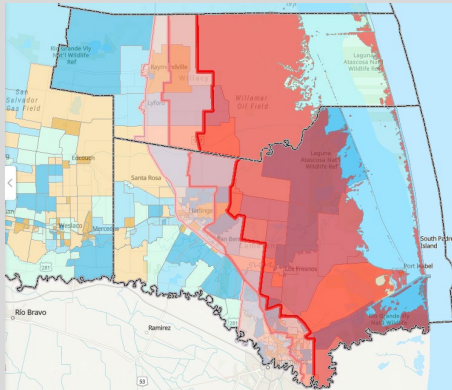


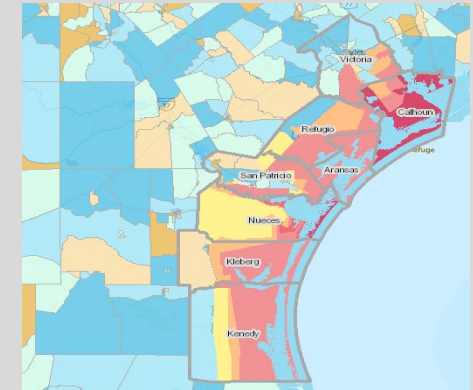


Hurricane Evacuation Studies

Risk-based evacuation zone planning in the Rio Grande Valley and Coastal Bend



Douglas Wunneburger – HRRC
Walt Peacock – HRRC
Alexander Aduabara – HRRC
David Bierling – TTI





Evacuation Zone Development

Set Guidelines, Principles, Criteria, and Data

- Kick-off meeting and two workshops (Brownsville)
- Addressed actual zone and zone boundary development
- Brownsville, Raymondville, San Benito
- 80 attendees (57 unique attendees)
- 37 governmental and agency representatives





General Guidelines and Principles

Life safety

Storm Surge is key hazard driving zone development

- Although the generally high flooding potential should be considered and wind issues, particularly for mobile homes

Facilitate risk/warning communication

- Boundaries should be easily communicable and interpretable and make sense for EM decisions

Rejection of using storm categories (Cat. 1-5)

Based off HES 2013 study

- Three zones: A, B, & C

Strove for consensus decision making





Data Development and Vulnerability Analysis

- Assemble, integrate, clean, and generate data
- Develop GIS layers and build web-based GIS platform
 - [Rio Grande Valley Evacuation Study](#) (2015)
 - [Coastal Bend Hurricane Evacuation Study](#) (2018)
- Conduct vulnerability analysis
 - Physical risk
 - Socio-demographic factors
 - Critical facilities
 - Transportation infrastructure





Principle data sources

The USACE's new
hurricane risk surge
data

HRRC "generalized"
USACE surge data

Topographical/imagery
information

Road network layers

Geospatial imagery
data

Landscan population
data

U.S. Census
American Community
Survey





Vulnerability Analysis and Data

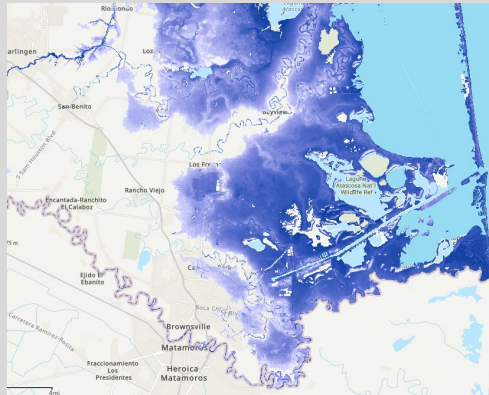
- Physical risk
 - Storm surge models
 - Flood risk maps
- Socio-demographic
 - Vulnerable populations and household estimates
 - Job locations and employee residences
 - Mobile homes, RVs
 - Total vehicles to evacuate
 - Property (residential, commercial, public)
 - Social vulnerability tool set
- Critical facilities
 - Health, schools, police, fire
 - Hotels, seasonal rentals
- Transportation infrastructure
 - Evacuation routes
 - Recognizable geography



