Follow the Water – Chemical Manufacturing Recycle/Reuse Opportunities and Solutions

Industrial Water Use and Reuse Workshop

International Society for Water Solutions

Gená Leathers
galeathers@dow.com
May 01, 2013

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Today's Agenda

- Dow's commitment and societal challenges
  - 2015 goals
- Manufacturing Operations: Water Footprint Management
  - Case Histories
- Dow and The Nature Conservancy Collaboration
  - Preliminary Results

Our Water Vision

Dow will be a leader in addressing the global water crisis by setting the standard for sustainable water use and management. We will develop innovative technologies and business models that lower the cost of water purification, set new levels for efficient water use at our manufacturing facilities while striving to reach zero water discharge. Dow will use creative partnerships to increase the global sense of urgency to solve this issue.

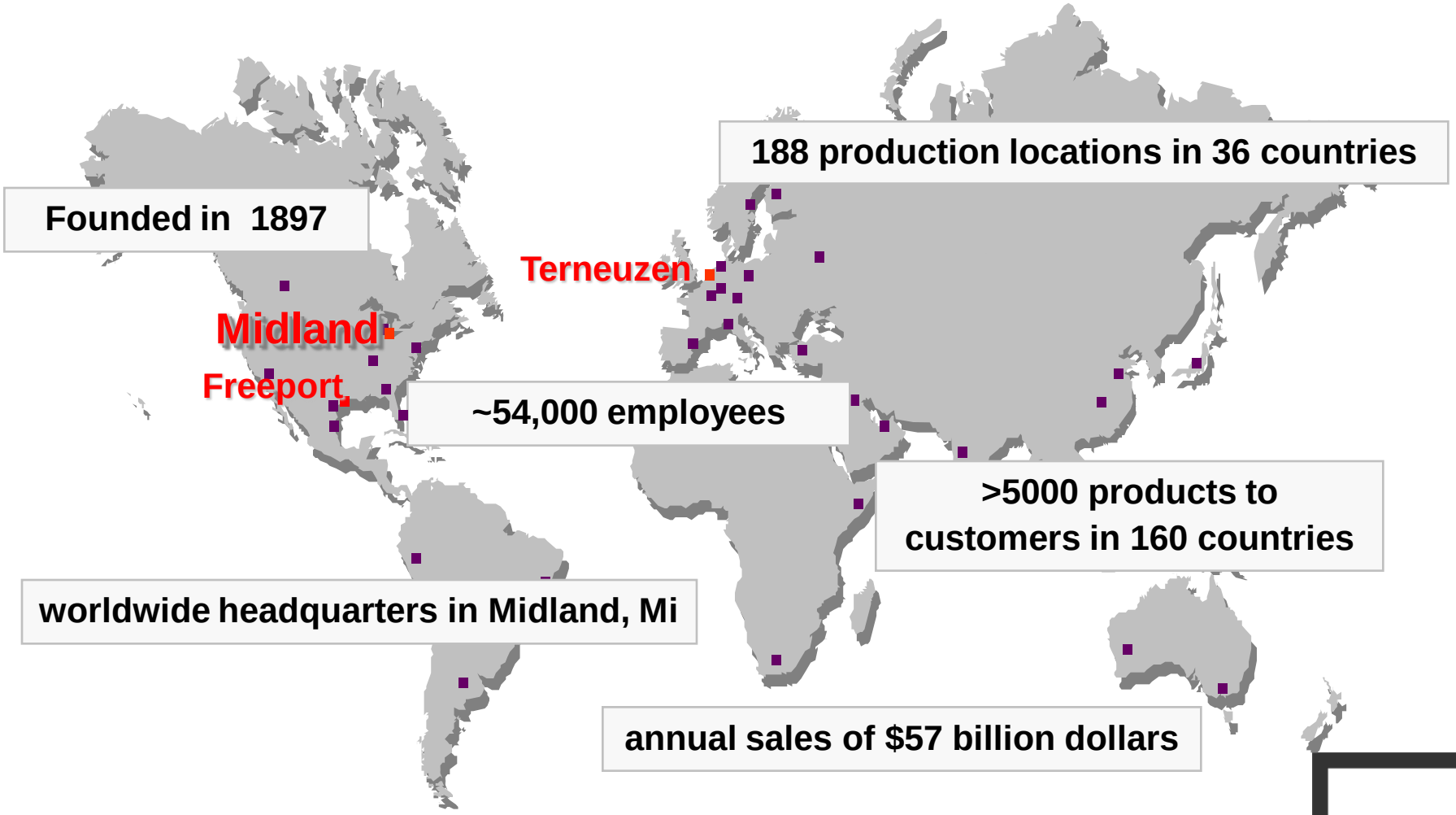
2015 Sustainability Goals*

- Our goals were inspired by the UN Millennium Development Goals and are consistent with the science and technology we do best. They will drive our growth profitability, continued EH&S performance improvements, and a focus to help address some of the world's most pressing challenges.

