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Towards a Market Solution to Water Shortage: The Case of Lower Rio Grande Valley

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Structural Vs. Market Approaches

- Traditional approaches to water allocation and conservation
- Far from effective in dealing with water shortage situations
- Non-structural approaches such as *market transfer* of water rights
 - Allocative Efficiency and Productive Efficiency
- Coase (1960) - Government intervention unnecessary if property rights are freely tradable

Lower Rio Grande Valley (LRGV) Region



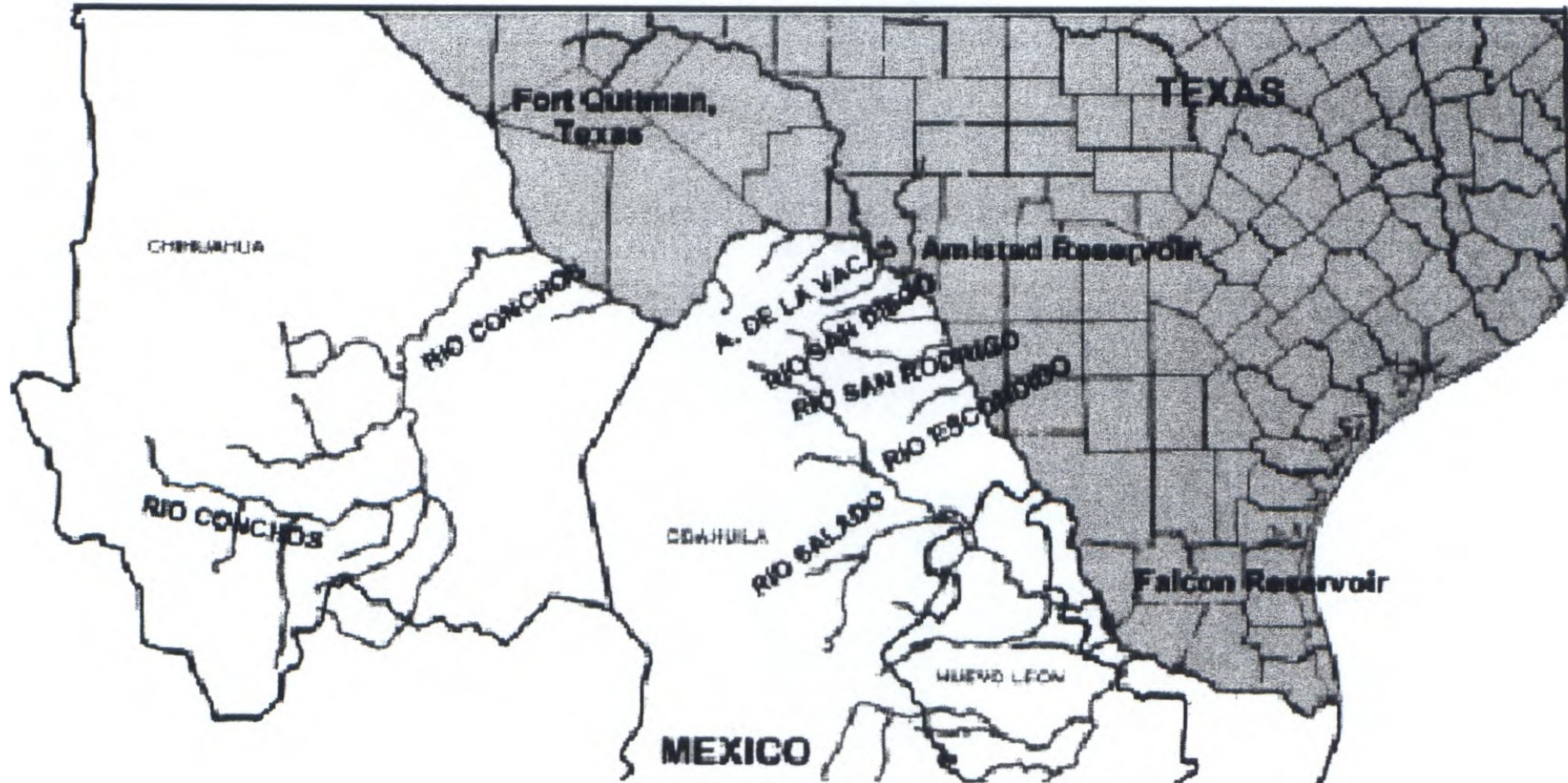
Lower Rio Grande Valley (LRGV) Region

- Dependent on the waters of Rio Grande for domestic, municipal and agricultural uses
- 4 counties – Hidalgo, Cameron, Willacy, and Starr has been under some water stress periodically
- Low average precipitation along with occasional hurricanes in the summer and fall
- Water requirements of this region is fulfilled by the Amistad- Falcon Reservoir system- a resource shared by Mexico