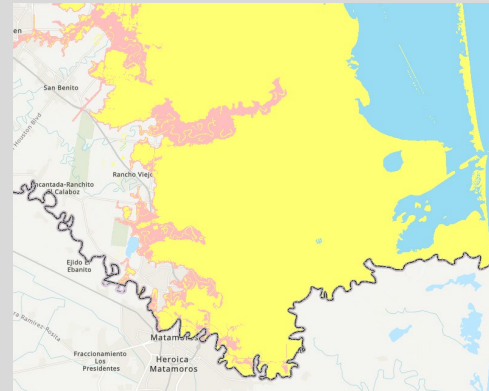


From Precise Surge to Evacuation Zone

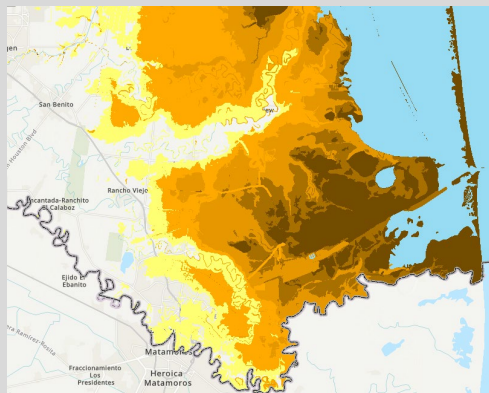
Precise
Category 5
Surge



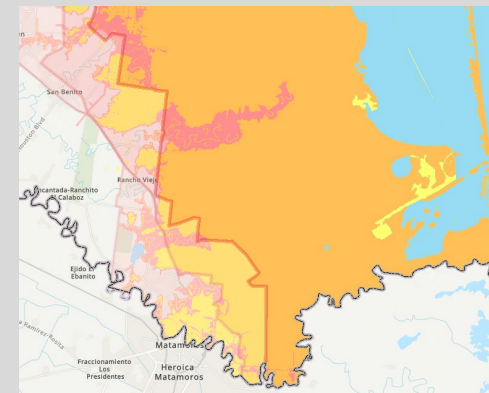
Aggregated
Category 5
Surge



Smoothed
Category 5
Surge



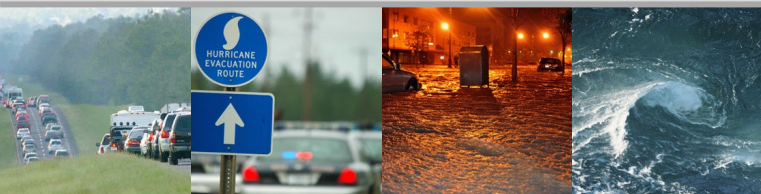
Smoothed
Category 5
Surge with
Evacuation
Zones





Socio-Demographic Factors

Field Name	Description	Count
SPHWC	Single Parent Household with Children	Households
CHILD	Child Population under 5 Years	Population
ELDER	Elder Population 65+ Years	Population
ELDERH	Elder Households	Households
ELDERPV	Elder Households in Poverty	Households
PTD	Public Transportation Dependent Households	Households
HUNOVEL	Households with no Vehicle Available	Households
VACHU	Vacant Housing Units	Housing Units
RENTER	Renter Households	Households
NONWHITE	Non-White Population	Population
YEAR1990	Housing Units Built before 1990	Housing Units
MOBILE	Mobile Home Households	Households
HUPV	Housing Units in Poverty	Housing Units
HUNOTEL	Housing Units with no Telephone Service Available	Housing Units
NOHS	Less than High School Graduate Population 25+ Years	Population
UNEMP	Unemployed Population in Labor Force	Population
SPENW	Population Speaking English Not Well or Not at All	Population