- The seven 2015 Goal components
  - **Local Protection of Human Health & Environment**
  - Contributing to Community Success
  - Product Safety Leadership
  - Sustainable Chemistry
  - Breakthroughs to World Challenges
  - Energy Efficiency and Conservation
  - Addressing Climate Change

* www.dow.com

Science and Technology Company



You find our chemicals everywhere

- Food
- Building Maintenance & Construction
- Transportation
- Furniture & furnishings
- Paper and Publishing
- Home Care Improvement
- Sports
- Personal and Household Care
- Health and Medicine
- Water Purification
- Electronics and Entertainment

Water is …

Regional

Local

Abundant… but not available

Different drivers require
Different solutions

One size does not fit all…

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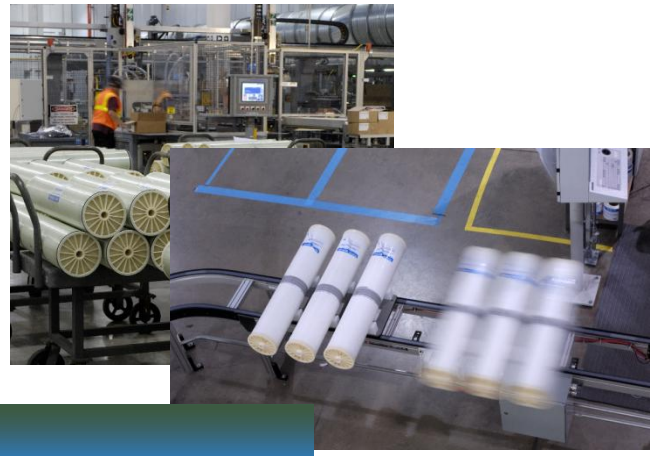
Water Availability

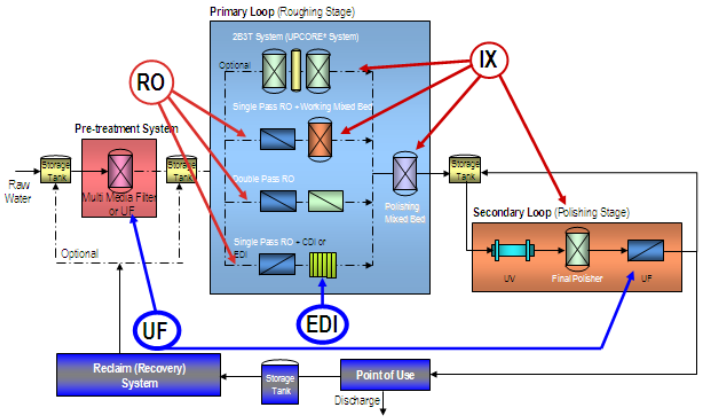
- Address on multiple fronts
- Technology
  - solution provider
  - solution implementer
- Recycle/reuse
- Operations Excellence
- Partnerships / Relationships

Dow Water & Process Solutions

- Business unit comprised of component technologies designed to advance the science of water purification around the world
- Target applications are seawater desalination, contaminant removal and water reuse.

- FILMTEC™ reverse osmosis membranes, DOWEX™ ion exchange resins, ADSORBSIA™ GTO™ titanium-based arsenic removal media, ultrafiltration, and electrodeionization





Technological Process Expertise and Innovative Solutions

- At BASF's site in Belgium, Dow and BASF jointly developed an innovative hydrogen peroxide to propylene oxide (HPPO) technology, which provides economies of scale, and reduces wastewater and energy usage.
  - New plants built using this technology:
    - receive a reduction in wastewater by more than 70 percent
    - energy usage reduced by 35 percent when compared with PO process technologies in use today.

- Dow's largest manufacturing site globally in Freeport, Texas, has designed and implemented a power plant using seawater for cooling instead of freshwater.
  - Seawater use saves $600,000 / year in avoided treatment, energy and water costs.
  - Resulted in 1,200 gallons per minute reduction in freshwater demand and this means that there will be 1,200 gallons per minute reduction for the life of this facility.