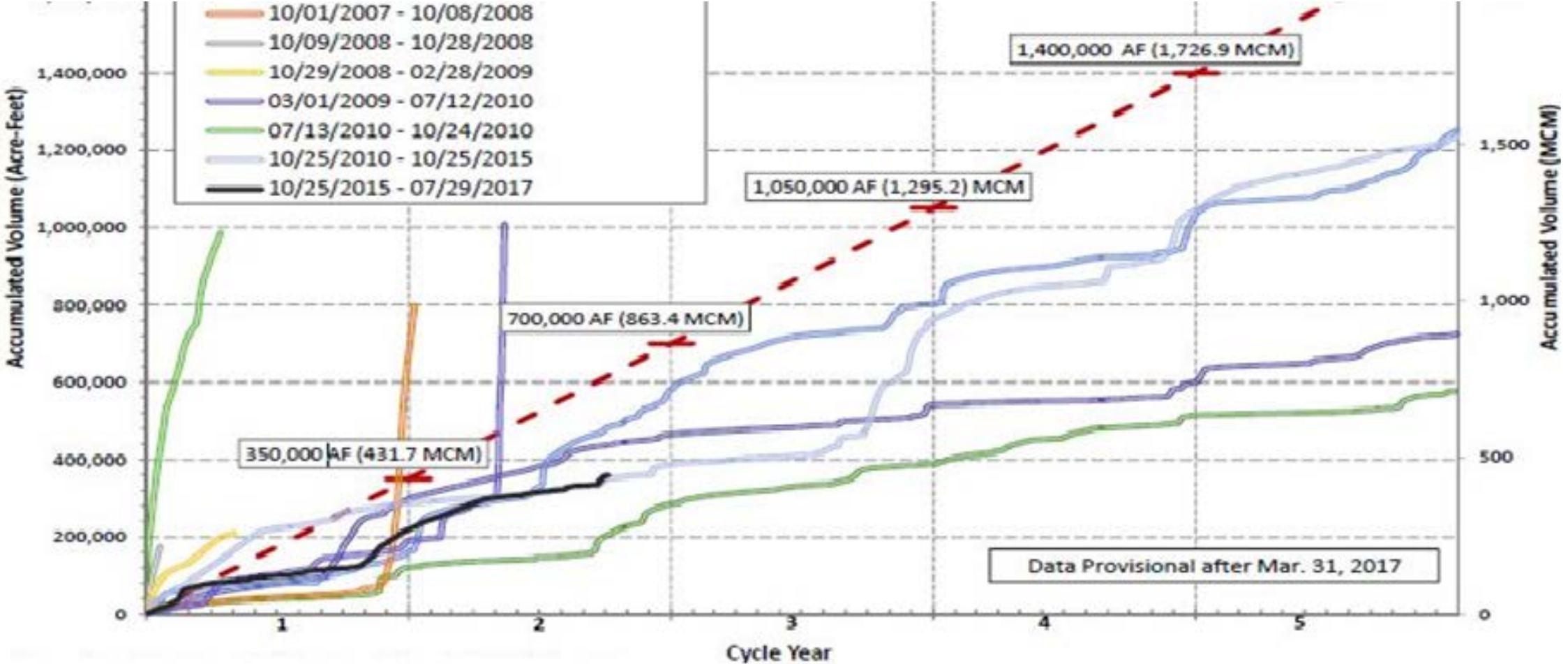
The Water Treaty - 1944

- To fix and delimit the rights is US and Mexico with respect to the water of:
 - Colorado and Tijuana Rivers and
 - Rio Grande from Fort Quitman to the Gulf of Mexico
 - One-third of the flow to Rio Grande from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo...**this one-third shall not be less, as an average amount in cycles of five consecutive years, than 350,000 acre-feet**
