Water Conservation at the Dow Chemical Texas Operations Freeport Site

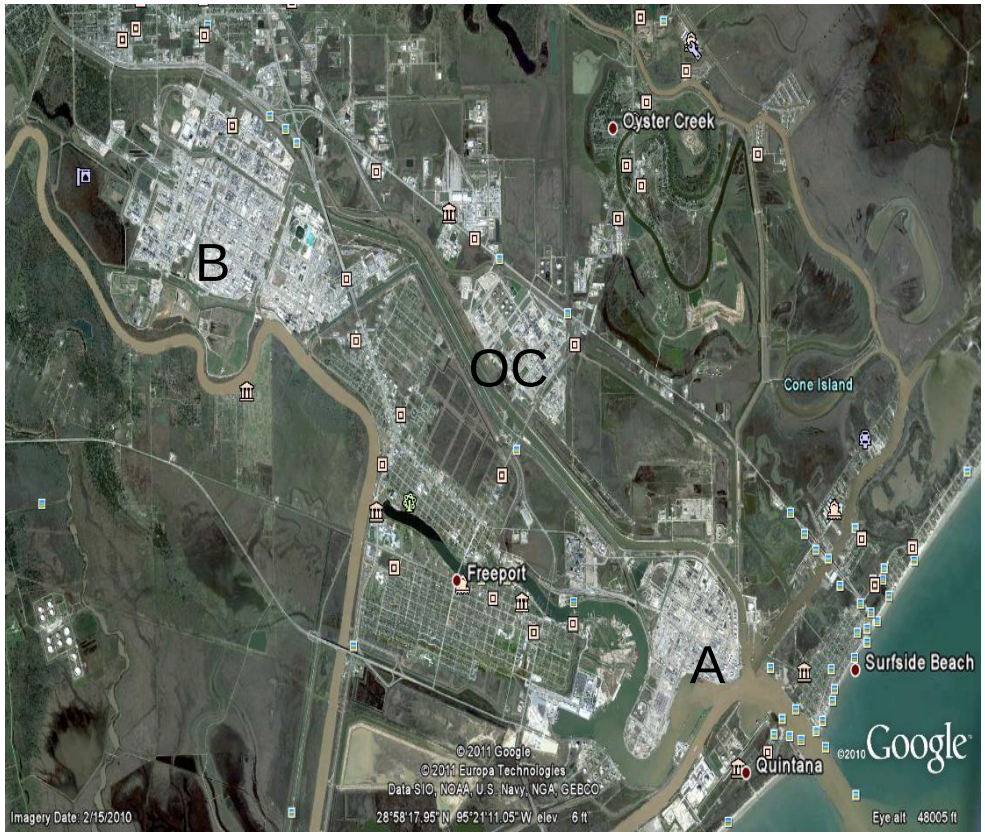
- Dow Freeport Site & Water Supply
- Driving Force For Change – The 2011 Drought
- Strategy and 2011/2012 Conservation Efforts
- Recent Years on the Brazos in the Context of the Past
- Perspective on Future Drought Risk Management
- Opportunities and Additional Water Efficiency Improvement

AICHE
Water Efficiency Conference

Tim Finley
Nov 17 2015

Dow Texas Operation, Freeport

The Largest Petrochemical Facility In The Western Hemisphere AND GROWING



Select Facts

- 65 production plants
- More than 5,000 acres
- 8000+ direct employee
- Est. 10+Texas jobs per employee
- At least 6 New Dow plants 2016+

Pre-Olin Deal

32 billion pounds/yr Production
44 % of Dow's US products
21 % of Dow's Global

Pre-Olin Deal

Fence Line Partners Include: **Olin**, BASF, Shintech, Nalco, SI Group, Others

- Multiple growth plans/plants announced

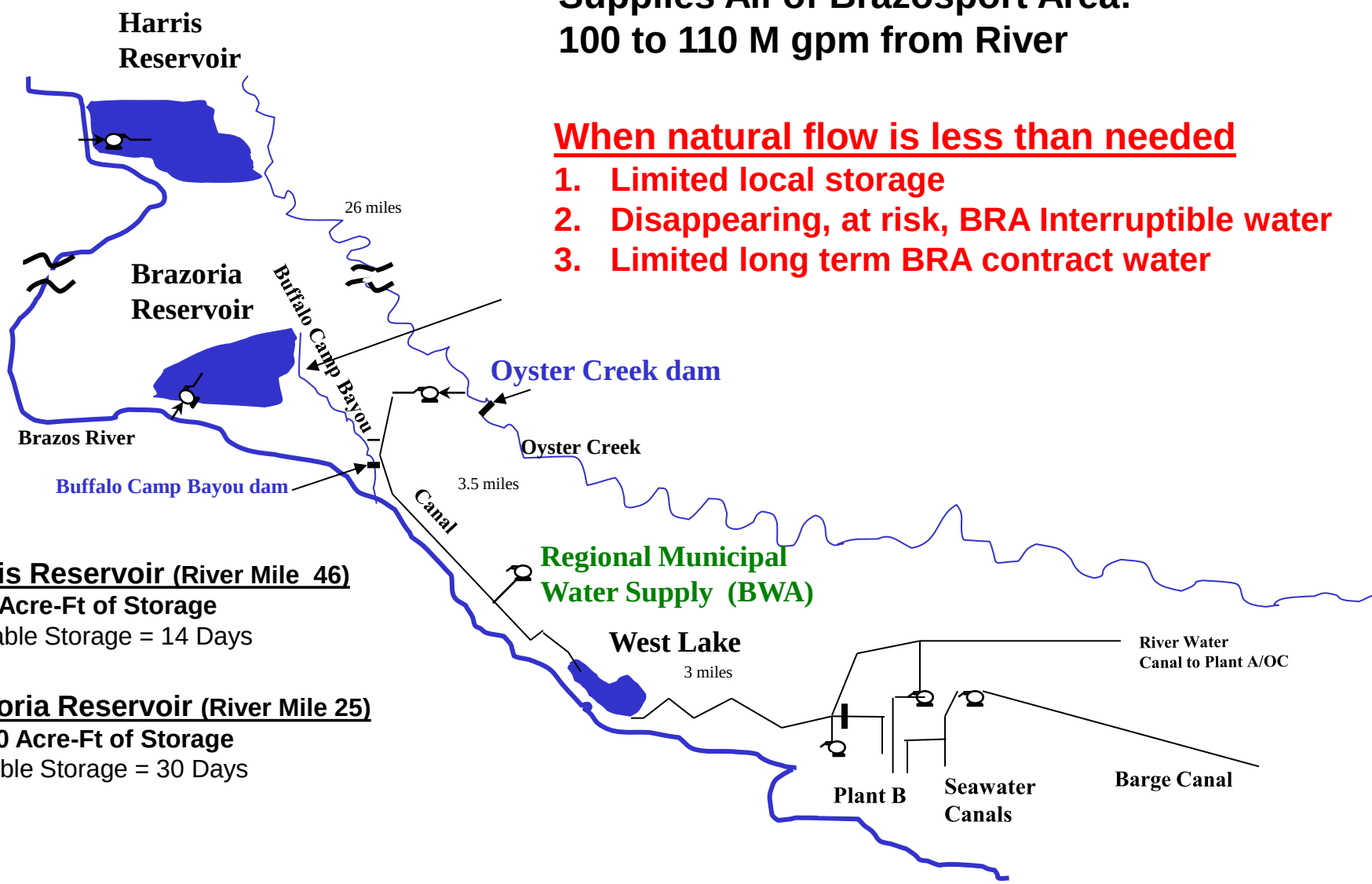
Market leading product pipelines for many of the products we supply

