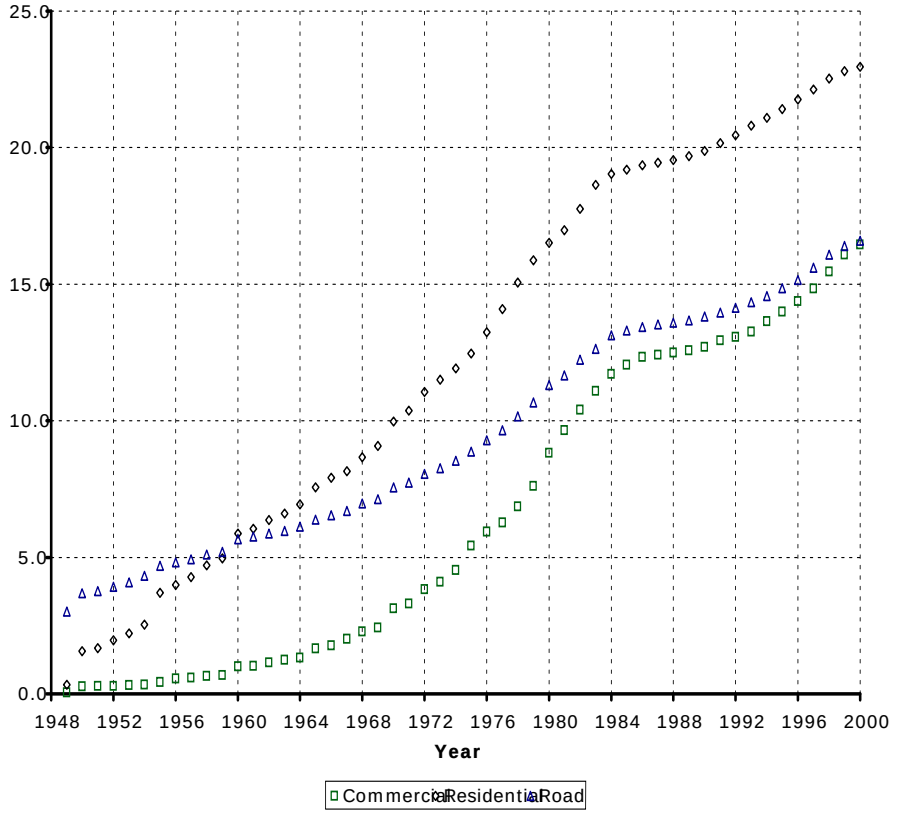
- where c_t is the area of impervious for each parcel at time t, and
- the total watershed area is constant.



Total Developed Area

$\Sigma(d_t)$/Total Watershed Area*100

- where d_t is the area (in hectares) of each parcel developed at time t



Regressions on Annual Residual Flow Ratio

	Residual Flow Model	Model statistics*:		Estimated Parameters*:	
	Model	Adj R^2	F Ratio	a	b
Total Dev Area:					
Roads	Lagged	0.754	153.0	-3.834	0.002
Parcels with Roads	Lagged	0.751	151.2	-3.099	0.000
Impervious Cover:					
Residential	Lagged	0.724	134.6	-3.129	1.074
Roads	Lagged	0.748	152.4	-3.827	0.500
Total Watershed	Lagged	0.726	137.7	-2.844	0.162

New Mitigation Efforts
After 1974

- 1984 New Drainage Criteria Adopted
- 1985 Detailed Flood Plain Maps Issued
- Updated Development Regulations
  - On site detention or $$ regional detention
  - No net gain outflow