 - In case of “extraordinary drought” or serious accident to the hydraulic systems on Mexican tributaries...**the treaty allows for the deficiencies to be repaid in the following five-year cycle**
 - **If reservoir levels exceed 85 percent full then deficit is forgiven and a new five-year cycle starts**

The Water Treaty - 1944

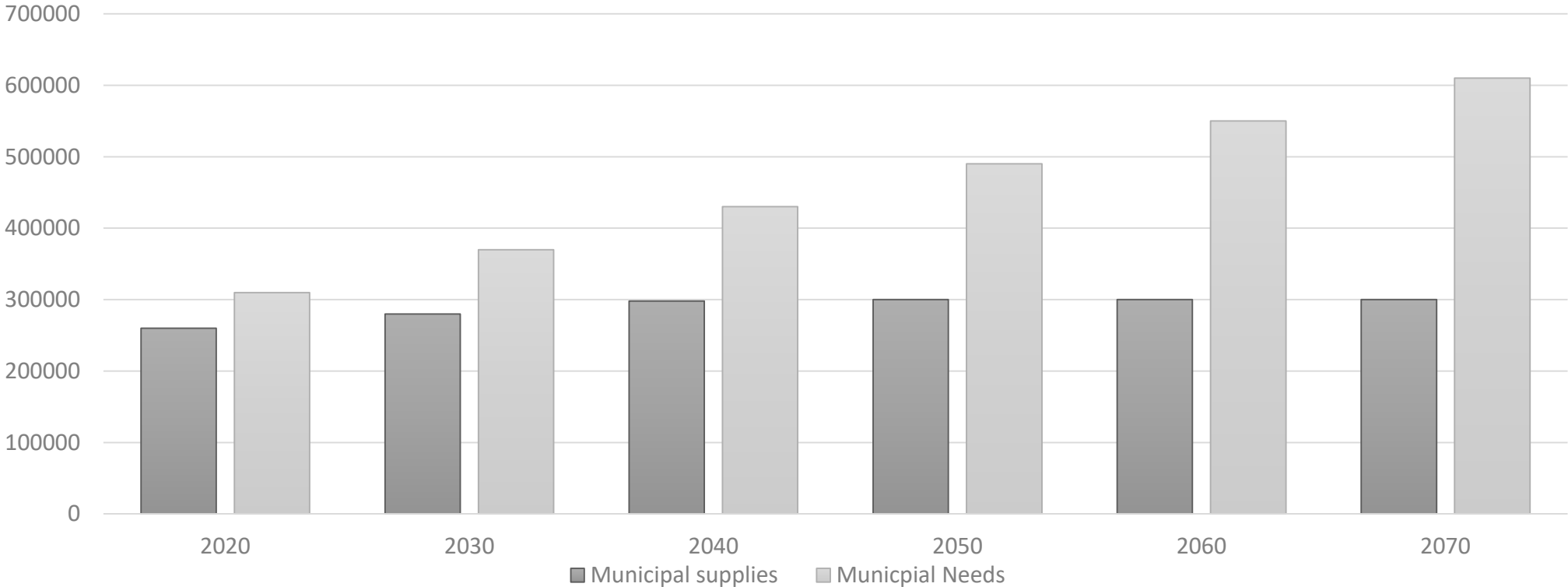


Mexico's Water Debt (IBWC)