Failure to produce at this site would have ripple effects on the State/US Economy

One of Many Petrochemical Facilities In Texas

Dow Freeport Water Infrastructure

Supplies All of Brazosport Area:
100 to 110 M gpm from River



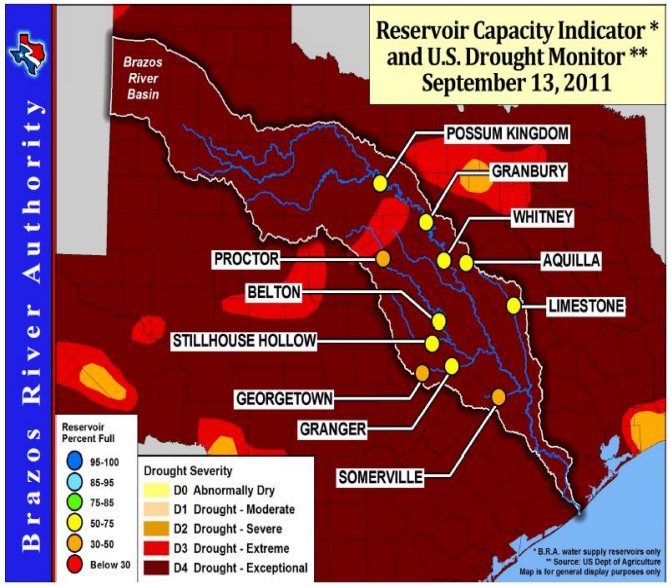
When natural flow is less than needed

1. **Limited local storage**
2. **Disappearing, at risk, BRA Interruptible water**
3. **Limited long term BRA contract water**

Harris Reservoir (River Mile 46)
7000 Acre-Ft of Storage
Available Storage = 14 Days

Brazoria Reservoir (River Mile 25)
21,700 Acre-Ft of Storage
Available Storage = 30 Days

Driving Force



June 2009 -<u>Texas's Largest River Trickles</u>

Drought conditions observed near the end of Brazos River - Upstream of Rosharon Gage and Dow Chemical's Harris Reservoir Intake

September 2011 – <u>Exceptional Drought</u>

The majority of Texas was in **exceptional** drought, with 15-20 inches below normal rainfall in 2011; Inflows were the lowest in recorded history at many locations

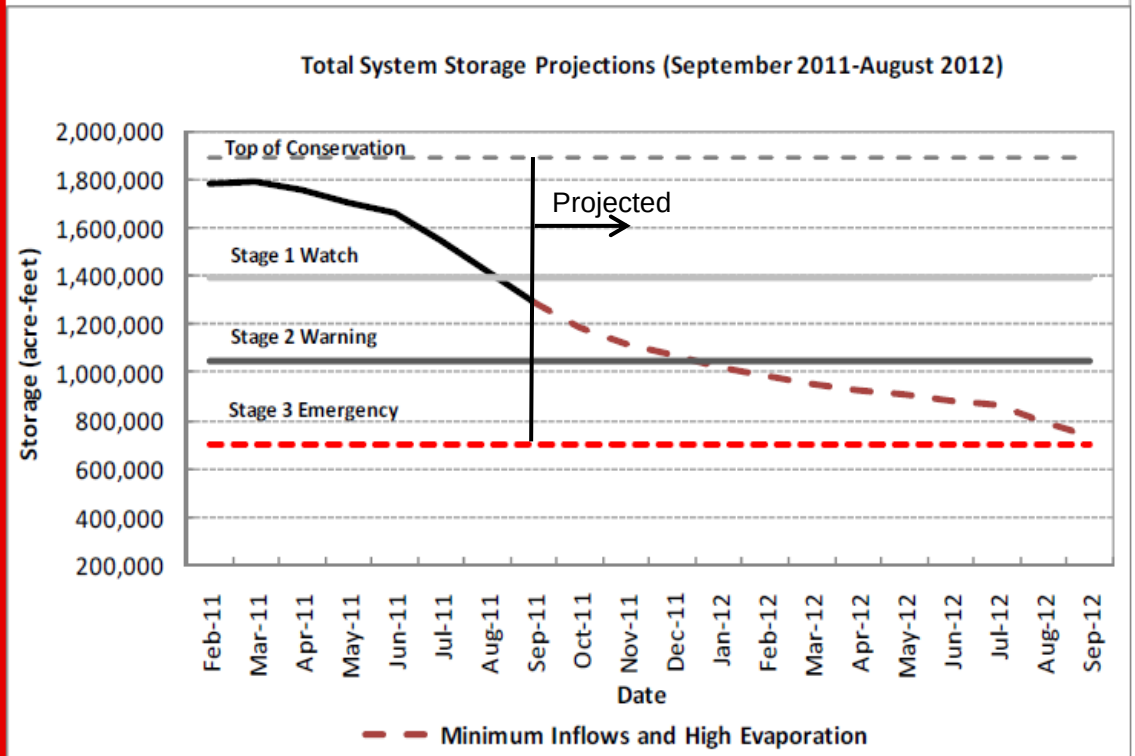
Reservoirs that started 2011 near full had been severely depleted by years end - many were nearing 50% of capacity

