

DuPont Water Solutions for Oil & Gas – **Unconventional**

Unconventional Hydrocarbons sustainable production through
DuPont innovative water technologies



Content

About DuPont Water Solutions 3

The broadest Portfolio in the industry 3

Water Treatment for Unconventional Oil & Gas..... 3

 Shale Oil4

 Coal Seam Gas.....5

 The SAGD Process.....5

 The resources to run optimally.....6



About DuPont Water Solutions

Companies, communities and homes around the world choose DuPont Water Solutions to help make water safer and more accessible. Industries and markets count on us to become more efficient. Our innovation and collaboration with the world's best water experts enables ecosystems of innovation to deploy vital technologies in new, market-shaping ways.

With a global network of accessible knowledge and a market-leading portfolio of purification and separation technologies, we enable the water productivity from which health, profits, and possibilities spring. In a world of increasing water scarcity, we provide a proven path that balances resource productivity and responsibility.



Our products are based on decades of industry leadership, and include ion exchange resins, reverse osmosis nanofiltration technology, ultrafiltration membranes, degasification modules and wastewater treatment products, with globally recognized brands like FilmTec™ Fortilife™, Memcor™ and the Amber series to meet your water, waste and other separation needs.

We provide support to markets and industries across the globe, including residential, municipal, power generation, oil & gas, healthcare, commercial industries, chemical & petrochemical, food & beverage and microelectronics, for a wide range of applications as well as minimal liquid discharge (MLD) consultancy.

Unmatched in our global reach, industry experience and expertise, our focus and dedication places us in a unique position to help industries, organizations, and communities prosper. We offer the broadest portfolio in the water treatment technology industry and provide leading innovations.

The broadest Portfolio in the industry

Water is the largest volume by-product of Oil & Gas production and requires treatment for use, reuse and discharge. To improve productivity, water with specific quality requirements is injected into the well for secondary and tertiary recovery. For discharge, the organic load (expressed as BOD, COD, TOC or oil & grease) is usually a limit for wastewater disposal permits.

Like no other supplier, we can provide ultrafiltration (UF), reverse osmosis (RO) elements, sulfate-removal nanofiltration (NF) membranes, degassing membranes and Wastewater solutions like membrane bio-reactor (MBR), polymeric adsorbents and selective ion exchange resins (IX). The use and details of these products are further described in this brochure, providing a sample of our expertise and growing portfolio of technologies that targets the unique needs of hydrocarbon exploration and production.

From injection to produced water, we provide a complete set of treatment technologies to handle oil and gas production

	Memcor® MBR & UF	inge® Multibore® UF Membranes	DesaliTec™ CCRO	DuPont™ Ligasep™ Degasification Modules	
Wastewater					Ultrapure Water
	OxyMem MABR	DuPont™ IntegraFlux™ Ultrafiltration	FilmTec™ Reverse Osmosis Nanofiltration	Amber Series Ion Exchange Resins	DuPont Electrodeionization

Water Treatment for Unconventional Oil & Gas

“Unconventional” oil and gas refers to extraction methods other than traditional vertical oil well pumping. The distinction arises from the accessibility of the oil deposits, and the unusual nature of their reservoirs. The conditions of unconventional oil extraction process requires the use of new, often complex, extraction methods. As it is becoming more popular, the exploration of this resources also raises environmental concerns such as groundwater contamination and overuse of scarce surface water.

Shale Oil

The hydraulic fracturing process can use more than 5 million gallons of water per well. A variety of organic and inorganic compounds are used in fracturing fluids to optimize formation fracture and proppant transportation. Consequently, it is of the utmost importance that the correct water quality is used during operations to ensure unwanted salts and compounds to not interfere with the performance of the fracturing fluid.

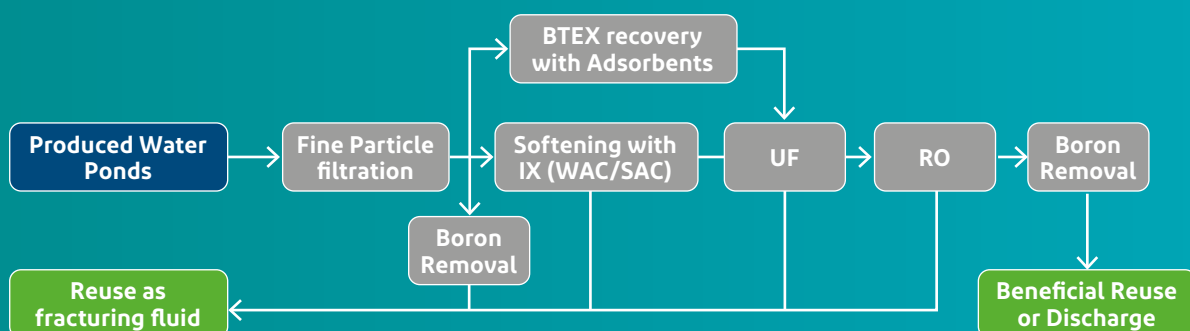
Although the process of hydraulic fracturing requires large quantities of water, there is no reason for this water to be of pristine, drinking water quality. Water sources to support oil and gas production can come from a variety of sources, including recycled water produced along with oil and gas.