Recycle / Reuse

- Stade Germany Site
  - Vigorous R&D and project implementation
  - Recycle of the wastewater generated from the propylene oxide production, after biological and physical/chemical treatment, back to the brine mining operation
  - Results is 10 million cubic meters per year of freshwater conserved and correspondingly, about 10 million cubic meters per year of wastewater not discharged.
- ***More on Recycle/Reuse***

Water Footprint Management
Manufacturing Operations
Case Histories

Water management

The 3X Water Model

Dow Terneuzen



Reusing Household Waste Water Through a Public Private Partnership

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The 3X Water Model

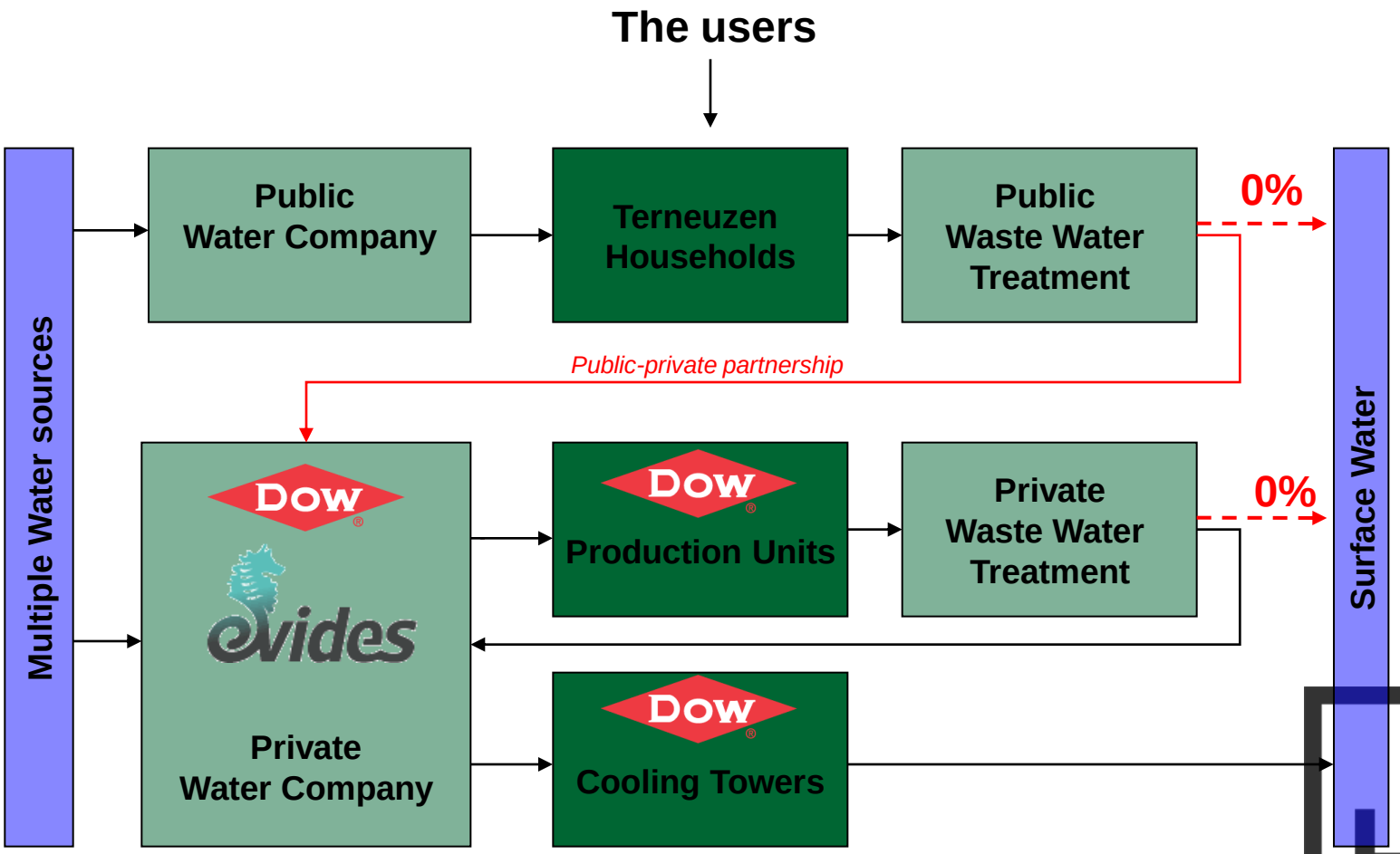
- **Closing the water cycle developed and implemented in the region Terneuzen:**
- Reduce pollution at source (in-process)
- Classic reuse (return steam condensate)
- Reuse industrial wastewater
- Regional integration by reuse of municipal wastewater for industrial application
- Utilize alternative sources in the region

