

2017

# SOUTHWESTERN ENERGY

IOGCC Award Application  
& Supplemental Materials

ECH<sub>2</sub>O

Energy Conserving Water

Submitted by Roy Hartstein  
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**swn**  
Southwestern Energy®



# CALL FOR ENTRIES

The Interstate Oil and Gas Compact Commission is seeking nominations for the 2017 Chairman's Stewardship Awards. The winners will be honored at the IOGCC Annual Conference in Pittsburgh, Pennsylvania, October 1 - 3. All nominations received will be mentioned in the Winners Booklet along with project title. All past winners and their projects will also be mentioned in the Winners Booklet.

You may apply on your behalf or nominate another project. Past winners are encouraged to apply with new projects. If you have applied in the past and received honorable mention and you feel your project has been added to we encourage you to resubmit your project. In the nomination form you will find the four different categories. Please choose one that best fits your nomination and provide a brief project summary. To see previous winning nominations, visit the IOGCC website at [iogcc.ok.gov/chairmansstewardship](http://iogcc.ok.gov/chairmansstewardship). For any questions or additional information please contact Carol Booth, communications manager for the IOGCC at 405-525-3556 ext. 114.

**Nominations must be received on or before August 3, 2017.**

## HISTORY

The Chairman's Stewardship Awards represent the Interstate Oil and Gas Compact Commission's highest honor for exemplary efforts by the oil and natural gas industry in environmental stewardship.

Since 1935 the IOGCC has voiced the need for sound oil and natural gas environmental policy. Many organizations have gone far beyond the basic mandates of law and regulation to protect and enhance natural resources. The Chairman's Stewardship Awards are an effort to single out these achievements as examples for others in industry, government and the public.

## AWARD CATEGORIES

### Energy Education

This award is presented to a group or organization that has created a program to educate the public about oil and natural gas and the hundreds of ways it affects the lives of Americans.

### Small Company

This award recognizes an innovative project by a small oil and natural gas company that demonstrates positive environmental stewardship. Small companies are those that operate in a limited area or region.

### Large Company

This award recognizes an innovative project by a large oil and natural gas company that demonstrates positive environmental stewardship. Large companies are those that operate nationwide and in many instances internationally.

### Environmental Partnership

The Environmental Partnership award recognizes an innovative project led by a non-industry organization(s) in cooperation with an industry partner(s).



CHAIRMAN'S  
STEWARDSHIP  
AWARDS

Briefly describe the nominated program on a separate attachment. Please limit your summary to 3 pages or less. Key points to include in your project summary:

- Provide a brief explanation of the project.
- Describe the purpose of the project.
- Explain the process taken to complete the project.
- Describe any contributions made to the environment.
- Describe what has been accomplished.

### Nominee Information:

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Contact Roy Hartstein  
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Phone 832-796-4875 Fax \_\_\_\_\_  
E-Mail Roy\_Hartstein@swn.com

### Submitted by:

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Address 10000 Energy Drive  
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Phone 832-796-4875 Fax \_\_\_\_\_  
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### Visual Aids, if available: (Electronic submissions are accepted)

- Video/DVD (10 minutes or less)
  - Photos
  - Brochures/Publications (10 copies)
  - Other
- Category: \_\_\_\_\_  
 Energy Education  
 Environmental Partnership  
 Small Company  
 Large Company

### SEND NOMINATIONS TO:

Stewardship Awards  
IOGCC  
P.O. Box 53127  
Oklahoma City, OK 73152-3127  
Email: [carolbooth@iogcc.state.ok.us](mailto:carolbooth@iogcc.state.ok.us)  
Fax: 405-525-3592

For more information call  
405-525-3556 or log on to  
[iogcc.ok.gov/chairmansstewardship](http://iogcc.ok.gov/chairmansstewardship)





**ABOUT SOUTHWESTERN ENERGY**

Southwestern Energy Company (SWN) is committed to providing the energy that powers our world, today and into the future. Creating Value+ is SWN's core goal, with a clear focus on continuous improvement, innovation, integrity and responsibility. The company seeks to create value for our shareholders and provide a safe and healthy workplace for our people, while acting as good environmental stewards and providing positive impacts in the communities in which we operate.