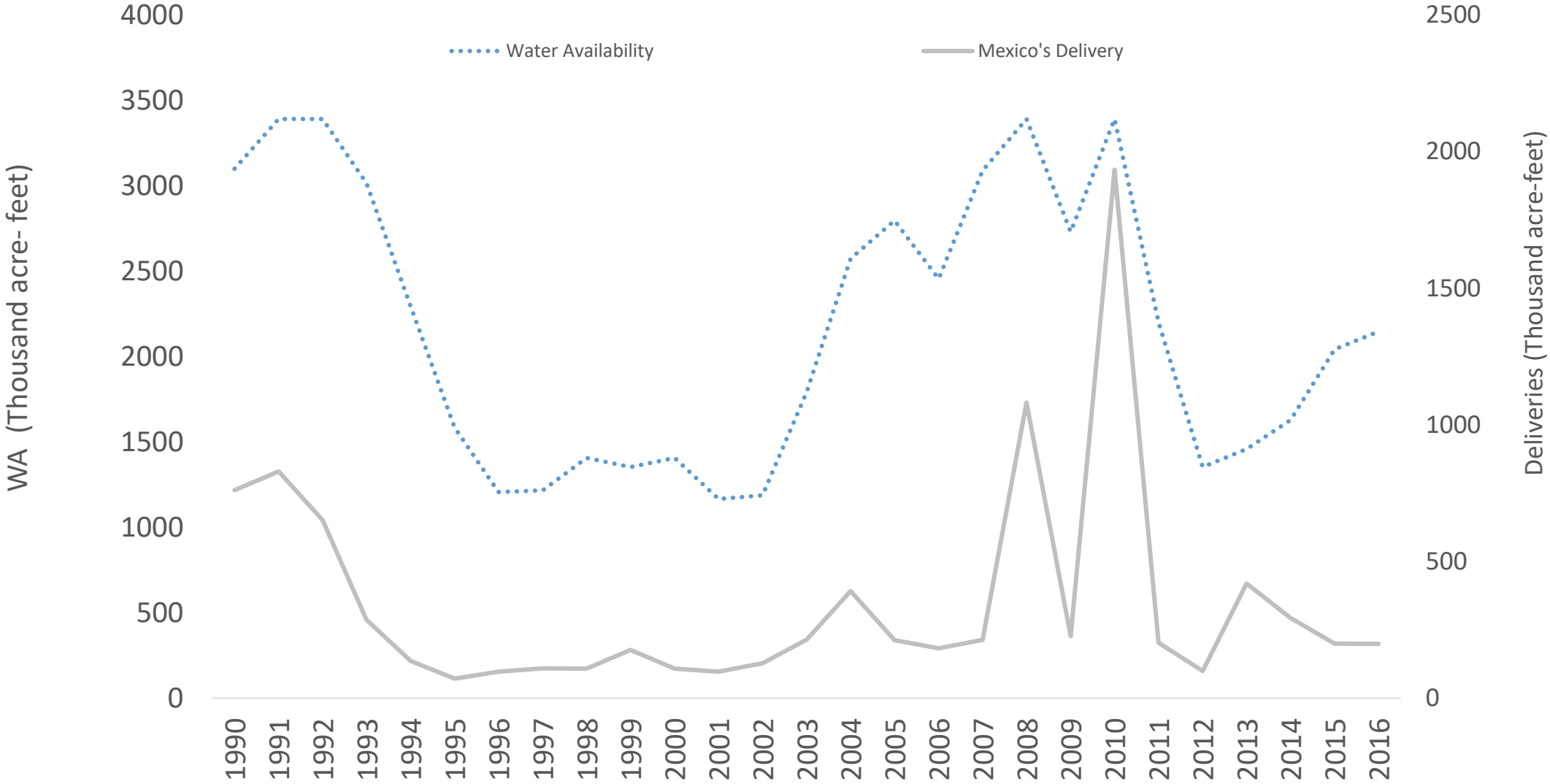


Municipal Availability vs. Requirement

ACRE-FEET / YEAR

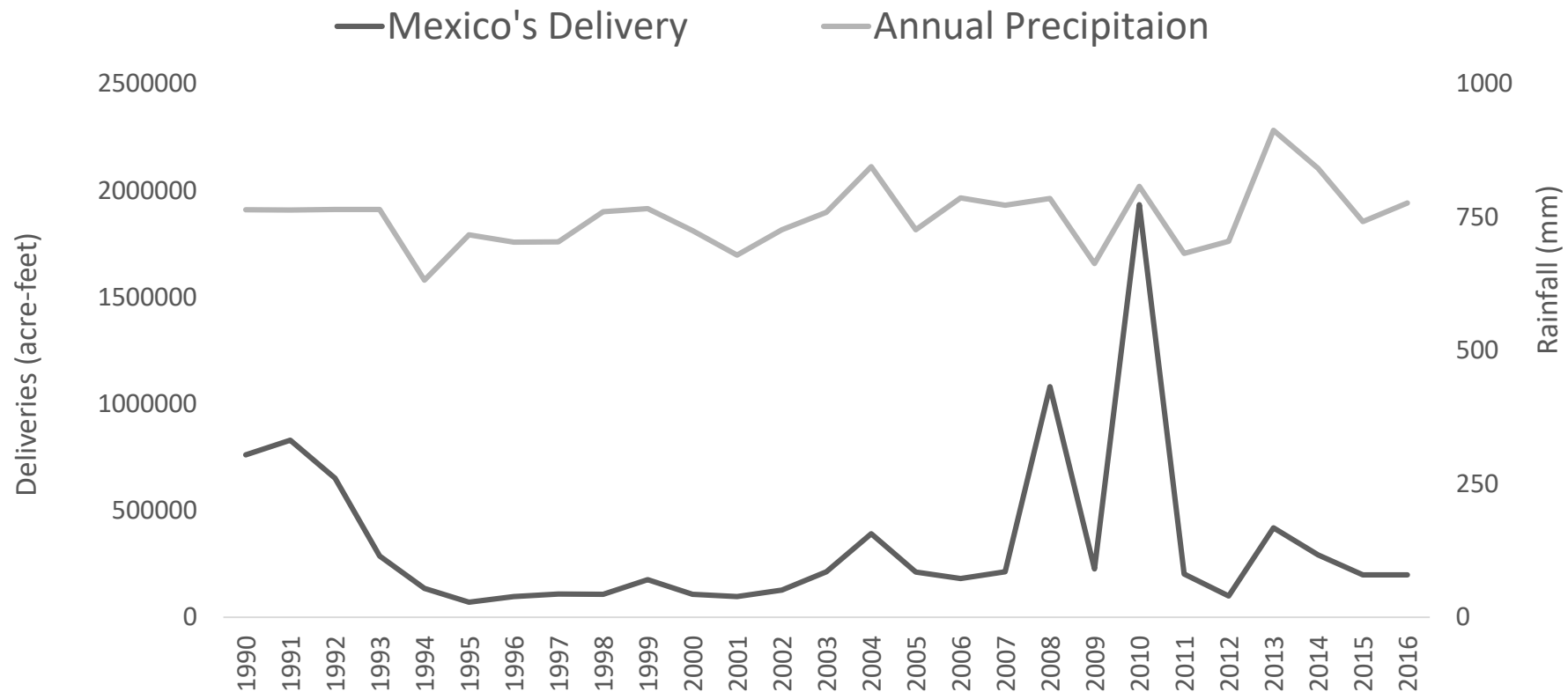


Water Availability Vs. Deliveries



Water Delivery and Rainfall

- Mexico's water delivery closely follow the amount of rainfall along the Rio Bravo riverbed