Population: Individuals, Households, and Vehicles

County		Zone A1	Zone A	Zone B	Zone Totals	County Totals
Calhoun	Estimate	15,640	5,989	115	21,744	21,744
	% of Co. pop.	71.9%	27.5%	0.5%	100.0%	
	Est. HHs	5,615	2,150	41	7,807	7,807
	Est. vehicles	10,764	4,122	79	14,965	14,965
Victoria	Estimate	n/a	620	2,047	2,667	92,084
	% of Co. pop.		0.7%	2.2%	2.9%	
	Est. HHs		225	743	968	33,433
	Est. vehicles		412	1,361	1,773	61,215
		Zone A	Zone B	Zone C	Zone Totals	County Totals
Aransas	Estimate	25,572	n/a	n/a	25,572	25,572
	% of Co. pop.	100.0%			100.0%	
	Est. HHs	9,990			9,990	9,990
	Est. vehicles	18,052			18,052	18,052
Refugio	Estimate	3,522	1,349	14	4,885	7,224
	% of Co. pop.	48.8%	18.7%	0.2%	67.6%	
	Est. HHs	1,333	511	5	1,849	2,735
	Est. vehicles	2,291	877	9	3,177	4,699
San Patricio	Estimate	24,854	2,464	13,683	41,001	67,219
	% of Co. pop.	37.0%	3.7%	20.4%	61.0%	
	Est. HHs	8,742	867	4,813	14,422	23,644
	Est. vehicles	15,876	1,574	8,740	26,190	42,938

Absolute number and percent of county population in evacuation/risk zones.

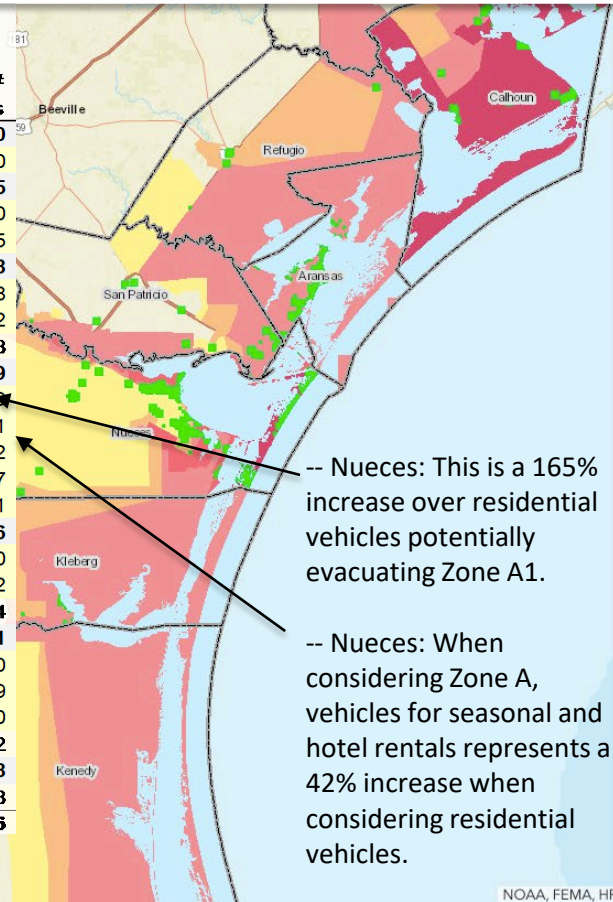
Total estimated vehicles by households in each county's highest evacuation/risk zone.





Hotels and season rentals estimates

Seasonal units (<5)				Hotel/Motel units (≥5)			
County	Count of locations	Rooms capacity	# of vehicles (25 veh. per unit)	Count of locations	Rooms capacity	# of vehicles (25 veh. per unit)	Total estimate # of vehicles
Aransas	411	591	1,478	75	2,411	4,822	6,300
A	411	591	1,478	75	2,411	4,822	6,300
Calhoun	97	130	325	38	945	1,890	2,215
A	-	-	-	4	110	220	220
A1	97	130	325	34	835	1,670	1,995
Kleberg	17	35	88	17	935	1,870	1,958
A	14	28	70	2	14	28	98
B	3	7	18	14	892	1,784	1,802
Out	-	-	-	1	29	58	58
Nueces	1,131	1,602	4,005	364	19,202	38,404	42,409
A1	1,072	1,513	3,783	224	5,013	10,026	13,809
A2	37	50	125	51	6,458	12,916	13,041
A3	2	7	18	15	2,057	4,114	4,132
B	5	6	15	14	1,216	2,432	2,447
C	15	26	65	60	4,458	8,916	8,981
Refugio	-	-	-	7	143	286	286
A	-	-	-	1	10	20	20
B	-	-	-	2	61	122	122
Out	-	-	-	4	72	144	144
San Patricio	9	10	25	39	2,018	4,036	4,061
A	8	8	20	22	985	1,970	1,990
B	1	2	5	1	62	124	129
C	-	-	-	8	680	1,360	1,360
Out	-	-	-	8	291	582	582
Victoria	6	12	30	32	2,329	4,658	4,688
Out	6	12	30	32	2,329	4,658	4,688
Grand Total	1,671	2,380	5,950	572	27,983	55,966	61,916