Adjustments After 1974

$$Y = a + b_1x + b_2x_p + b_3x_px$$

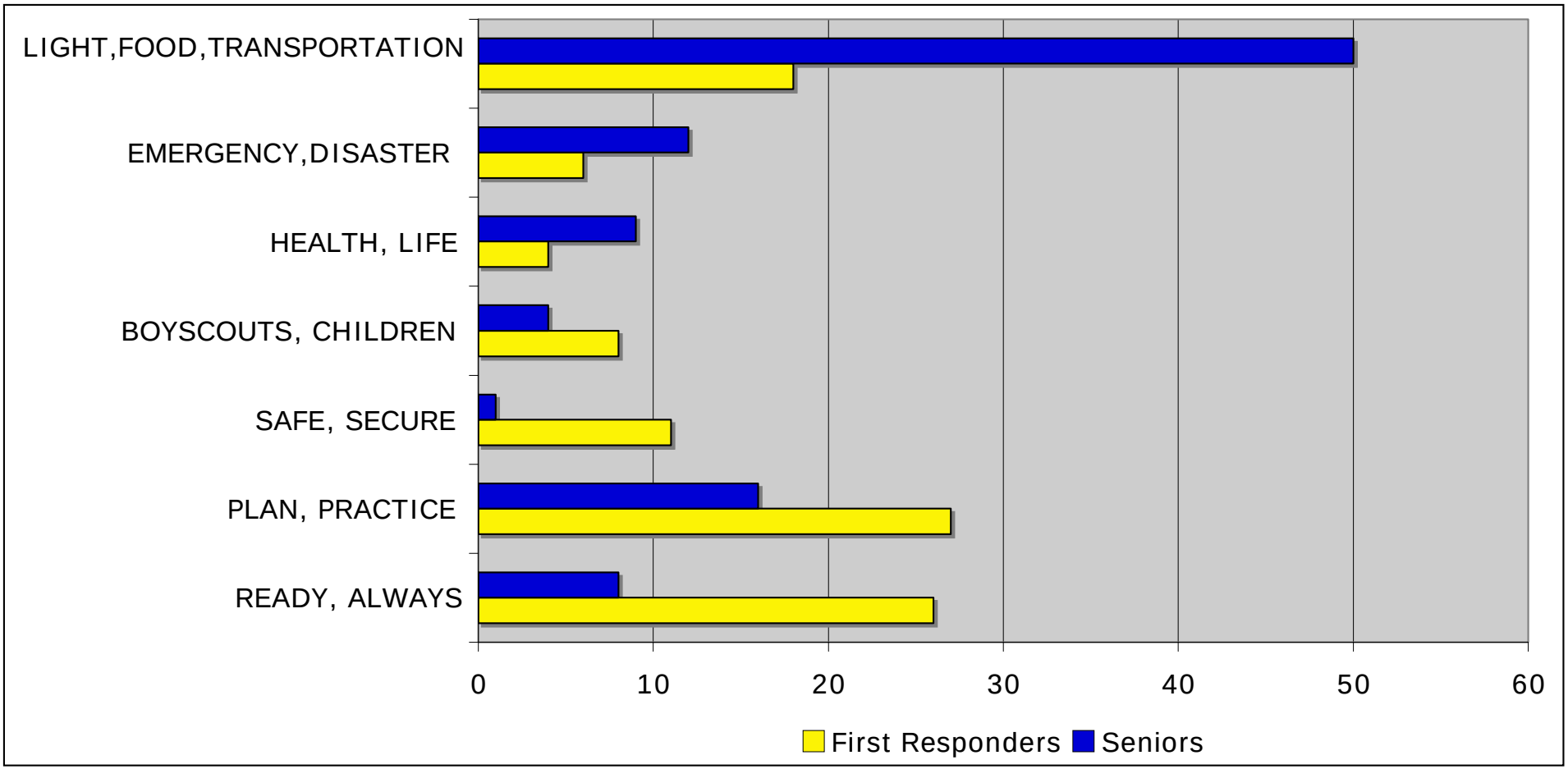
Model Parameter*	Estimated Parameters:			Slope Adjustments:	
	Adj R^2	a_1	b_1	Prob	b_3	Prob
Total Dev Area:						
Roads	0.890	-0.4510	0.0006	0.0104	0.0005	0.0008
Parcel with Roads	0.889	-0.1820	0.0001	0.0213	0.0001	0.0037
Impervious Cover:						
Residential	0.883	-0.0776	0.3039	0.0719	0.4398	0.0004
Roads	0.890	-0.4453	0.1818	0.0109	0.1507	0.0008
Total Watershed	0.883	-0.0808	0.0610	0.0546	0.0589	0.0147