Estimation and Forecasting

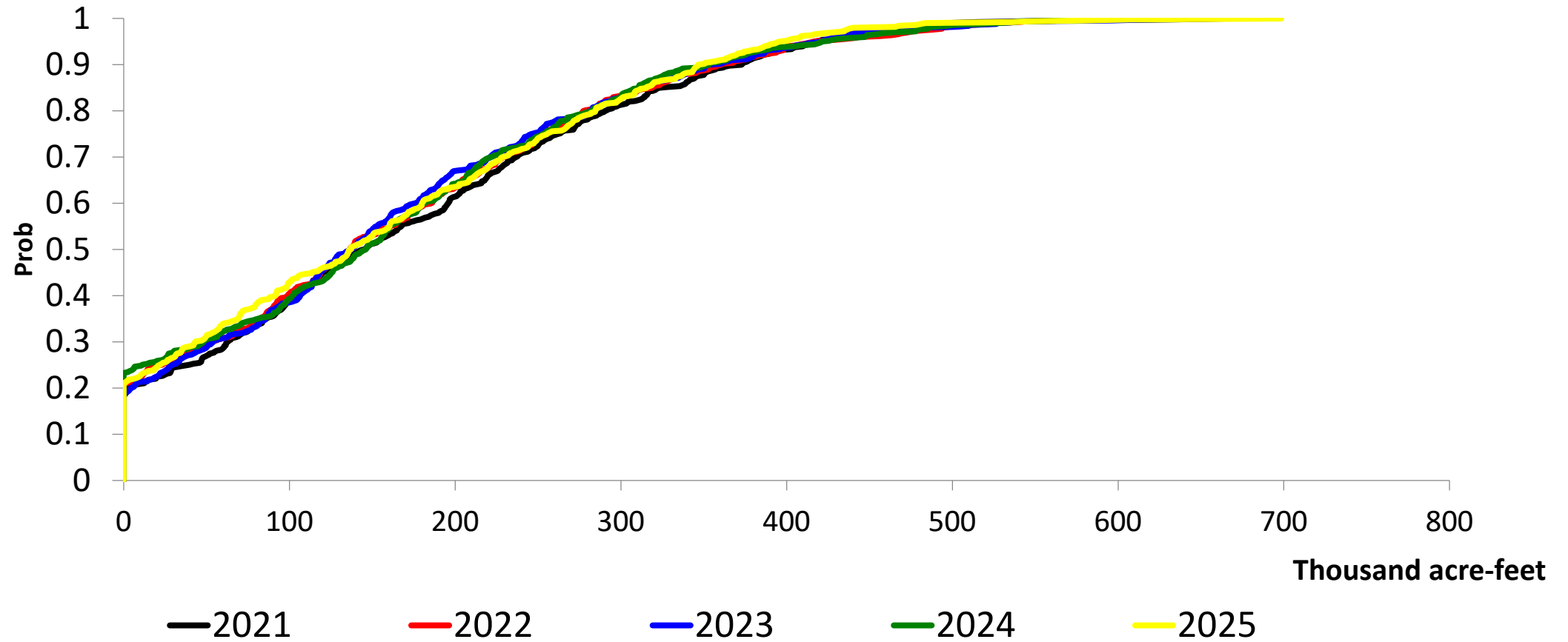
- $\text{Water Deliveries}_t = f(\text{Rainfall in the Rio Bravo Watershed}_t, \text{Cumulative Deficit}_t, \text{Delivery}_{t-1}, \text{Irrigated Acreage}_t, \text{Population}_t) + \varepsilon_t$
- An OLS model will give deterministic forecasts
- Dependent variable – Annual Water Deliveries by Mexico
- Independent Variables – Rainfall in the Riverbed, Irrigated Acreage, Population