However, deep gas seams are often associated with hyper-saline, deep aquifers, which generate hyper-saline formation water. After the process of hydraulic fracturing is complete and the gas reservoirs are opened, the micro-fractures in shale rock pressurize and push a percentage of the hydraulic fracturing fluid back to the surface. This flowback water contains fracturing fluid, hydrocarbons, minerals and other substances that flowback from the deep sub-surface and must be contained in tanks for further treatment.

Fracturing operators face challenges when it comes to recycling of flowback water. New advances in minimum-liquid-discharge (MLD) desalination processes for treating hypersaline shale oil wastewater, can play a key role in the mitigation of public health and environmental impact, and improvement of overall process sustainability.

MLD reclamation installations in shale oil applications may use a combination of:

- Polymeric adsorbents such as **DuPont™ AmberSorb™ L493** for the removal of oil and organics and BTEX recovery.
- Weak (WAC) acid cation IX resins such as **DuPont™ AmberLite™ IRC83 H and DuPont™ AmberLite™ HPR8300 H** for hardness removal.
- Ultrafiltration for the treatment of particle removal.
- Nanofiltration **FilmTec™ Fortilife™ XC-N** Elements for produced water make-up.
- Reverse osmosis elements for the treatment of high salinity streams. The options available are varied, to suit a wide array of needs: **FilmTec™ SW30XFR-400/34, FilmTec™ Fortilife™ XC-70, FilmTec™ SW30XHR or DuPont XUS180808.**





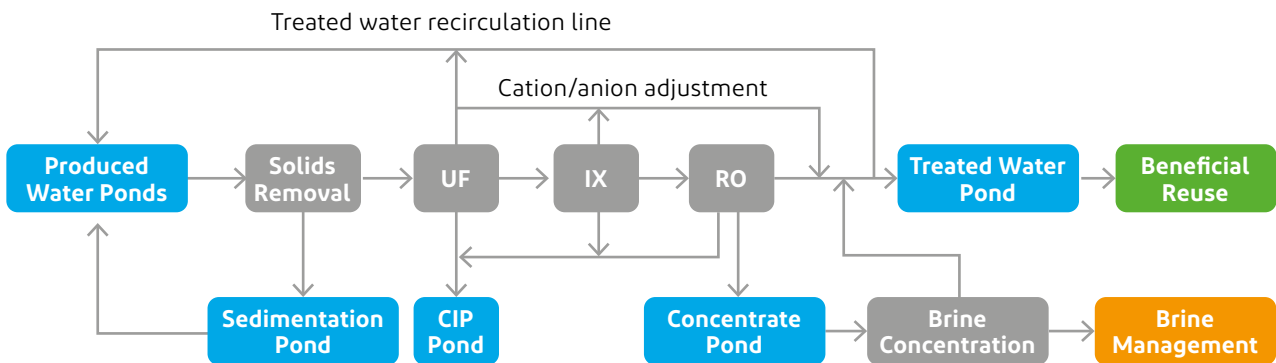
Coal Seam Gas

Coal seam gas (CSG) is natural gas found in coal deposits and is classified as an unconventional gas resource which contains over 98% methane and small amount of nitrogen and carbon dioxide. CSG is produced by extracting water from the formation, which reduces the pressure and releases the gas from the coal seam. The gas extraction process produces a significant amount of produced water.

This type of produced water has an extremely variable water quality, with typical TDS between 1000 and 9000ppm. Most of the salinity is contributed by sodium, chloride, bicarbonate, and carbonate ions. However, there are a multitude of other ions: Cations – K, Ca, Mg, B, Sr & Ba – and Anions – SiO₂ (dependent on pH), F & Br. Additionally, it may contain other harmful substance that potentially damage to the environment (chemical additives, bitumen, etc.).

Many facilities opt for high-recovery solutions which allow the beneficial reuse of treated wastewater. This typically includes an ultrafiltration (UF) pre-treatment system, ion exchange (IX) resins for softening and reverse osmosis (RO) membranes for the removal of dissolved salts. Installations in CSG applications can use a combination of DuPont™ technologies such as:

- UF products such as **DuPont™ IntegraFlux™ SFP-2880** and **DuPont™ IntegraFlux™ SFP-2880XP**.
- **DuPont™ AmberLite™ IRC83 H**, is a stable IX product with extremely high capacity.
- Low-pressure antifouling RO products include **FilmTec™ SW30XFR-400/34**, **FilmTec™ BW30XFRLE-400/34**, **FilmTec™ ECO PRO-400**, and the **FilmTec™ Fortilife™ Series**.
- **DuPont XUS180808** Ultra High-Pressure RO Elements for high-recovery and high-pressure systems.