Background

- The region suffers from a structural lack of sweet fresh water
- The Dow site in Terneuzen, the Netherlands, is the largest single water user in the region; it uses approx. 60,000 m^3 water per day
- Dow strives to constantly improve water efficiency
  - reduce fresh water use
  - maximise re-use

- Dow's focus is to not use scarce fresh water sources which are suitable for drinking water
- Dow and Water supplier Evides pro-actively engaged with the city of Terneuzen and the Water Board to manage the regional water balance

The 3X Water Model
- A successful PPP -



Data Dow Terneuzen

- **Daily water usage**
  - Dow location ~ 60,000 m^3 (excluding seawater and potable water)
  - Fresh water demand 22 million m^3/yr
  - 5 x regional consumption in households
- **Realized Reuse**
  - Classic reuse of condensed steam 6 million m^3/yr
  - Dow wastewater 3 million m^3/yr
  - City of Terneuzen wastewater 1.5 million m^3 /j
  - Rainwater 0.5 million m^3/yr
- **Added Value**
  - Energy saving vs. seawater evaporative desalination (60 kton/yr CO2)
  - Less chemicals 500 ton/yr
  - Reduced discharge to receiving water body
- **Present fresh water intake 11 million m^3/yr**
- **Goal for 2015 is 7 million m^3/yr (or less …)**

Fresh water supply

1st cycle

Potable water for households

Sewage Treatment Plant (municipality)

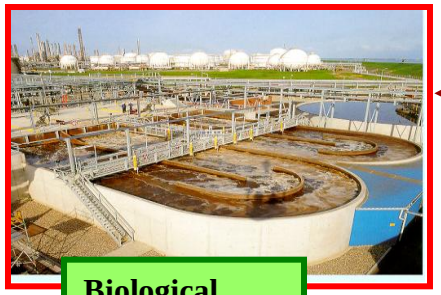
Desalination of effluent with membranes

2nd cycle

Ultra pure water

Fresh water used to produce steam at Dow site

Waste water



Biological wastewater treatment

Discharge to river

water evaporates

Water to supply cooling towers

3rd cycle

Process cooling

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Next Steps

Terneuzen

- PPP Phase 2: building of a new membrane installation at public treatment facility:
  - Increased volume of water available for the 3X model
  - Improvement of the pretreatment in the Dow/Evides facility
  - Increased capacity of the public water treatment facility

- A study has been initiated into additional sources of fresh water which after treatment can either feed into the 3X model or into agricultural sector

Global

- Leverage (parts of) the 3x model to other Dow locations
- Incorporate the concepts in new facility design
- Development of components that will allow the reuse of cooling water

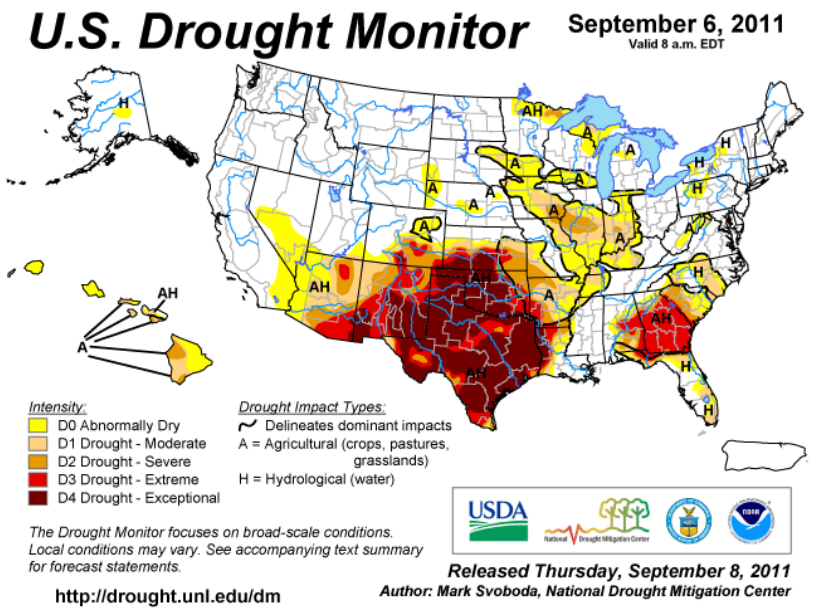
Largest chemical manufacturing facility in the world