where x_p is 1 after policy, else zero

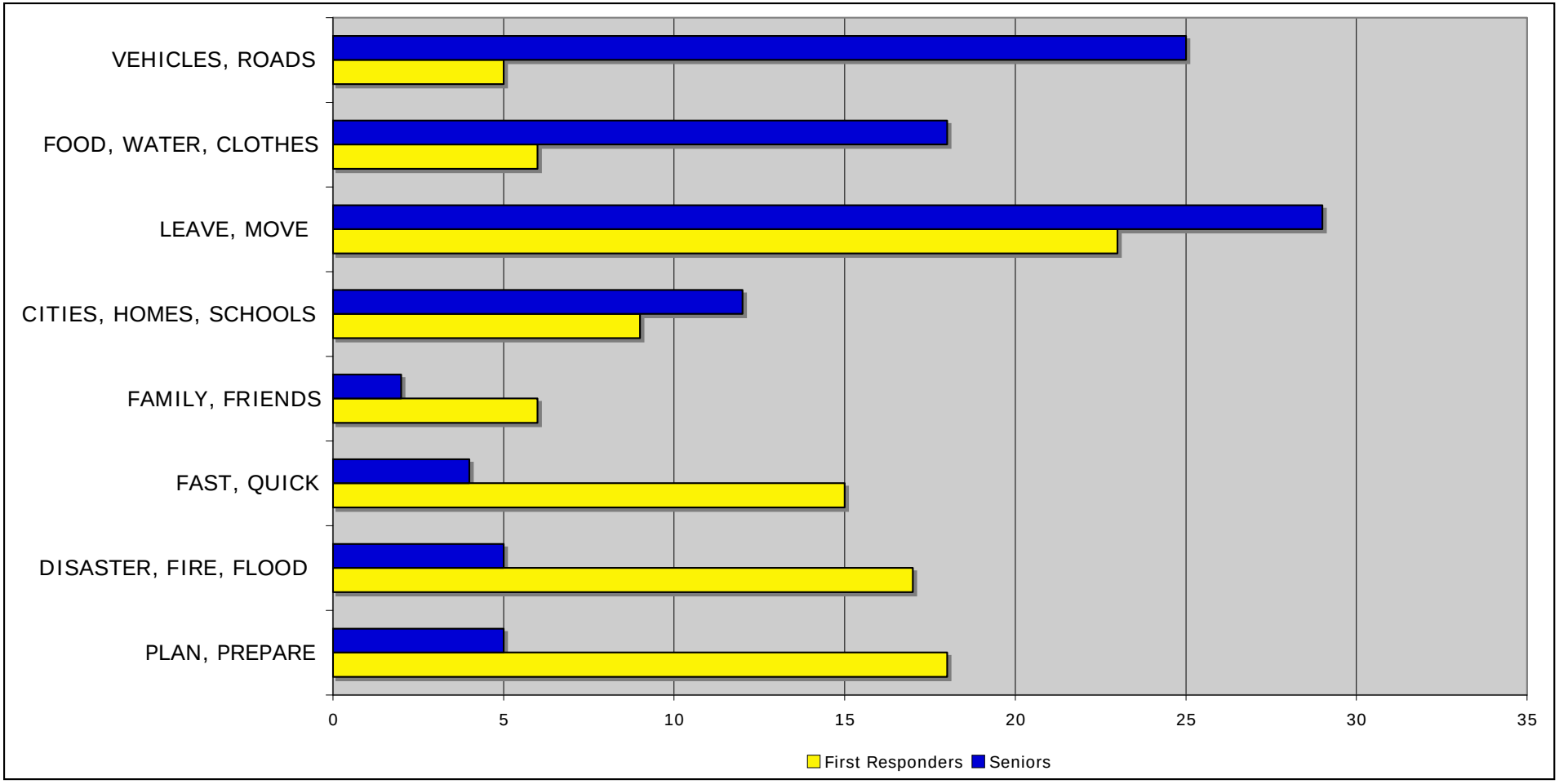
Risk In Two Cultures

	Army	Natives
Place Name	Johnston Atoll	Kalama
Location	800 SW HI	Part of HI
History	Military > 1940	Stolen from Kingdom HI
Perceived Risk	Probability > 10^{-8}	Happen
Acceptable Risk	Minimal Risk	No Risk
Perspective	Deductive Linear Bounded	Inductive nonlinear Expansive