**THE ECH<sub>2</sub>O PROGRAM**

In 2012, SWN launched our ECH<sub>2</sub>O, Energy Conserving Water (H<sub>2</sub>O), program to support our commitment to be neutral regarding the use of fresh water in our operations by 2016. The goal of the program sounds simple: For every gallon of fresh water we use in our operations, we return a gallon of fresh water to the environment. Achieving freshwater neutrality, however, is more complicated. It requires time, effort and innovative thinking. It's an approach that begins with evaluation of total water used and compares it with the reduction of demands on fresh water through use of alternative sources, operational offsets and finally conservation projects that improve water quality and availability. When these elements balance, we have achieved freshwater neutral.

The ECH<sub>2</sub>O program includes four focus areas - protection, reduction, innovation and conservation.

**PROTECTION**

We initiated the ECH<sub>2</sub>O program with a focus on protecting water resources, minimizing the potential for impact on natural resources and watersheds where we work. While hydraulic fracturing takes place thousands of feet below the Earth's surface – well below any aquifer containing suitable drinking water – our wellbores pass through aquifers that provide water for drinking and agriculture. We have adopted strict programs for wellbore integrity, chemical management and other processes to protect groundwater and surface water resources from surface activity.

In 2012, our Strategic Solutions Division partnered with the Environmental Defense Fund (EDF) to develop a Model Regulatory Framework (MRF) that protects groundwater by establishing technical specifications for production wells. The MRF has been used by regulators in several states as a guide for developing rules governing the construction of production wells.

In 2014, SWN's Right Products program was launched, which assesses each chemical used in our fracturing fluid against regulatory watch lists and a range of environmental and mammalian health hazards — such as toxicity and bioaccumulation potential. Based on the assessment, each product receives a numerical score. We evaluate products with higher scores for replacement or other action to mitigate potential exposure.

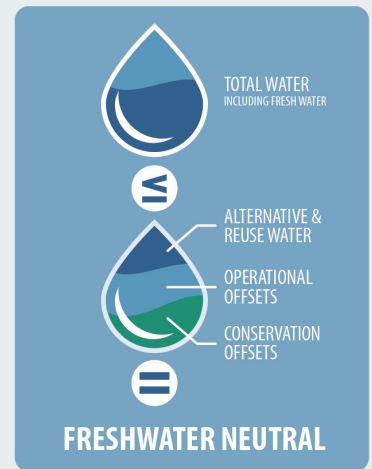
Since inception, the Right Products program has processed 209 chemical products across four corporate divisions and 14 service providers. Of these products, 150 have been approved after the hazard assessment, 35 have been approved after further evaluation and recommendation by SWN's Chemical Advisory Board, and 24 have been denied for use in SWN operations. Despite initial challenges, the Right Products Program has been embraced by both internal operational teams and service providers; driving some providers to develop greener products.

**Freshwater Neutral Formula**

When the **Total Water Used** in our operations is less than or equal to

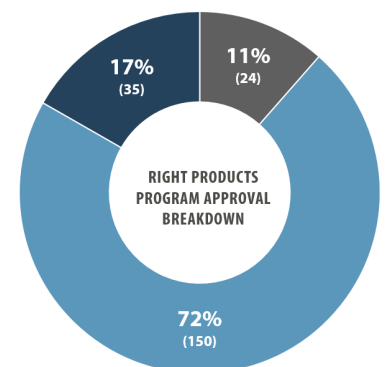
the sum of **Alternative & Reuse Water, Operational Offsets, and Conservation Offsets** for each of our operating areas,

we will have achieved **Freshwater Neutral**.



**209** products scored for **14** service companies

- 72%** approved after initial assessment
- 17%** approved after further evaluation
- 11%** denied for use in SWN operations
- 18** currently being evaluated



Erosion control is critical for protecting natural water systems because it keeps sediment at our operating sites. Sediment can harm streams, fish and other aquatic life by degrading water quality, altering water flow and reducing water depth. Working with The Nature Conservancy, SWN developed StreamSmart, a half-day workshop that trains our employees and contractors in effective erosion and sedimentation control. We also encourage participation from regulatory agencies and industry organizations, who are given the opportunity to present their own training modules. More than 600 SWN employees, as well as staff from other energy companies, consulting firms, contractors and regulatory agencies, have been trained in the StreamSmart program.

### REDUCTION

We have reduced the demand for fresh water in our drilling operations by changing some completions practices that decrease the total volume of water needed, and by replacing fresh water with alternatives, such as recycled fluids or non-potable water sources. We work with our industry peers to advance policies and practices across the drilling and completion spectrum, such as pursuing the safest, most responsible and efficient means to reuse and recycle flowback and produced water. In addition, we are examining how we can work with other companies that produce non-potable water to reduce freshwater use, minimize industrial process water disposal and redirect some of it for hydraulic fracturing.