Dow Freeport Burning Platform

Seawater Intrusion

Reality

Perception: The Brazos River Has Large Flows Relative to Dow/Local Demand



- Previous Strategy → Interruptible Water

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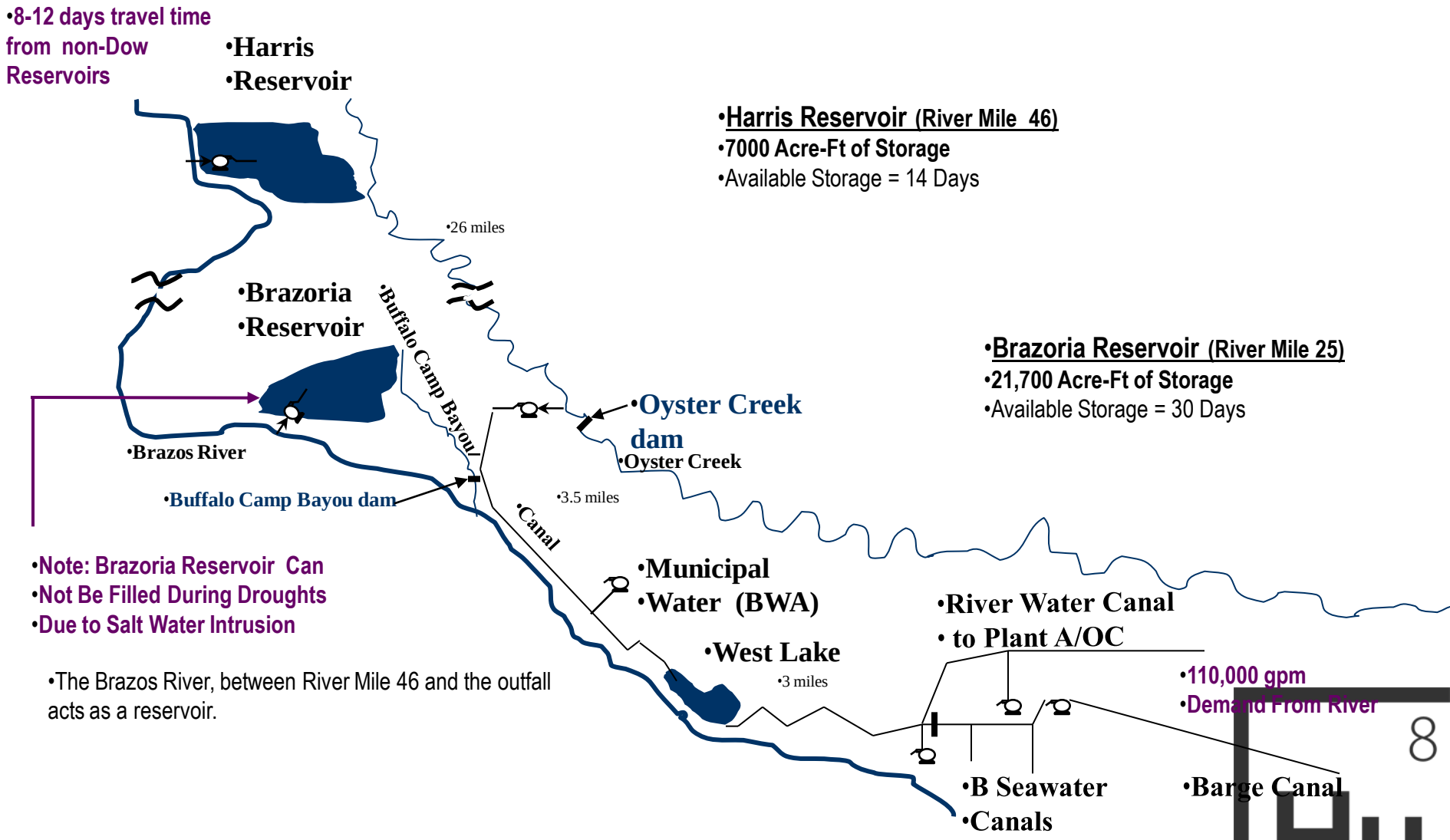
•Dow Freeport Water Infrastructure

•Dow Intakes, Reservoirs and Canals



Call to Action

- Water Summit in November 2011

- Initiated site contest to identify water conservation opportunities – raise awareness and tap into the brainpower of all employees – September 2011

- Hosted a Water symposium in May 2012 with the Brazoria County Petrochemical Council

Water Summit November 2011

- 60+ Dow water and non-water experts

- **Outcome**
  - 276 ideas to address:
    - Demand Reduction
    - Improved Storage
    - Long Term Secure Supply
  - **Water Strategy Team Formed**

Texas Operations Water Strategy

Element 1 - Conservation

Water is not free or infinitely available, and must be managed as a valuable resource in the future.