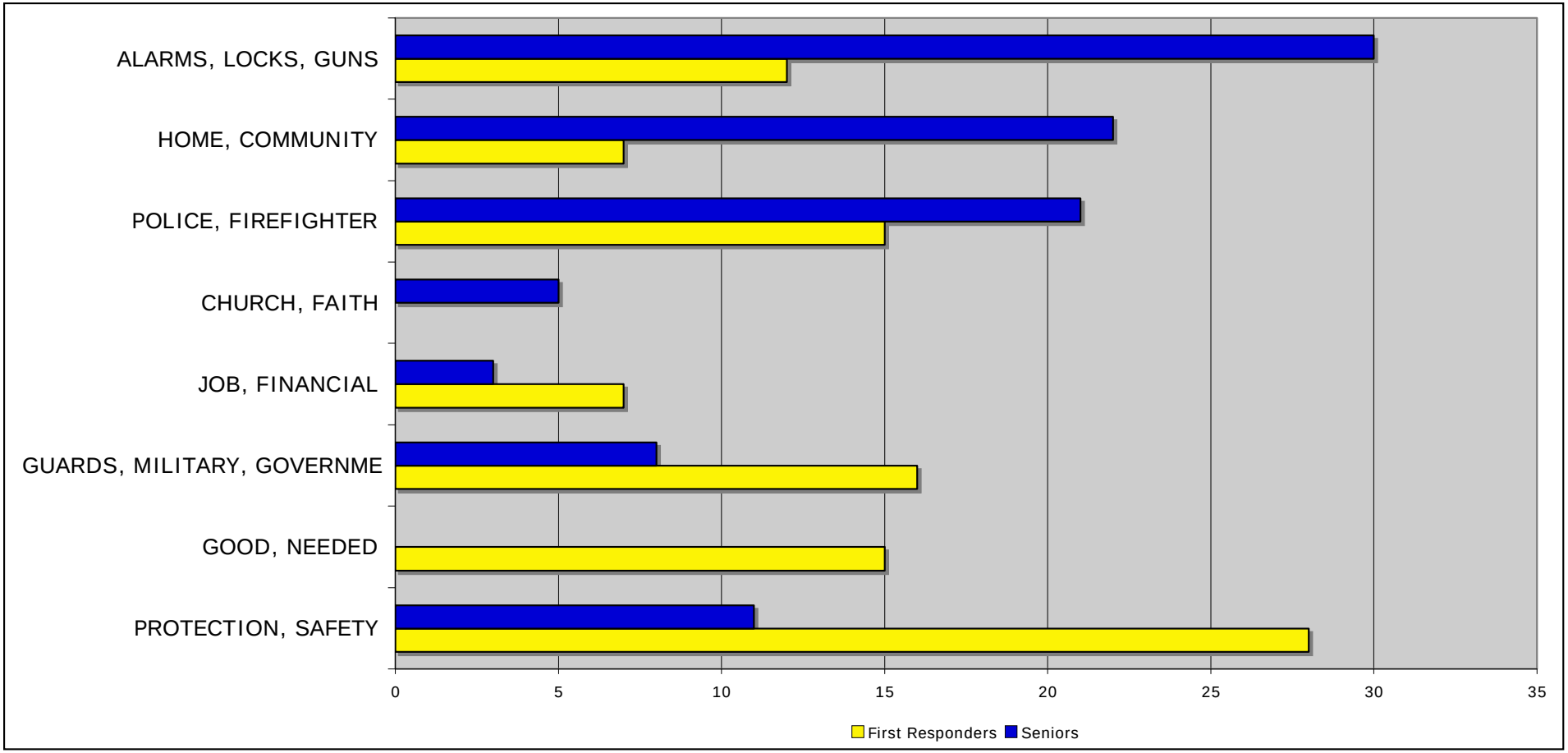
Be Prepared


LIGHT,FOOD,TRANSPORTATION
EMERGENCY,DISASTER
HEALTH, LIFE
BOYSCOUTS, CHILDREN
SAFE, SECURE
PLAN, PRACTICE
READY, ALWAYS
0
10
20
30
40
50
60
First Responders
Seniors