What we know now? Recent conditions appear to have established a new drought of record above Possum Kingdom. Preliminary data suggests that BRA's capability to supply may be reduced by ~70 M AF or greater which is more than 10% vs. prior baseline

Sept. 2011 BRA Projection

(assuming drought continued)

Brazos River Authority



Meeting Date: September 19-21, 2011

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In late 2011, BRA was predicting storage reserves to drop to just 30% if the 2011 drought continued into summer of 2012

BRA's Brazos reservoirs are designed for 4-7 years of drought but only contain storage reserves for their ~670 M AF portion of the basins permitted supply

2011 draw on BRA reservoirs was never close to 670 M AF permitted rates

Lost Production Trumps Water Cost

Element 1– A Secure Water Supply is Essential

A “secured” water supply is critical for business success. The value of water in times of drought is closely linked to the productivity it enables. For industrial users, revenues on the order of $100,000-300,000 /AF are not uncommon.

Element 2 – Conservation is Required To Reduce Risks & Enable Growth

In water stressed areas, water must be managed as a resource that will have continually increasing value as supplies become more stressed. We must strive to drive conservation projects at a price point that aligns to the future cost of new water supplies.

Dow Response

ASSESSMENT AND ADVOCACY

- Understand factors impacting the situation
- Advocate for management of water supply consistent with water law

SECURE “SPOT” SUPPLIES AS NEEDED AND AVAILABLE, ADVOCATE FOR TRADING

INCREASE LONG TERM STORED WATER RESERVE

- Acquire land for a reservoir expansion project (2011)
- Striving to add pumping and reservoir capacity
- Striving to identify supplemental water supply opportunities

REDUCE INTERNAL DEMAND (drive conservation)

- **10% reduction achieved 4th qtr 2011**
- **Additional 10% reduction capability achieved in 2012; Added 10% targeted by 2025**
- **We changed how we think about water, reliability is more important than costs**

DEFINE AND PROGRESSIVELY REFINE MULTI-DECADE STRATEGY

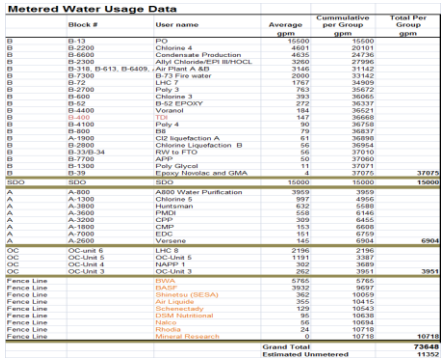
- How do we supply growth water for new facilities
- How do we diversify supply / Enable use of alternative water technologies
- How do we incorporate real / perceived risk of climate change

Water Conservation Efforts

- 2011 & 2012 effort proceeded by years of opportunity assessment ….and some projects
- Required increased clarity regarding driving force (**Financial motivations**)
  - Primary motivation shifted to **Revenue Protection** versus Cost Optimization
  - Necessitated broad stakeholder education (Full Day Leadership Workshop – Nov 2011)
- Required ongoing re-assessment of usage and opportunities
  - Site Water Balance and Usage Data (Primarily a 2009 Activity)
  - Site Ideation Program (Summer 2011 focus with nearly 300 ideas submitted)
  - Conducted "Large User" Opportunity Reviews (January 2012)
- Required focus on most impactful opportunities while striving to considered everything
  - Pareto opportunities based on normalized cost per unit water saved
  - Development and management of an evergreen list of potential projects
  - Established multiple project teams in various business units to implement projects
- **Required implementation projects at price points justified by risks & cost of future supply**