Element 2 – Security of Supply

A “Secured” Water Supply that Dow can control or influence is critical for business operations.

What is Dow doing?

STORAGE AND PUMPING CAPACITY

- Acquire land for a reservoir expansion project (2011)
- Add pumping capacity
- Design and permit reservoir

REDUCE INTERNAL DEMAND

- 10% reduction achieved 4th qtr 2011
- An additional 10% reduction achieved in 2012/early 2013
- Change the way we think about water

DETERMINE STRATEGIC DIRECTION

- New Facilities
- Alternative Water Technologies

Harris Reservoir Expansion Plan

- Sought legislative action 2011 to make land available for sale

- **Dow gets prison land**
- THE FACTS - Dow Chemical Co. will deepen the pool of water resources for the company's Freeport site and southern Brazoria County residents after a $5.5 million bid won the company a 2,200-acre parcel of former prison land on Thursday…

Figure 1-3. Harris Reservoir with Pre-sedimentation Basin and Brazos River Intake and Pump Station in Foreground

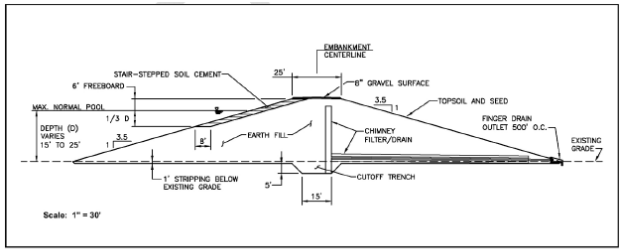


Figure 3-1. Harris Reservoir Expansion Project, New Reservoir Alternative, Conceptual Embankment Section

Figure 2-2. North Levee of Harris Reservoir with Prison Farm Land to the Right

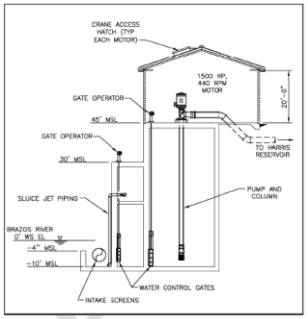


Figure 4-3 Harris Reservoir New Pump Station Concept Cross-Section Looking Upstream

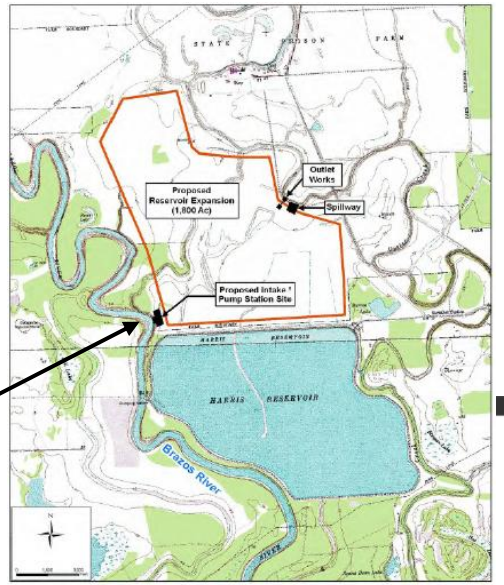


Figure 2-1. Harris Reservoir and New Reservoir Alternative Site Layout

Waste Not, Want Not

Creative Water Conservation Makes an Impact

Texas has a history of droughts, including during the summer of 2011.

"Last summer was one of the driest periods on record and put substantial stress on water availability and consumption of storage reserves," says Tim Finley, water and waste water technology leader atDow Texas Operations. "Water is critical to the community and to Dow's operations. We need fresh water to operate in the same way a city needs fresh water to function. When Texas water supplies are relying on storage reserves, it is critical that all measures be taken to conserve."

And that is why Texas Operations got creative and decided to reuse the local municipality's waste water – conserving water, saving money, and providing an income stream for Lake Jackson, too.