Legend

Administrative Boundaries

County Bndy



Built Environment

Hotels

- Rental Housing/Condo
- Hotel (Cap 6+)

Evacuation Zones (2020)

Coastal Bend

Zone A (Region)

Zone B (Region)

Zone C (Region)

Zone A (Calhoun)

Zone B (Calhoun)

Zone C (Calhoun)

Zone A1 (Nueces)

Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

Zone A1 (Nueces)

Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

Zone A1 (Nueces)

Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

Zone A1 (Nueces)

Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

Zone A1 (Nueces)

Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

Zone A1 (Nueces)

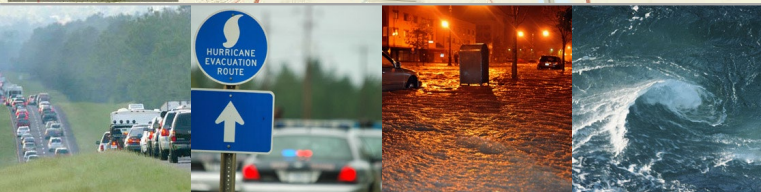
Zone A2 (Nueces)

Zone A3 (Nueces)

Zone B (Nueces)

Zone C (Nueces)

NOAA, FEMA, HR



**US Army Corps
of Engineers®**

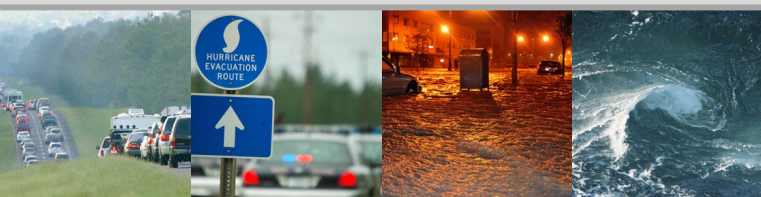
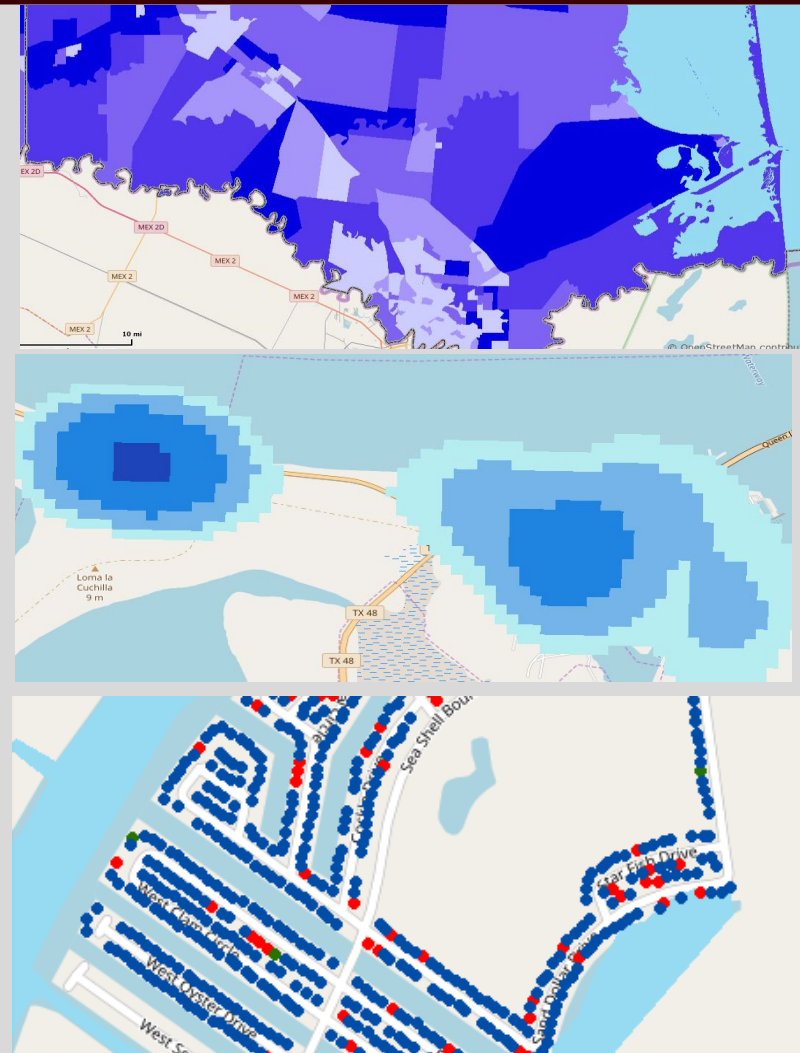