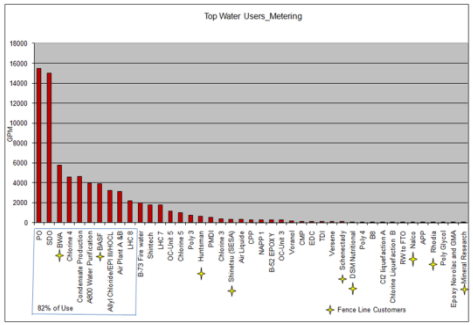
Perspective on Opportunity ID Effort

Meter Data Review

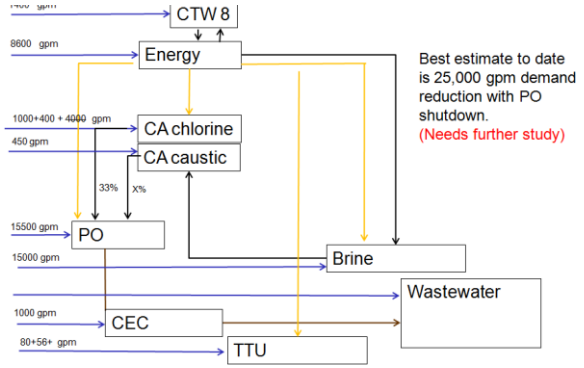


Metered Water Usage Data

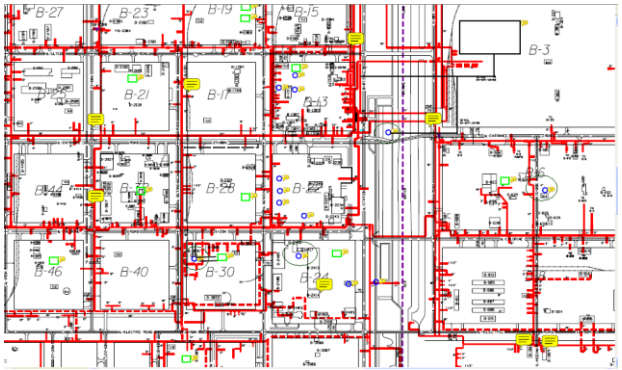
	Block #	User name	Average gpm	Commulative per Group gpm	Total Per Group gpm
B	B-13	PO	15500	15500	
B	B-2200	Chlorine 4	4681	20181	
B	B-6600	Condensate Production	4635	24736	
B	B-2300	Allyl Chloride/EPI III/HOCL	3260	27996	
B	B-318, B-513, B-6409,	Air Plant A &B	3146	31142	
B	B-7300	B-73 Fire water	2090	33142	
B	B-72	LHC 7	1767	34909	
B	B-2700	Poly 3	763	35672	
B	B-600	Chlorine 3	393	36065	
B	B-52	B-52 EPOXY	272	36337	
B	B-4400	Voranol	184	36521	
B	B-400	TDI	147	36668	
B	B-4100	Poly 4	90	36758	
B	B-800	B8	79	36837	
B	A-1900	C2 liquefaction A	61	36898	
B	B-2800	Chlorine Liquefaction B	56	36954	
B	B-33/B-34	RW to FTO	56	37010	
B	B-7700	APP	50	37060	
B	B-1300	Poly Glycol	11	37071	
B	B-39	Epoxy Novolac and GMA	4	37075	37075
SDO	SDO	SDO	15000	15000	15000
A	A-800	A800 Water Purification	3959	3959	
A	A-1300	Chlorine 5	997	4956	
A	A-3800	Huntsman	632	5588	
A	A-3600	PMDI	558	6146	
A	A-3200	CPP	309	6455	
A	A-1800	CMP	153	6608	
A	A-7000	EDC	151	6759	
A	A-2600	Versene	145	6904	6904
OC	OC-unit 6	LHC 8	2196	2196	
OC	OC-Unit 5	OC-Unit 5	1191	3387	
OC	OC-Unit 4	NAPP 1	302	3689	
OC	OC-Unit 3	OC-Unit 3	262	3951	3951
Fence Line		RWW	5765	5765	
Fence Line		SASW	3932	9697	
Fence Line		Mitsubishi (SESA)	362	10059	
Fence Line		Air Liquide	355	10415	
Fence Line		Schmeckwitz	129	10543	
Fence Line		DSM Nutritional	95	10638	
Fence Line		Naico	56	10694	
Fence Line		Rhodia	24	10718	
Fence Line		Mineral Research	0	10718	10718
		Grand Total			73648
		Estimated Unmetered			11352



Integrate Water Cycle Maps



Block Water Use Surveys



Major Water Use Reviews

- PO — 15,500 gpm plus
  - Reactor water
  - Cell Effluent
  - Cooling
- Brine Mining/Chlorine — 21,050 gpm plus
  - Mining
  - Cooling
  - Steam/condensate cycle
- Cooling Towers (some double counting) — 18,000 gpm plus
  - Significant contributor to unmetered flows
- Energy — 10,500 gpm plus
  - Steam/condensate cycle
  - Cooling
- Hydrocarbons — 4,000 gpm plus
  - Steam/condensate cycle
  - Cooling