"We produce 3.0 to 3.5 million gallons of treated waste water per day," says Dave Ellis, superintendent of utilities, City of Lake Jackson. "Dow's idea of putting it back into reuse makes good sense. It's a win-win situation – for Dow and for our kids down the road."

Fighting Droughts

"Conservation of water has been important to Dow for many years, but effects of the recent drought provided added incentive to explore additional creative water conservation measures – including the initiation of projects that have resulted in a 10 percent savings in water demand at the Freeport Site since January 2011," says Doug Whipple, water strategy project director. "Every gallon of fresh water demand that can be reduced lessens the draw on local reservoir levels and reduces the need to pump water from the Brazos River.

This is particularly important when Dow and the local communities are in a low-water situation and need to request or purchase water from upstream reservoirs.

"This is a beneficial reuse of water. It benefits the city, Dow, the state…everyone!" says Dave.

The waste water reuse project in Lake Jackson is expected to recycle approximately 1.3 billion gallons of water each year, reducing demand for Brazos River flows and stored water.

Opening the Valve

The 2011 drought helped launch the waste water reuse project – all with the opening of a valve at the Lake Jackson Waste Water Treatment Plant on November 1, 2011. Since then, 100 percent of the city's treated waste water has been diverted to Dow's fresh water canal for use in its manufacturing processes.

"The project demonstrates the collaboration and effort of Dow and the local community to go to extensive measures to be water conscious," says Tim. But this isn't the end. "There are many more collaborative projects needed statewide to protect water supplies and stored water reserves in times of drought."

A History of Drought

1950s - Drought
- Dow installs local reservoirs
- Water-supply contract established for existing/future reservoirs in Brazos Basin

1990s – Population Growth
- Growth – both locally and in the entire Brazos Basin – adds stress on water reserves in reservoir storage

2000s – Water Conservation
- Dow begins projects to conserve water/ improve water supplies capabilities
- Extensive studies completed to better understand reliability of local reservoirs and Brazos Basin reservoirs to meet demand
- As a result of this work, Dow procures land for additional local storage

Today – Waste Water Recycling
- Freeport site adds waste water reuse program with the City of Lake Jackson

You can make a difference, too! For tips on conserving water, visit http://www.wateruseitwisely.com/100-ways-to-conserve/index.php.

- Waste water reuse project in Lake Jackson
- Expected to recycle approximately 1.3 billion gallons of water each year
- Reducing demand for Brazos River flows and stored water.

2011 Conservation Action

Conservations Projects

- Lake Jackson Water Recycle 2500 gpm
- Chlorine 4 recycle 2000 gpm
- Cooling Tower Optimization 1000 gpm
- “As Needed” conservations measures 3500 gpm

Total 2011 Impact **10,000 gpm**

Freeport 2012 Site Water Reduction Efforts

Project	Status	Maximum gpm	% Site Demand	% River Demand
Enable a process technology Soft Water Recycle (Contingent plan)	July, 2012	5,000	6.60%	5.00%
Demin. Water Resin	August, 2012	1,600	2.10%	1.60%
Recycle Projects	December, 2012	5210	7.00%	2.70%
Salt Recycle Opportunity	Completing Feasibility	1,000	1.30%	1.00%
Additional cooling water system optimization	Scoping	2,500	2.60%	2.00%
Total Water Demand Reduction (Max.)		**10,710**	**14.1%**	**10.7%**
Water reduction with contingent option		**15,710**	**20.7%**	**15.7%**

- Freeport Site Water Demand
- Total from River
  - = 100M gpm
- Net to Freeport Site After
  - BWA and Fence Line Industry
  - = 76M gpm