FEMA



Mobile Homes

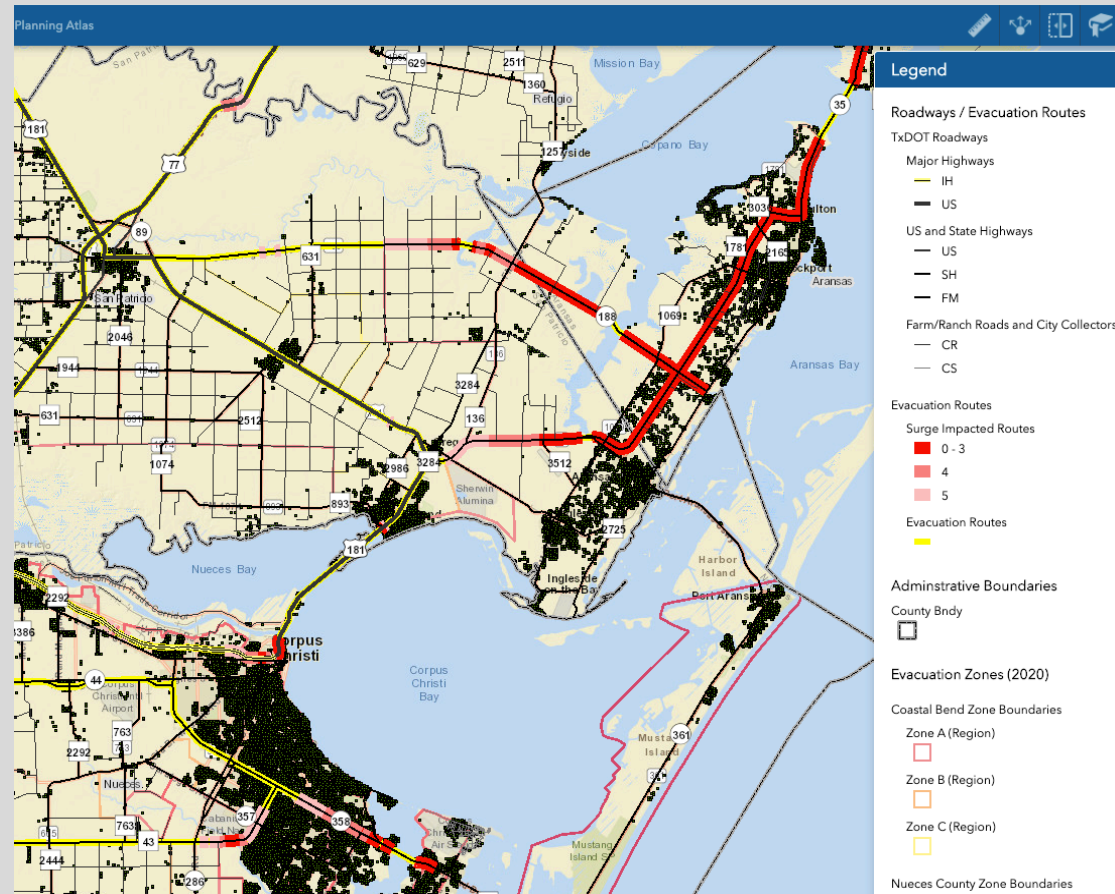
		Zone A1	Zone A	Zone B	Total MH in Zones	Total MHs in Co.	Total Co. HUs
Calhoun County	Estimate	1,658	195	75	1,928	1,928	11,837
	% of County occ.hhs.	14.0%	1.6%	0.6%	16.3%	16.3%	100.0%
Victoria County	Estimate	n/a	440	166		4,046	36,507
	% of County occ.hhs.		1.2%	0.5%		11.1%	100.0%
		Zone A	Zone B	Zone C	Total MH in Zones	Total MHs in Co.	Total Co. HUs
Aransas County	Estimate	3,380	n/a	n/a	3,380	3,380	16,002
	% of County occ.hhs.	21.1%			21.1%	21.1%	100.0%
Refugio County	Estimate	53	206	119	378	395	3,734
	% of County occ.hhs.	1.4%	5.5%	3.2%	10.1%	10.6%	100.0%
San Patricio Count	Estimate	936	11	143	1,090	2,633	27,492
	% of County occ.hhs.	3.4%	0.0%	0.5%	4.0%	9.6%	100.0%
		Zone A	Zone B	Zone C	Total MH in Zones	Total MHs in Co.	Total Co. HUs
Kenedy County	Estimate	9	0	0	9	9	253
	% of County occ.hhs.	3.6%	0.0%	0.0%	3.6%	3.6%	100.0%
Kleberg County	Estimate	154	165	n/a	319	864	13,194
	% of County occ.hhs.	1.2%	1.3%		2.4%	6.5%	100.0%