Employee Idea Collection

Pareto Opportunities

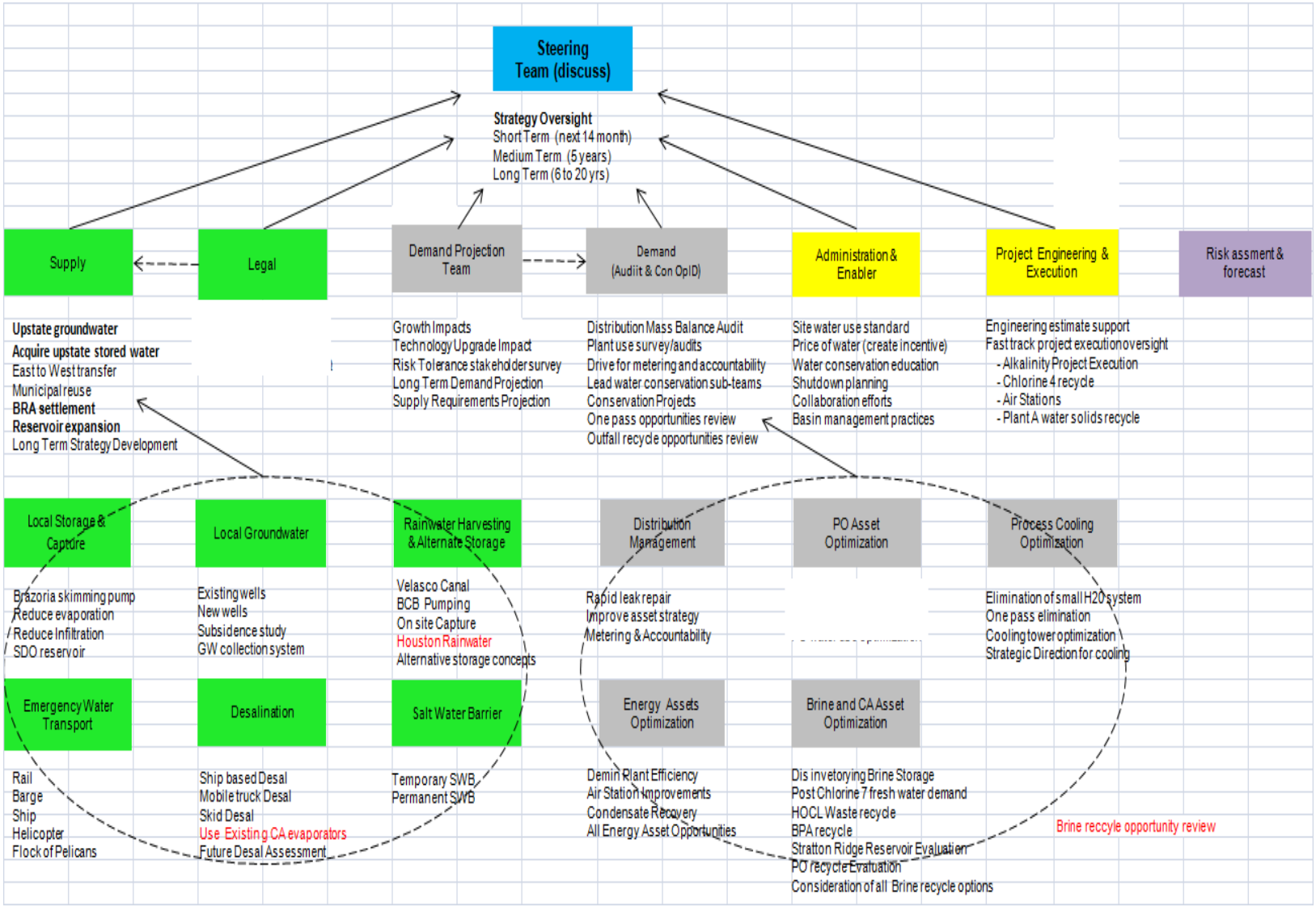
Project Cost Comparison

Clarified River Water Conservation/Supply Projects Underway or Under Consideration

Project	Year	Clarified Water Demand Reduction (gpm)	Cost ($M)	Cost to Water Ratio ($/gpm)	Cost Comparison Index ($/M gal accumulated for 10 yr.)
Prod. Unit Soft Water Recycle -	2012	3,000	220	73	0.01
Dorr Pond Water Reduction	2012	400	50	125	0.02
Air Station Once-Thru Water (CTW Ready)	2011	600	203	338	0.06
Current Variable Cost of Water					0.11
Demin. Water #4 Resin Change	2012	1,600	900	563	0.11
Cl_2 4 Rectifiers & B-318, B-2400 A/B Recycle	2011	2,650	2,500	943	0.18
Air Station Once Through Water (On-goin	20	1,	,5	0	0.18
Small Cooling Tower Optimization	2011	1,000			
Lake Jackson Waste Water Recycle	2011	2500	50	962	0.18
Harris Reservoir Expansion*		6 78	2,000	1,807	0.35
Harris Pump Station Expansion ***		17 53	50,000	2,800	0.54
River Water Alkalinity Adjust	Hold	2,100	8,300	1,303	0.75
Current Book Cost of Water					0.76
HOCL Recycle Opportunity (Brine Recovery)		1,500	7,000	4,667	0.89
Anolyte Brine Conc. and Recover Demin Water**		2,600	15,000	5,769	1.10
Target Prod Unit Wastewater Recycle		10,000	70,000	7,000	1.33
Replace Prod. Unit Inducters w/Titanium Reboilers		500	5,000	10,000	1.90

* - Based on water conservation equivalent required to increase current storage from 1.5 months to 6.0 months
** - Capital is a Guess - do not have a preliminary estimate.
*** Impact is estimated based fill and draw use Harris Reservoir that is estimated to captures additional 14400 AF convert to equivalent require conservation in 6 months