The SAGD Process

Steam-Assisted Gravity Drainage (SAGD) is an Enhanced Oil Recovery (EOR) technology for producing crude oil and bitumen. It is a form of thermal oil production in which steam is injected into the reservoir through an upper well to reduce its viscosity, causing the heated oil to drain into a lower wellbore, where it is pumped out. The steam condenses inside the formation generating large quantities of produced water that are discharged from the production process.

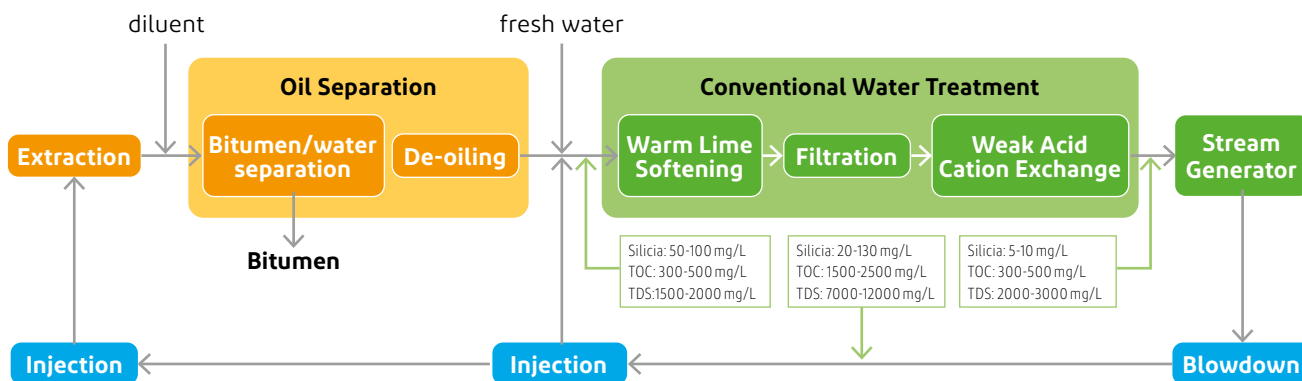
This produced water has very challenging physical and chemical properties which include: oil, grease, silica, hardness and organics.

Water needs to be treated and reused because bitumen production requires continuous steaming, and boilers require clean water to prevent scaling. Regulations that limit freshwater withdrawal and produced water disposal, force the industry to recycle and re-use more than 95% of their water. A viable water treatment process is fundamental to maximizing the production of SAGD oil extraction.

Typically, most SAGD facilities use a precipitation softening process. This involves using a warm lime softener (WLS) for silica removal, followed by filtration for suspended solids removal, and a weak (WAC) acid cation exchange resin to remove dissolved calcium and magnesium ions.

DuPont is a provider of the IX resins used for water hardness removal. Most facilities use IX resins such as **DuPont™ AmberLite™ IRC83 H**, an osmotically stable resin with extremely high capacity. For plants that use strong (SAC) acid cation resins, IX resin such as **DuPont™ AmberLite™ IRC120 Na** or **DuPont™ AmberLite™ HPR1100 Na** can be used.

The implementation of reverse osmosis systems for tailing pond management can successfully aid in site recovery, using **FilmTec™ Eco Pro™** and **Fortilife™ Series Elements**.



The resources to run optimally

DuPont provides the support you need to operate productively and minimize unscheduled outages. From the stability of manufacturing on a global scale to technical expertise in addressing challenging conditions and situations, we are here to help – with system design, field support, plant optimization and more.

Technical support

Our technical service and development specialists can work with you at any point in the design and operation of your plant to optimize performance; from water quality evaluation and system design consultation with our Water Application Value Engine (WAVE) design software, to monitoring and analyzing operational data, to troubleshooting and problem solving.

Research and development

DuPont has been a partner to the water treatment industry for decades, with a history of innovations in ion exchange and membrane technologies driving key improvements in productivity and efficiency. Our global R&D capabilities allow us to address specific local water conditions and requirements, with a holistic focus on water quality and component-based design and research, providing improved performance.

Powering performance worldwide

With a large global manufacturing footprint, strong R&D expertise and technical support services and systems, we supply high market volumes with high quality. DuPont™ partners with you, our customer, to understand unmet needs and develop tailored solutions.



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Hyderabad, India
KAUST Jeddah, KSA
Midland, MI, USA
Shanghai, China
Singapore
Tarragona, Spain*
Wilmington, DE, USA

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Manila, Philippine
Melbourne, Australia
Mexico City, Mexico
Midland, MI, USA
Moscow, Russia
Mumbai, India
Nairobi, Kenya
Paris, France
São Paulo, Brazil
Seoul, Republic of Korea
Pfaeffikon, Switzerland
Shanghai, China
Singapore
Surubya, Indonesia
Taipei, Taiwan
Tokyo, Japan
Warsaw, Poland

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Fombio, Italy
Huzhou, China
Jubail Industry City,
Saudi Arabia
Midland, MI, USA
Qingpu, China
Soma, Japan

*Global Water
Technology Center

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Water Solutions
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