Data Source

Rainfall - CNA, Mexico (1990 – 2017), Monthly

- Water Deliveries- *FOIA*, IBWC (1990 – 2017), Daily Flow Data
- Irrigated Acreage and Total Extraction - CONAGUA/ CNA (2002 – 2016, Annual Data)

CDF of Water Deliveries



A Dry-Year Option Program

- Dry year option contracts, in exchange of an initial payment guarantees the purchaser the right to lease water at a future date at an agreed upon “exercise” price (Characklis et al., 2006)
- Certainty around water availability for the buyer at a mutually acceptable price
- Also allows for allocative efficiency
- The agricultural water users have a lower willingness to pay and present as a likely source (Brown and Carriquiry, 2007)

Provisions of an Option Contract

- **The Threshold** - As water level go below a threshold level, the framers who have enrolled their rights in the program will be notified to suspend irrigation by the concerned authority
- **The Payment** - The program requires that the farmers be paid an enrollment fee per acre-foot of water and an additional suspension fee if the option is called
- **Required Enrollment** – The amount of water to be enrolled in the option program by the sellers

The Threshold in the Valley

- As water level goes below a threshold level, option will be called
- Water distribution channel is not the same across all irrigation districts – reservoirs vs. unlined canals of unknown shape
- The critical levels therefore, differ from one district to the other
- The trigger date is expected to be in the Fall-Winter season before the next crop year begins
- Evaluation of water availability status prior to the trigger date so farmers make necessary adjustments

The Payment

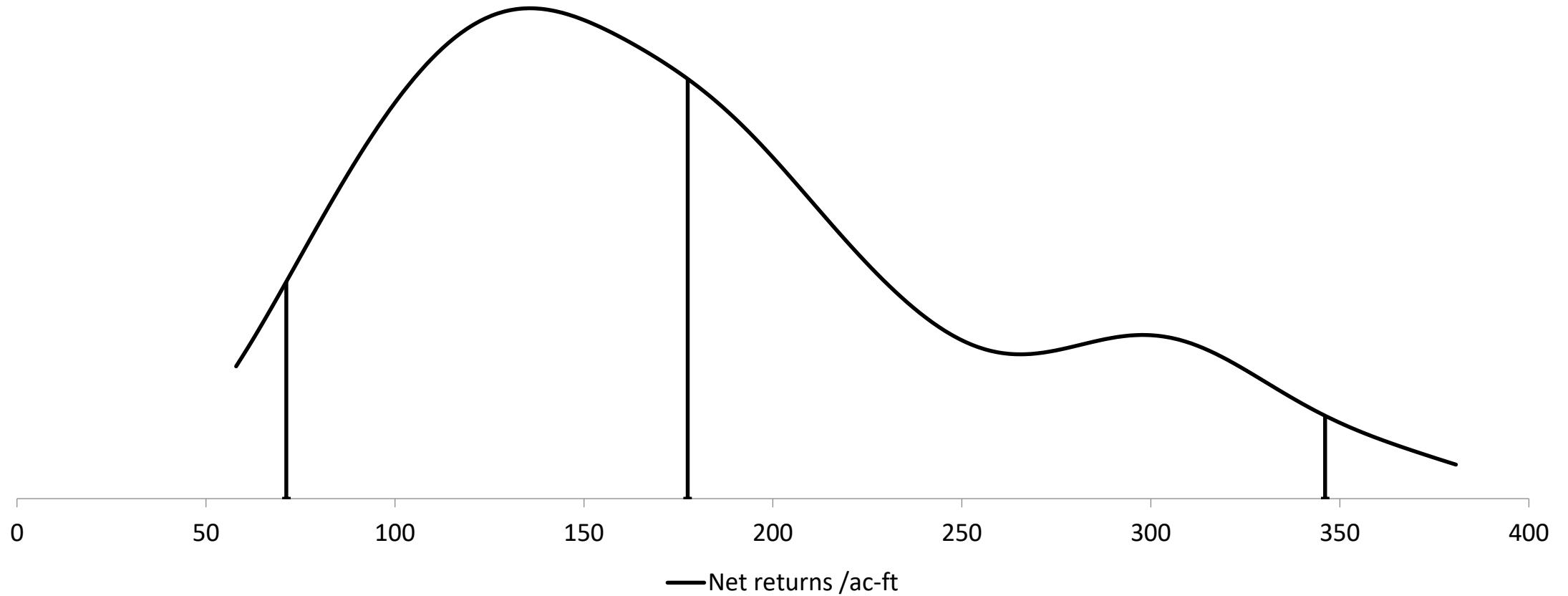
- The payment farmers will be willing to accept to suspend using their water rights must at least compensate them for revenue loss from irrigated agriculture
- Deterministic and stochastic estimates of value of irrigation water is obtained to approximate the value of forgone benefits of water to the seller
- The crop budgets developed by Texas AgriLife Extension; Historical yields and prices are available from USDA-NASS
- Thereafter, the residual imputation method is used