Tactical Exploration, Planning & Execution



2011 & 2012 Conservation Results

Conservations Projects

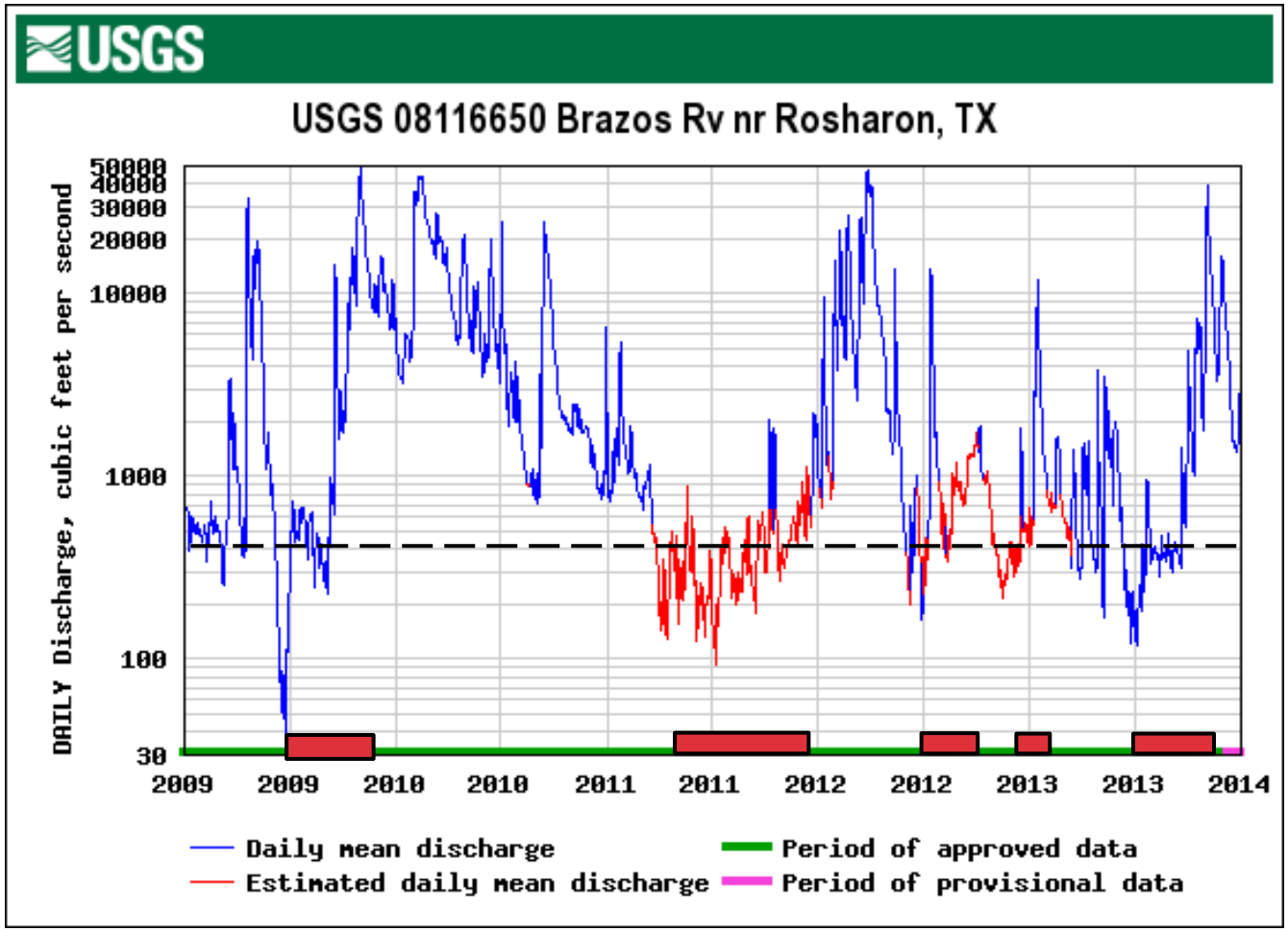
• Temporary conservations measures (as needed action)	3500 gpm
• Lake Jackson Waste Water Recycle	**2500 gpm**
• Chlorine 4 recycle (phase I)	**2000 gpm**
• Small Cooling Tower Optimization	**1000 gpm**
• Door Pond Water Reduction	**400 gpm**
• Air Station One-pass Water Elimination	**1500 gpm**
• Prod Unit Soft Water Recycle (5000 gpm intermittent benefit)	**3000 gpm**
• Power 4 Demin IX Resin Upgrade	**1600 gpm**
• Air Station Rental Cooling Tower Ready (as needed action)	600 gpm

Bold indicates continuous reduction impact

Estimated Permanent Demand Reductions	**~12,000 gpm**
Additional Drought Response Reductions	~4,100 gpm

Efforts gained Dow Freeport recognition with its first ever Texas Environmental Excellence Award