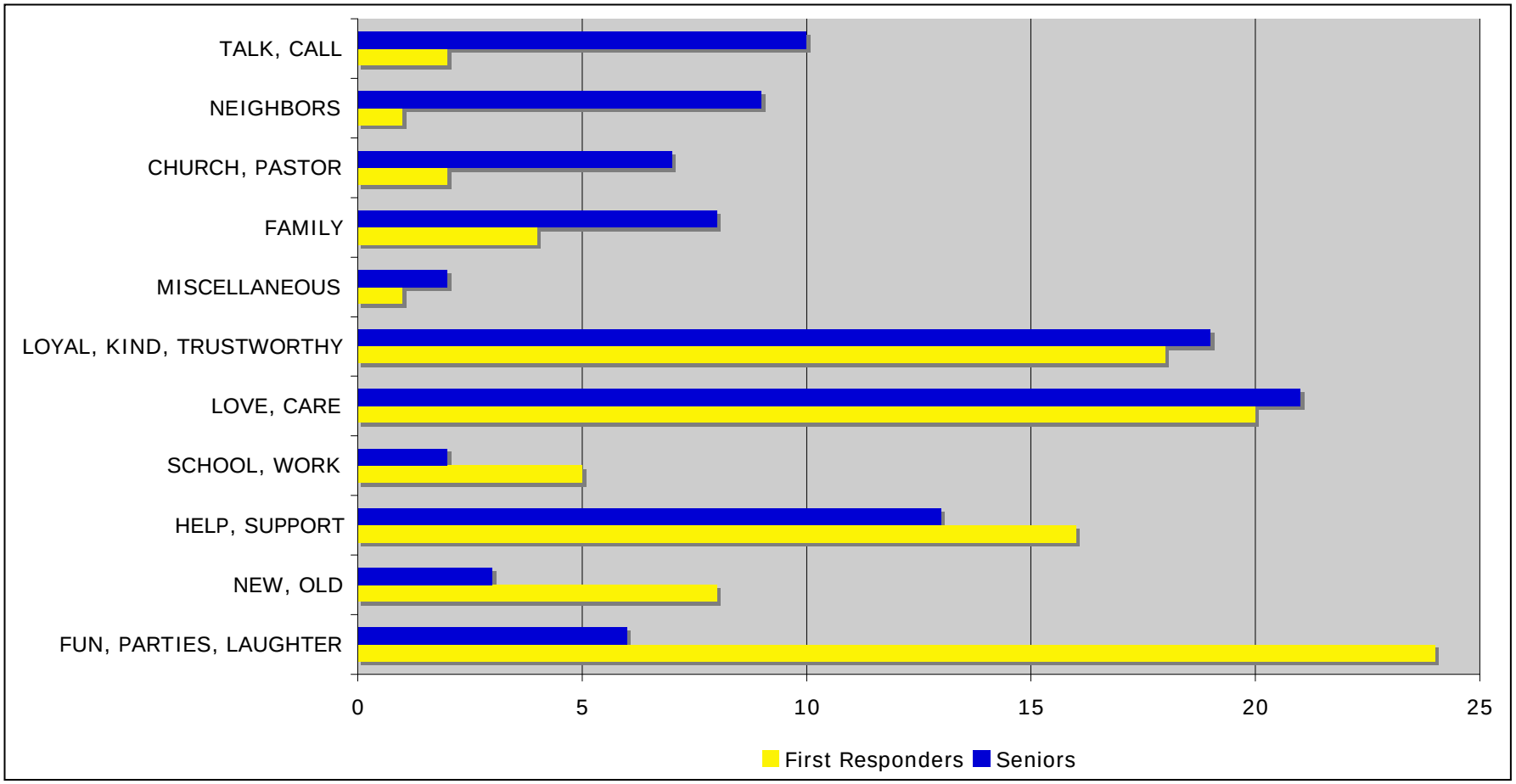
Evacuate


VEHICLES, ROADS
FOOD, WATER, CLOTHES
LEAVE, MOVE
CITIES, HOMES, SCHOOLS
FAMILY, FRIENDS
FAST, QUICK
DISASTER, FIRE, FLOOD
PLAN, PREPARE
0
5
10
15
20
25
30
35
First Responders
Seniors

Security


ALARMS, LOCKS, GUNS
HOME, COMMUNITY
POLICE, FIREFIGHTER
CHURCH, FAITH
JOB, FINANCIAL
GUARDS, MILITARY, GOVERNME
GOOD, NEEDED
PROTECTION, SAFETY
0
5
10
15
20
25
30
35
First Responders
Seniors