The Dow Chemical Company Texas Operations Received

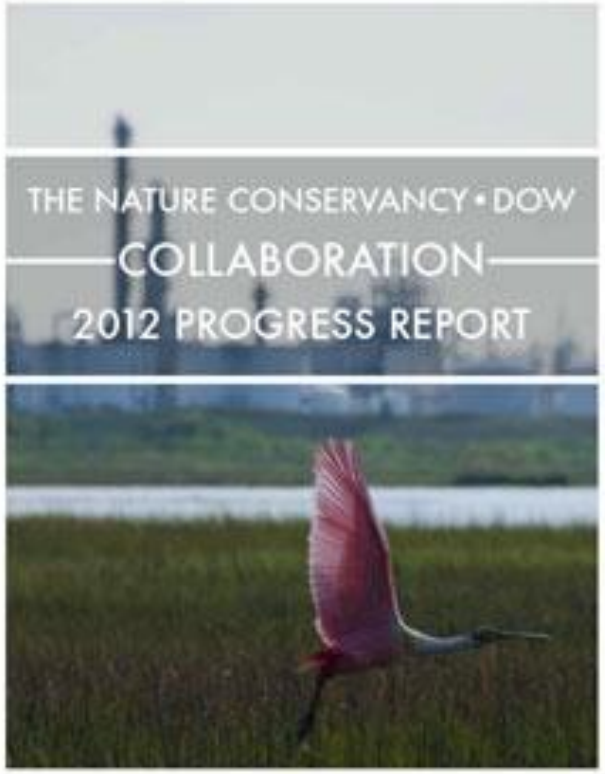
2013 Texas Environmental Excellence Award – Water Conservation

The Economics of Ecosystems

The collaboration between Dow and The Nature Conservancy demonstrates that protecting nature can be

- both a global business strategy and
- a company priority

By combining our resources and expertise, we are integrating the value of nature into Dow's business decision-making



Freeport Freshwater Pilot Selected

The Brazos River - primary source of freshwater to Dow's Freeport Site

- critical for the site operations as well as for other water users and wildlife in the water basin.

The State of Texas Region H Water Plan forecast the water demand, on the Brazos, to increase 54% by 2060.

- Municipal and industrial demands are the primary contributors to the demand increase.

Trend associated with climate models predict increased average temperatures along with increased water loss from evaporation

- which if occur, will affect volume of flow in the Brazos.

Early Work

Collaboration scientists incorporated the effects of predicted climate change and increase demand into existing models of the Brazos River basin to predict future water availability.

- Previous analysis had not considered these synergistic effects.

The models predict that there will be:

- more frequent and severe basin-wide water shortages
- with the maximum length of shortages in the lower basin where Dow withdraws its water potentially increasing three-fold

Analysis confirmed scenarios of potential reduction of future freshwater flows in the Brazos :

- studies conducted independently by Dow using historic flows,
- while adding new information about the influence of predicted higher temperatures

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Stepping Into the Cost Side

Traditionally,

- companies may have projected the i… f water.
- Disruption to a…

Ecosystem service models can help better predict the frequency of these drought events, improving financial models.

…pay much more than …upply is not disrupted.

Mus…

…hen available (costs of water rights) but …cost during water interruptions (up to and including cost of desalination),

- associated loss impacts must be factored into cost comparisons.

Macro Results

Nature-based and collaborative solutions may provide cost-competitive ways to improve the value of Dow's freshwater assets incrementally, while also benefiting other users and ecosystems.

Collaboration experts brainstormed potential response initiatives, which were narrowed to the following five that were analyzed in more detail:

- **Wastewater reuse – construct wetlands to filter purchased municipal wastewater**
- **Reservoir flood pool reallocation – support the reallocation of flood pool storage at U.S. Army corps of Engineers' reservoirs and complementary floodplain restoration**
- **Panhandle land management – replace high water-use invasive plants with lower water-use native plants in the Texas panhandle**
- **Municipal Rebate – support re bate program for municipal users to buy water efficient appliances or switch to native landscaping that does not require watering**
- **Agriculture Water Reallocation – support for fund improvements in irrigation technology and purchase saved water**

Results (cont.)

All response initiatives, except for wastewater reuse, were found to be cost-competitive with the base solution of expanding Dow's existing reservoir system.

- Potential to enhance basin supplies of water by 60,000 acre-ft per year.
- These types of solutions could complement traditional engineering approaches.

Initiatives also provide additional benefits to the public and ecosystems.

- Collectively these initiatives could protect 21,500 acres of habitat and generate public benefits of at least $10 million over the next 30 years.
- However, these actions have legal, political and technical challenges, which would need to be addressed before implementing.

Companies are beginning to shift their thinking about water.

- Previously considered an almost limitless, free or low-priced commodity
- Now recognized as a finite resource that needs to be considered when making strategic decision.
- The importance of understanding the "economics of water" will continue to increase as higher demand and reduced supply lead to water scarcity in varying regions around the world.

Working Together

- Private and public sectors must work together
- Solution goes beyond just technology
- Government must drive integrated policies
- Society must conserve and reuse supplies
- Businesses must create technology solutions that make economic sense and solve problems
- Partnering to solve the world's water crisis is possible and is happening as we speak

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