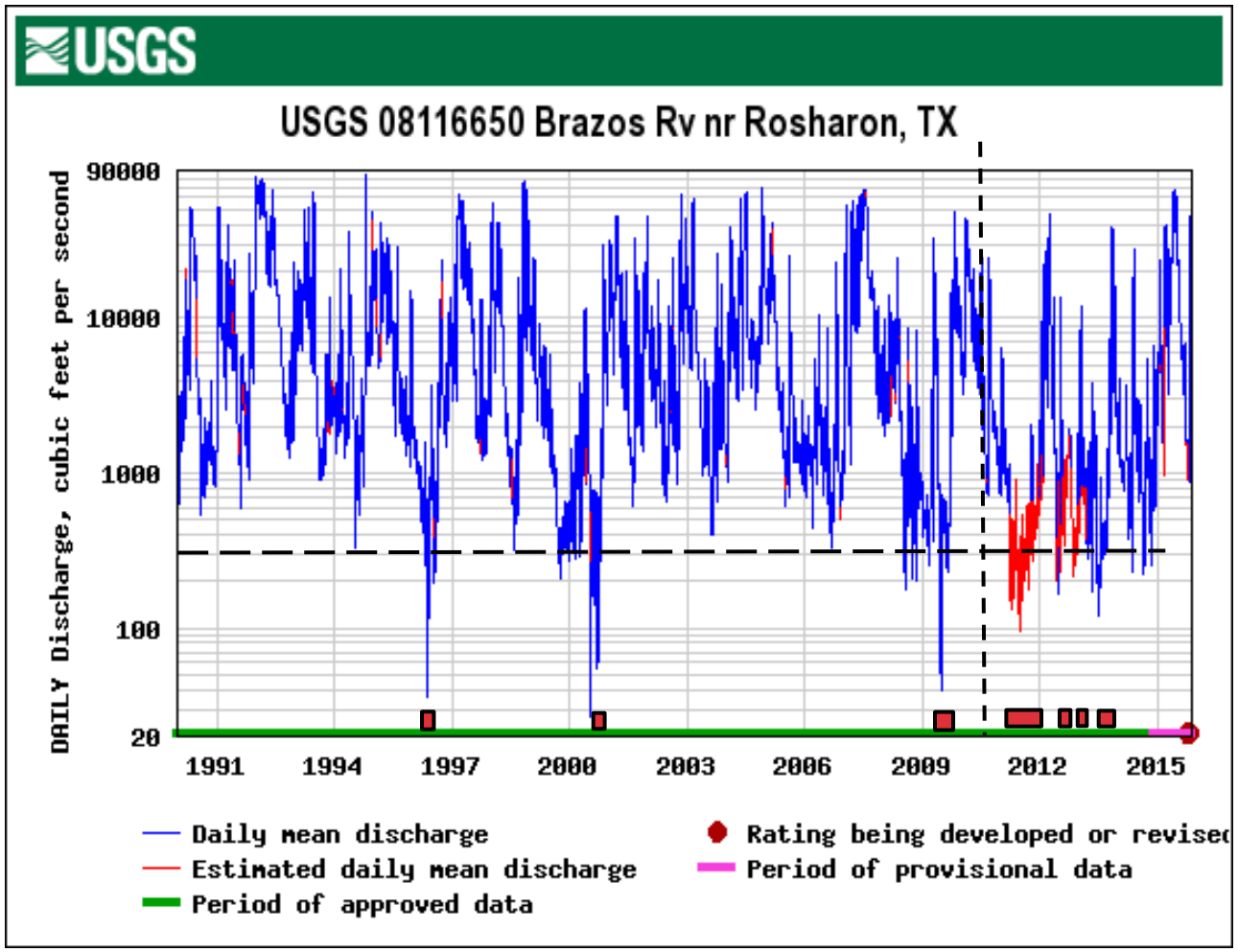
2011 in perspective of past 5 years



Approximate Rosharon gage flow required to sustain the Dow intake

Periods when BRA stored water releases have been required to sustain Rosharon gage flows

Past 5 years in context of past 25 years



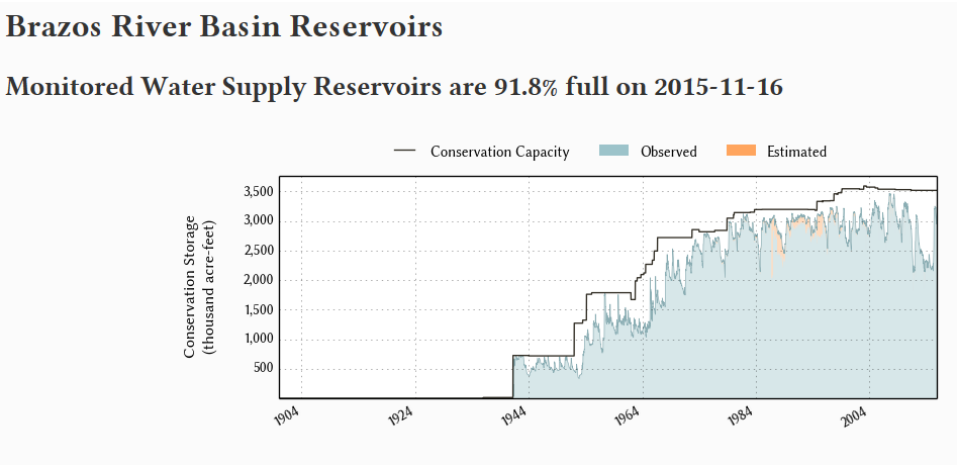
Approximate Rosharon gage flow required to sustain the Dow intake

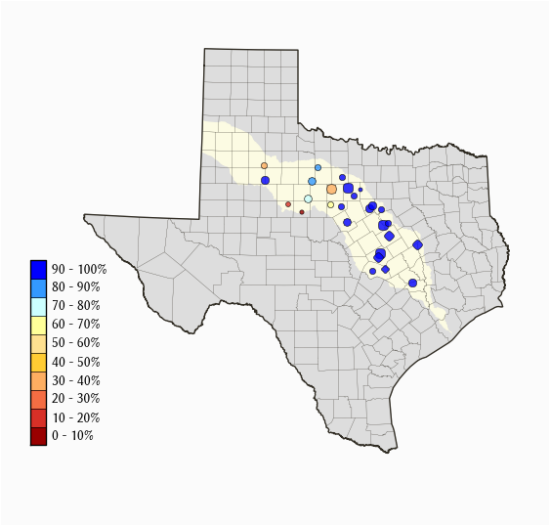
Periods when BRA stored water releases have been required to sustain lower basin demands & Rosharon flow

Drought and changes in basin management result in 5 years period from 2009 to 2014 being significantly different than previous 20 years

Future Outlook – It's raining, right?

- Dow was very close to initiating a Water Rights call multiple times in 2014
- Brazos reached flood stage in May 2015, by September severe drought conditions returned
- BRA currently has no added "Reliable" water to sell and Allen's Creek is decade away
- BRA is only able to supply ~40% of 2016 Interruptible water contract requests
- The impact of a new "Drought of Record" must be fully accounted for in planning
- New Brazos basin water sources are 5-10 time more expensive than current BRA water
- Both industrial and municipal demand are growing rapidly
- The Brazos is uniquely stressed in that nearly all reliable surface water is already allocated to municipal, industrial in and power.