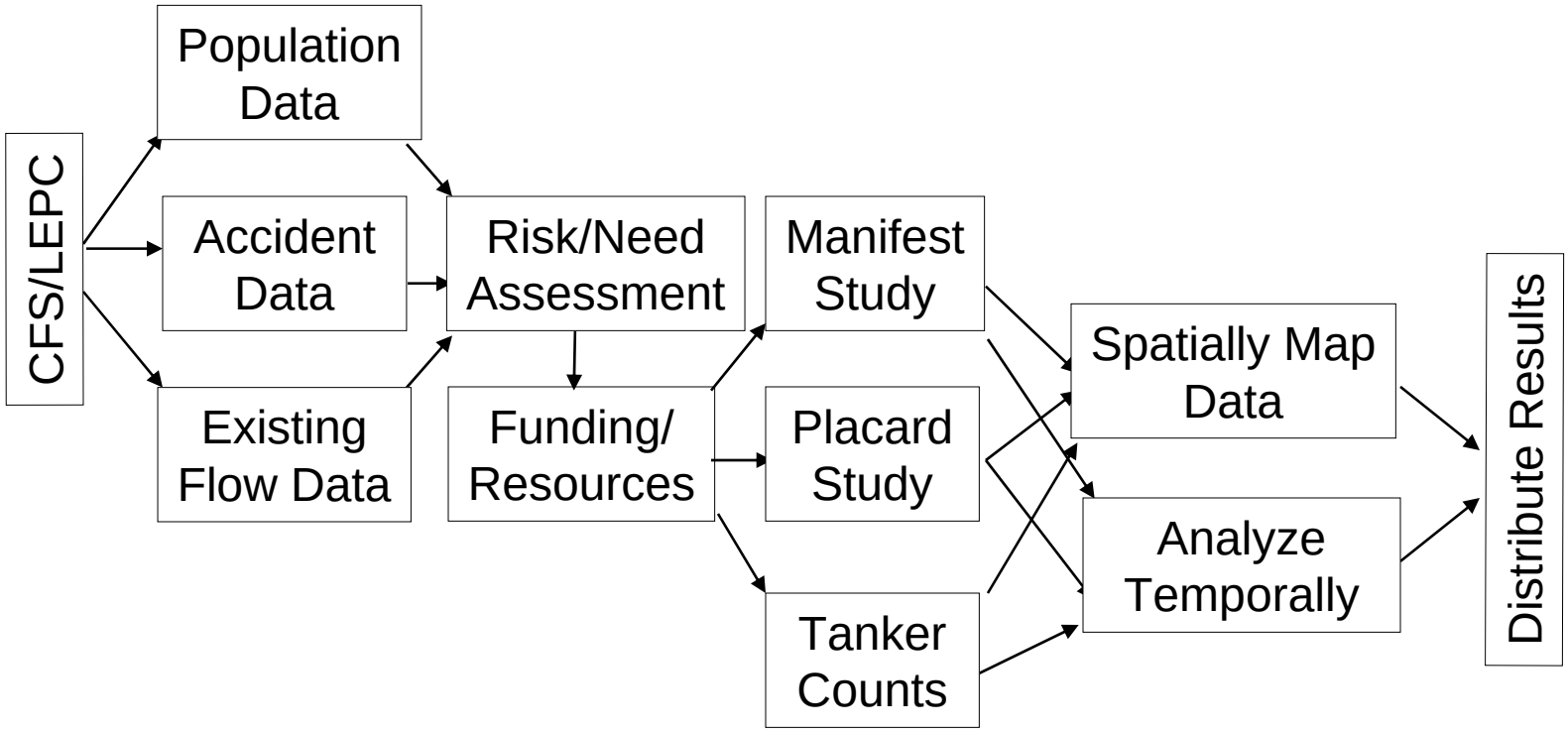
Friends


TALK, CALL
NEIGHBORS
CHURCH, PASTOR
FAMILY
MISCELLANEOUS
LOYAL, KIND, TRUSTWORTHY
LOVE, CARE
SCHOOL, WORK
HELP, SUPPORT
NEW, OLD
FUN, PARTIES, LAUGHTER
0
5
10
15
20
25
First Responders
Seniors

Hazardous Materials CFS

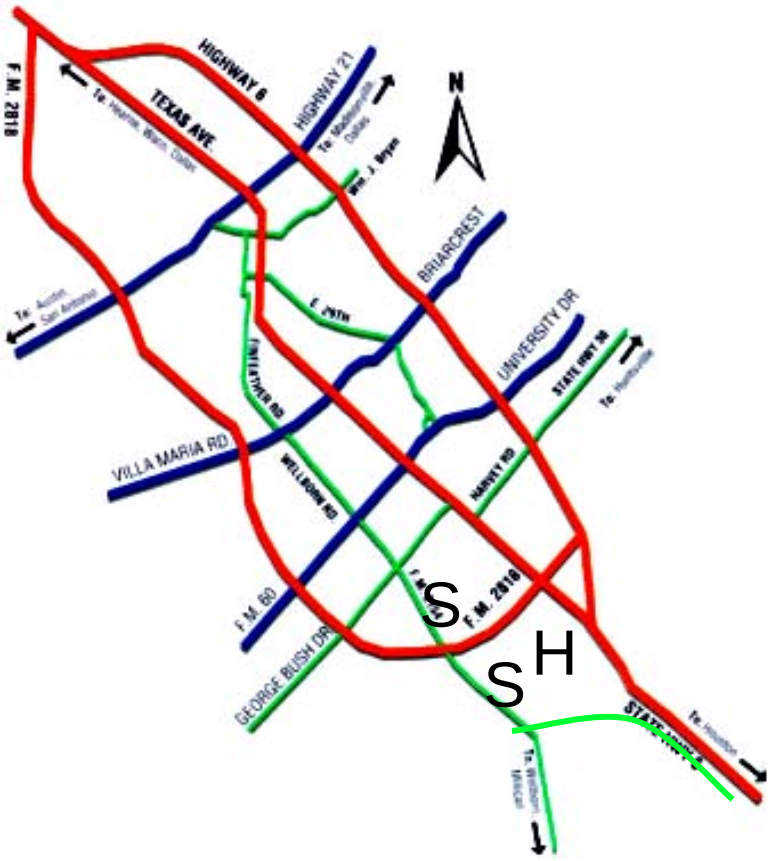
- Designate Hazardous Materials Routes
- Improve Emergency Response & Training
- Increase Compliance & Enforcement
- Enhance Highway Safety