In the Fayetteville Shale, our efforts centered on fresh water reduction led to recycling 99.4% of our flowback and produced water in 2014, which made up over 40% of the total water SWN used that year. Last year, these percentages decreased some as lower commodity prices constrained operational activity levels and limited opportunities for recycling.

### INNOVATION

In addition to the water management practices we use, SWN has fostered research and other innovative programs:

- In Pennsylvania, Yale University initiated a groundwater study in the vicinity of SWN operations prior any oil and gas activity or infrastructure. The Yale study was designed to obtain and interpret a set of high-quality measurements of shallow groundwater chemistry and flow patterns before, during and after hydraulic fracturing. SWN assisted Yale in this study by advising future well pad locations, laterals, and timing of operational activities. Yale installed and 8 groundwater monitoring wells adjacent to our locations, and has regularly collected data for 3 years. Data gathered will help researchers assess if hydraulic stimulation of the wells affects drinking water aquifers.
- We funded a study with experts at the Colorado School of Mines regarding underground transport of proppant in a complex fracture system. This work will help determine the optimum fluid system for hydraulic fracturing and ensure that the fluid is effective in placing proppant into fractures to deliver well performance. The study was presented at the Society of Petroleum Engineers' Hydraulic Fracturing Conference in February 2014 in The Woodlands, Texas.
- We sponsored research by the Membrane Science, Engineering and Technology Center at the University of Arkansas (part of a National Science Foundation-sponsored organization headquartered at the University of Colorado) investigating the use of membrane technology for desalinating flowback and produced water.

We continue to pursue innovative technologies that will provide new means for water treatment or new ways of replacing water. We have also pursued new drilling and completions technologies directed at reduction in water use.

### CONSERVATION

Our conservation projects offset our freshwater use. They were selected, in many cases with help from The Nature Conservancy, to provide significant impact and benefit to the environment.

It was important to us that the value of our projects would be determined by a credible expert. Our conservation projects are reviewed and evaluated by LimnoTech, a recognized technical expert in water protection and restoration. They calculate the beneficial volume produced by each project in gallons of water.

The benefit is determined by using standard watershed modeling techniques or simple empirical data analysis which may incorporate multiple methods (such as irrigation water savings, volume of water provided to wetlands, increased floodplain infiltration, decrease in runoff or water quality improvement), to arrive at a water-benefit used to quantify our freshwater offset volumes. In each case, project benefits are counted for up to a five-year period after which conditions are re-evaluated.



## **Archey Fork – Arkansas**

### *Channel & Habitat Restoration*

SWN funded a conservation project, completed in 2015, that restored the river's channel and reconnected two reaches of the river, while maintaining the flood conveyance required by the Corps of Engineers in this area. The project, designed and constructed by The Nature Conservancy, incorporated a natural channel design that allows the river to meander, riffle and pool. With the aquatic habitat restored, the populations for two threatened and endangered species which exist in this watershed have been strengthened. The project also mitigated severe erosion zones, which resolved water quality issues. The restoration beautified Archey Fork Park and inspired the community to build a launching area for canoes and kayaks, as well as a walking path alongside the river.

## **Upper Little Red River Tract I & II – Arkansas**

### *Reforestation of Floodplain & Upland Areas*

SWN funded two major conservation easements that preserved property along the Upper Little Red River from being developed. These easements will increase groundwater infiltration and recharge in the watershed, improve biodiversity in the upland areas, and reduce upland runoff. From 2014 to 2016, a reforestation effort planted 100,000 tree seedlings across these 260 acres.

## **Ed Gordon Point Remove – Arkansas**

### *Improvement of Wetland Habitat*

SWN funded the renovation of 1,036 acres of wetlands within this Wildlife Management Area to maintain proper water levels and to produce abundant food for waterfowl. The project allowed management of the timing and amount of water by filling "borrow pits" with soil, reducing the water volume required to provide optimum levels for water fowl and improving foraging habitats. Another 103 acres of scrub were converted to new wetlands, and a flume ditch with a new piping system were installed to retain and distribute water to the wetlands more efficiently.