Potential Opportunities List

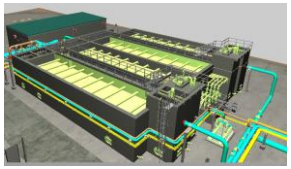
Minimize Transfer Losses	Eliminate Distribution Leaks	Optimization Evaporative Cooling Systems	Eliminate or Recycle One Pass (even small)	Use Air Cooling to cool Hot Processes
Implement Thermal Pinch	Production Process Redesign	Upgrade Demin Water Treatment Plants	Recycle Municipal Effluent	Treat and Recover Effluent Streams (membrane/thermal)
Improved Land Use Practice	Prevent Groundwater Depletion	Design For Groundwater Recharge	Conjunctive Surface & Groundwater Use	Aquifer Storage & Recovery
Lower Basin Off-channel Reservoirs	Reservoir Management Optimization	Agricultural Water Use Optimization	Watershed Trading	Promote Municipal Conservation
Brackish Groundwater Desalination*	SWRO to Demin	SWRO*	Integrated Water & Power Production	Seawater Cooling Towers

Consider Dow Water and Process Solution

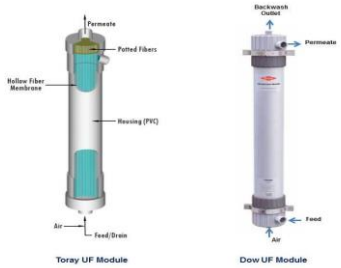
a Market Leading Membrane& Water Solution Technology Supplier

New Demin Plant in Freeport Conserves Water

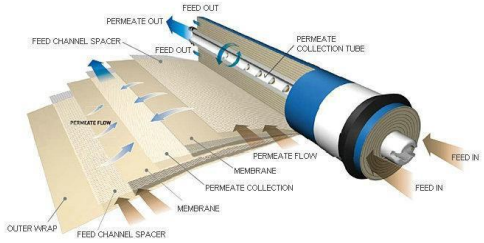
Product water is ~ 80% of feed



Water is clarified



Dow UF membranes efficiently remove solids ahead of RO; Most rejects recycled

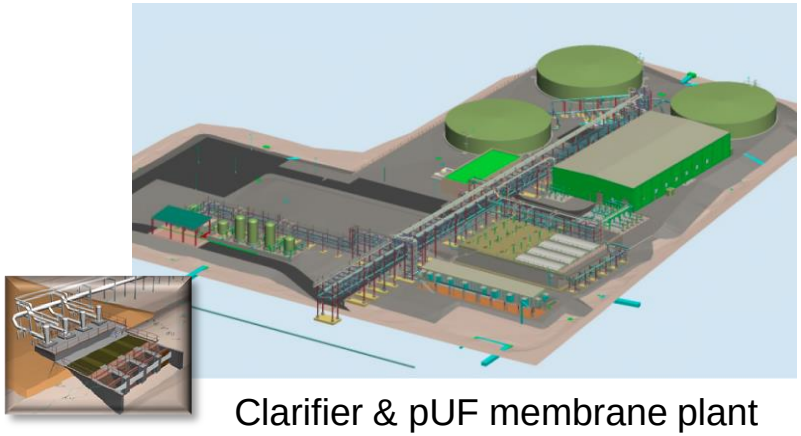


Dow RO membranes remove majority of salt with low reject ratio

Dow IX resins remove residual ions to produce demin water

New Freeport UF Filtered Water Plant Will Save Water

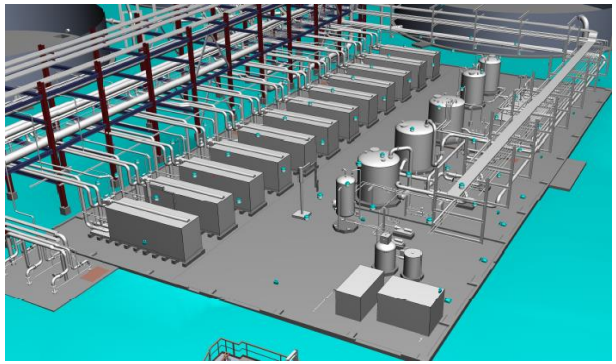
Nearly 100% of feed water will be delivered as product; Improved quality will enable better performance and water savings in cooling systems



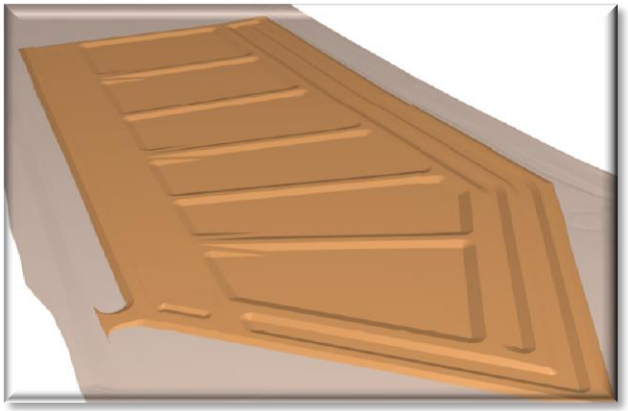
Clarifier & pUF membrane plant

- Plant will utilized Dow pUF Membrane to produce 25 MGD of high quality water
- Process recovers/recycles water and incorporates green infrastructure concept

pUF membrane Module



Internal view of pUF membrane bldg



Grading Plan for solids and water recovery System

Distribution Rehabilitation Saves Water


Before


After


Before


After

Use of Innovative welded cement lined carbon steel pipe in Dow Freeport

In Summary

- Demand growth, systematically decreasing inflows and periodical occurrence of severe drought condition create potential for water shortage and severe financial consequence

- Approximately 80% of the time, the lower Brazos experiences excess flows but roughly 20% of time demands exceed natural flow of the river

- Brazos river droughts require storage; basin storage reserve are insufficient
  - The need for storage includes virtually all users
  - Storage reserves must be conservatively sized/planned to assure reliability
  - Lower basin storage reserve increase when infringement occurs –rights enforcement needed

- Conservation increases useful life of storage reserves and is therefore critical

- **<u>Risks mitigation,</u> not just costs, must be considered in the determining what needs to be done!!!**

Thank You