Hazardous Materials CFS

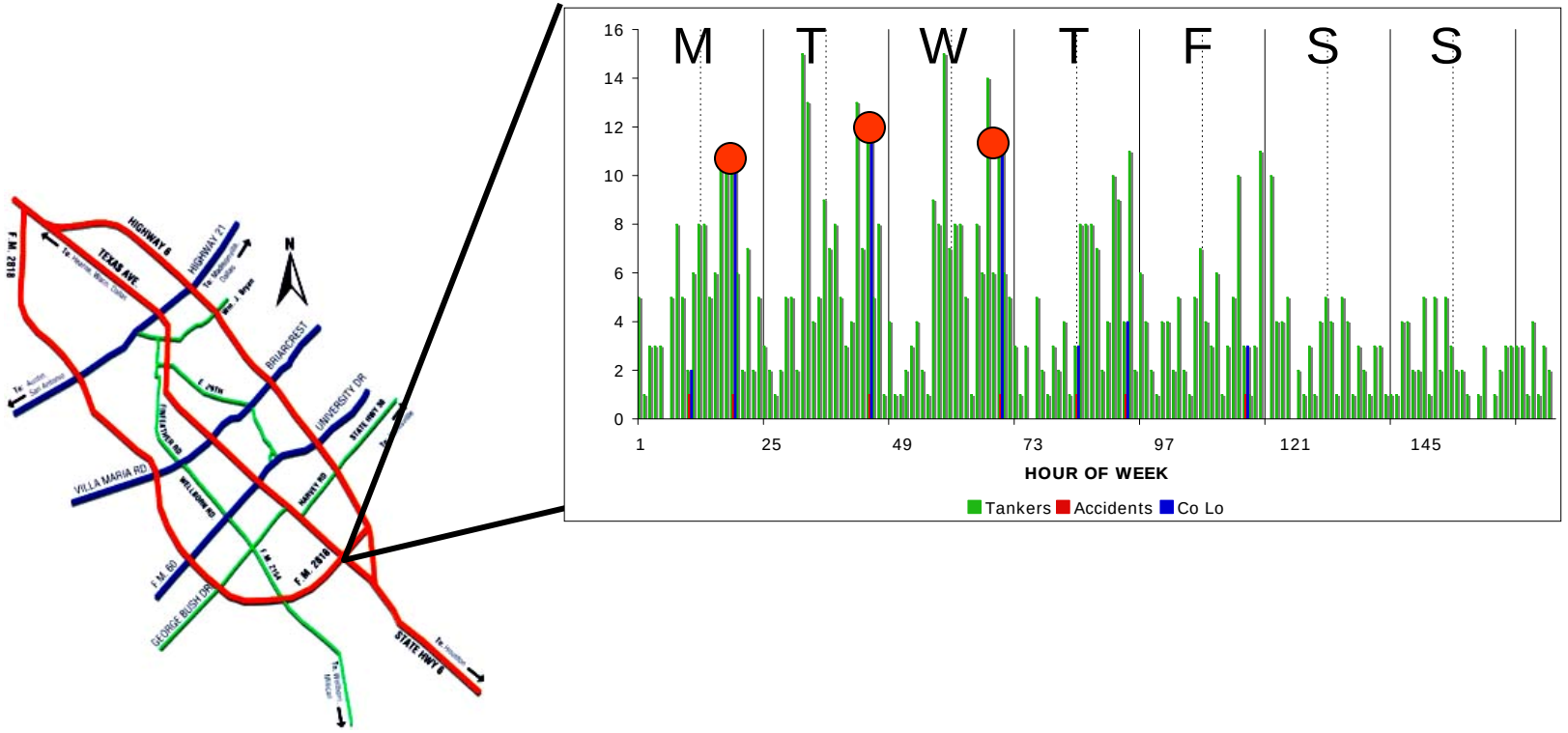


Mapping Hot Spots

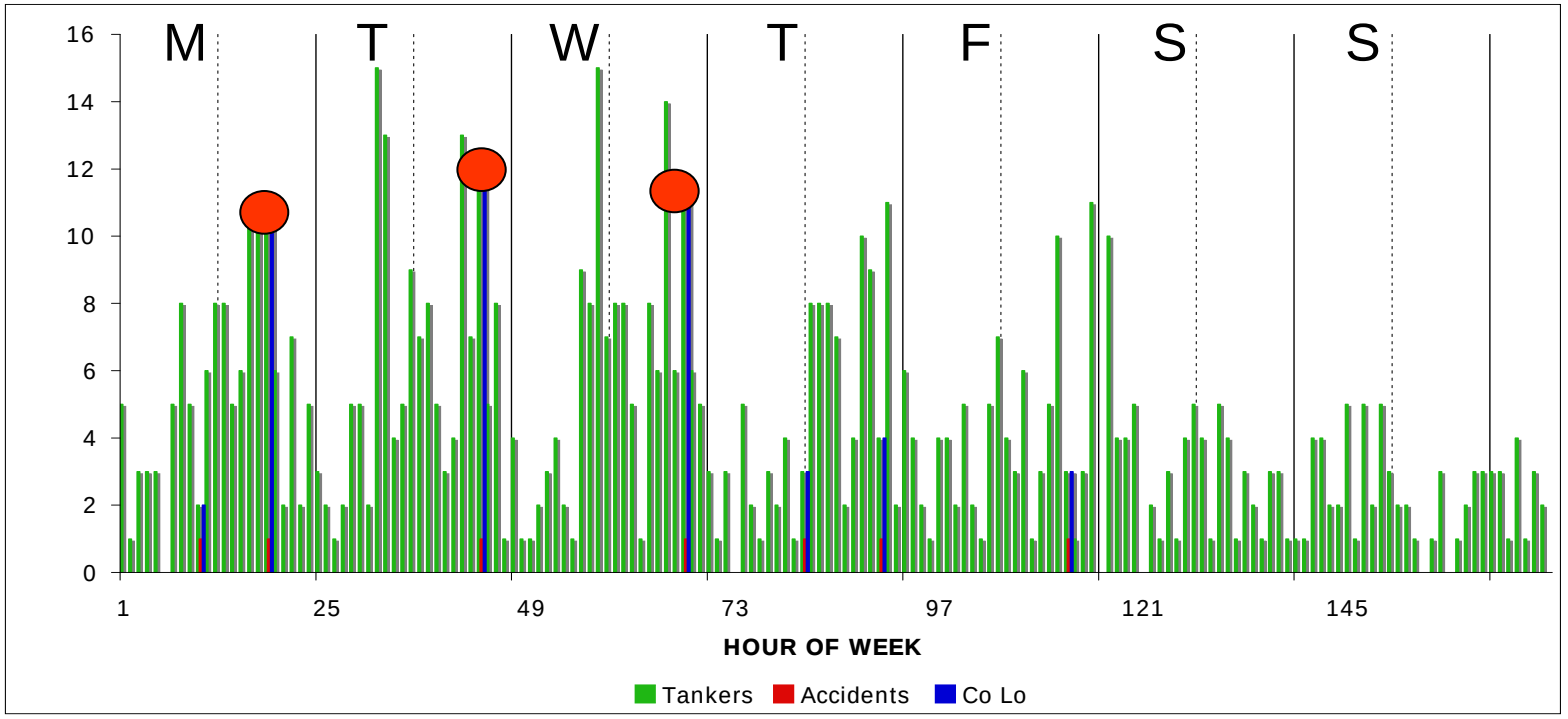
- Co-location of:
- Hazardous Materials
- Population
- Traffic & Accidents
- Vulnerable Populations



Temporal Analysis



Temporal Analysis



Conclusions

- Land Use
- Risk Communication
- Risk Analysis
- Full Cycle Risk Management
- Innovation by Local Communities