Residual Imputation Method and Empirical Distribution

Per-acre	Corn	Cotton	Sorghum
(Stochastic) Yield	100.0	1388.6	76.0
Price	3.8	0.6	7.5
Variable Cost	282.3	712.6	244.5
Water Use (ft)	1.5	2.1	1.3
Irrigation labor	26.4	13.2	13.2
Total Water Cost	56.4	55.2	39.2
Net Returns	158.6	174.6	362.8
Irrigated Acreage	31.10%	25.80%	43.10%
Composite Returns	250.7		
Composite Water Use	1.6		
Net returns /ac-foot	159.8		

$$F(x) = \begin{cases} 0 & \text{if } x < X_{(1)} \\ \frac{i-1}{n-1} + \frac{x - X_{(i)}}{(n-1)(X_{(i+1)} - X_{(i)})} & \text{if } X_{(i)} \leq x < X_{(i+1)} \text{ for } i = 1, 2, \dots, n-1 \\ 1 & \text{if } X_{(n)} \leq x \end{cases}$$

PDF of Composite NRTW per acre-foot



The Required Enrollment

- Irrigation districts are responsible for distribution of water to the municipalities and agricultural farms
- Small amount of municipal water in comparison to agriculture
- The distribution canals are recharged using irrigation water
- Absence of irrigation water, which cannot be ruled out under critical drought situations makes it impossible to convey municipal water

Push Water

- Push water - water required in the canals for carrying urban water
- Municipal Water Supply Network defined as parts of the irrigation water distribution network that also convey municipal water
- The MSN water assessment was done under normal operational conditions accounting for evaporation and seepage losses
- The sum of individual enrollments in each district should at least be as large as their static volume

Push Water Volumes

District	Static Volume	
	Min	Max
Delta Lake	1884.4	2916.2
Donna	1714.8	1832.3
Edinburg	688.2	1038
Harlingen	375.7	550.1
HCID 3	75	110.5
HCID 16	2008	2011.1
La Feria	1525.3	1525.3
Los Fresnos	186.6	279.9
Mercedes	1453.8	1710.6
mission 6	404.5	431.6
San Benito	2059.1	2243.3
San Juan	2344.9	2344.9
Santa Cruz	661.9	676.2
United	447.7	449.9
Totals	15829.9	18119.9

Potential Welfare Implications

- Direct impacts of the program is on (i) the farmers enrolling their water rights into the program (ii) the municipal and industrial water users (iii) and the irrigation district
- Farmers in the program will benefit if payments received from enrollment and suspension compensates for loss from change in crop-mix to dry-land cropping
- DMI users ought to benefit from the program in terms of water security every year. “insurance” against any shortages that might occur in exchange for a premium
- In order to keep the irrigation districts’ welfare unchanged, they will need to be compensated for the loss from withdrawal suspension

- *Thank you!*