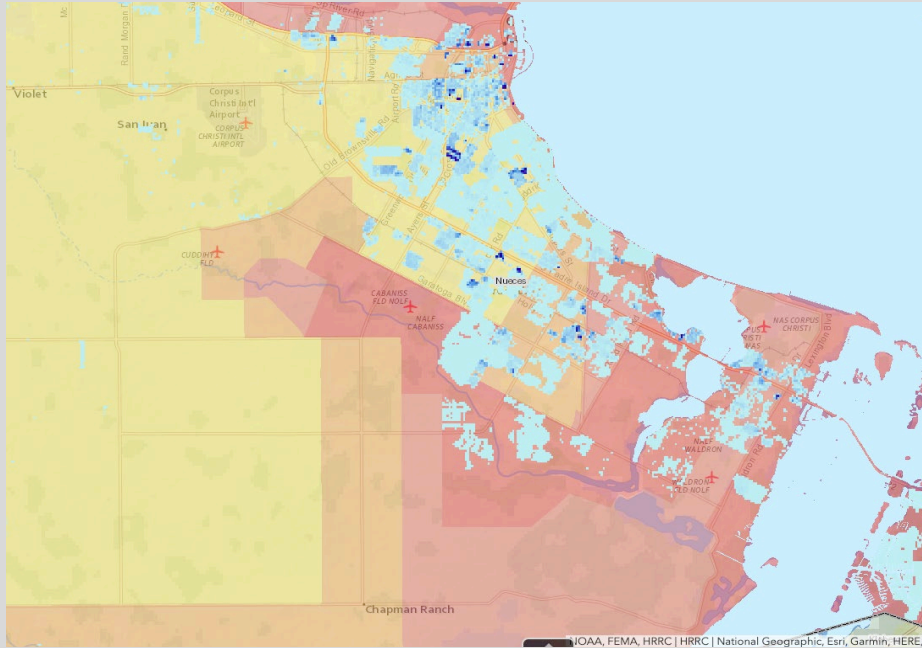
Critical Facilities layers

- EOCs
- Health Resources
 - Hospitals
 - Critical care facilities
- Nursing homes
- Child and day Care
- Schools
 - Public
 - Private
- Emergency response agencies
 - Police
 - Fire
 - EMS





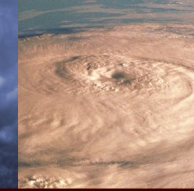
Built Environment and Infrastructure



- Built environment
 - Structures
 - Residential
- Roadways
 - Evacuation routes
 - Surge impacted routes

County	EvacZone	Single Family Residences	Mobile Home	Other Residential
Aransas	A	\$1,739,186,041	\$174,305,126	\$1,197,900,954
Calhoun	A1	\$853,125,552	\$37,330,873	\$44,797,309
	A	\$112,265,463	\$5,642,941	\$5,247,009
	B	\$4,096,970	\$800,450	\$134,660





GeoDesign in Planning

Design grounded in fact

- Holistic
- Iterative
- Multiscale

- Requires management of complexities while engaging stakeholder's local knowledge