## **Fall Brook – Pennsylvania**

### *Acid Mine Drainage (AMD) Reclamation*

In 2014, SWN joined the Pennsylvania Department of Environmental Protection, the Tioga County Conservation District, the Tioga County Concerned Citizens Committee and several other organizations in the Fall Brook AMD Reclamation project to improve water quality. The project consisted of collecting and treating multiple sources of AMD in the Fall Brook watershed. The process adjusts the acidity of the water and removes aluminum, iron and manganese, and returns clean water back to the river. Recent tests show drastically improved water quality, and native brook trout have been observed once again in portions of the Tioga River benefitting from this project.

## **Taylor Run – Pennsylvania**

### *Dam Removal & Stream Restoration*

SWN joined a project team to remove the remnants of two dams and clean up sediment captured in the former reservoir areas which disrupted the normal streamflow. The project restored the river to a natural condition in which the brook trout can once again migrate upstream and down. To assist with stabilizing the restored channel, we added seedlings and native plants to improve the riparian buffers and restore the area's overall appearance.

## **West Fork River – West Virginia**

### *Dam Removal & Aquatic Life Habitat Restoration*

SWN joined with the U.S. Fish and Wildlife Service to remove three dams and modify a fourth to allow aquatic life passage. By removing them, the upstream and downstream river lengths were reconnected, significantly expanding the habitat for fish and as many as 25 different species of freshwater mussels, including two endangered species. Boulders, woody debris and bank protection were placed in the stream for stabilization and habitat enhancement.

## **Cheat River – West Virginia**

### *AMD Collection & Treatment*

SWN is partnering with the West Virginia DEP to collect and treat AMD that has severely polluted Muddy Creek and the Cheat River in West Virginia. Current loading of aluminum and iron from AMD within Muddy Creek is fifty times allowable amounts, and there is no aquatic life present in the affected waterways. The proposed project, which is currently underway, will collect AMD from multiple abandoned mine discharge points and deliver the water to the T&T AMD treatment facility. Once the project is complete, this project will restore water quality in Muddy Creek and the Cheat River, improve natural aesthetics, and provide a means for the once-thriving ecotourism in the area to return.

## **CONCLUSION – The Goal was Achieved**

In 2016, Southwestern Energy achieved its goal of becoming freshwater neutral.

This achievement was only possible in the collaboration with environmental groups, community leaders and governmental agencies that partnered with SWN and provided technical expertise and local knowledge and rallied local political support.

Finally, while we met our freshwater neutral imperative in 2016, ECH<sub>2</sub>O's objectives remain in place. We will continue to reduce our freshwater use, explore alternative water sources, seek innovative water treatment technology and completion techniques, and partner with communities in conservation efforts.

We will maintain our ECH<sub>2</sub>O commitments as we initiate and expand operations in new plays. We will identify and review alternative water sources in each area before development, and design the infrastructure plan to maximize the efficient use of flowback water, produced water and other applicable alternative sources.

We believe our holistic approach to water management through ECH<sub>2</sub>O demonstrates our commitment to creating Value+ in the community, the economy and the environment. It is an essential part of our culture and our way of doing business.



# ECH<sub>2</sub>O FACT SHEET

One-page fact sheet developed by Southwestern Energy (SWN). This sought to provide information and generate interest in the ECH<sub>2</sub>O program.

# ECH<sub>2</sub>O<sup>®</sup>

energy conserving water



## Southwestern Energy is committed to being neutral regarding our use of fresh water in operations.

Simply put, our commitment means that for each gallon of fresh water we use in our operations, we will replenish or offset an equivalent amount through conservation and innovation. Southwestern Energy (SWN) launched ECH<sub>2</sub>O, to address our use of fresh water and drive our efforts to reduce, reuse, and replenish the water we use.

Water has always been, and will continue to be, an essential resource for

energy development. The importance of water, not only to energy, but also to local communities, the environment and the economy is why SWN is pursuing ECH<sub>2</sub>O.

Is it really possible to offset the volume of fresh water used to become neutral? We're committed to demonstrating it is possible. Taking the lead is part of our Value+ approach. By working proactively, we take a balanced

approach to developing energy for our country and achieving our goal.

We believe being freshwater neutral is not only the right thing to do, but delivers extra value both economically and for the environment.

To achieve freshwater net neutral, we focus on four key areas: **Conservation, Reduction, Protection and Innovation.**



### Conservation

We work with state agencies, municipalities, non-governmental organizations and other industries to enhance water quality and develop conservation projects that enhance local watersheds.

We create partnerships with other industries to improve water availability through mutually beneficial projects.



### Reduction

We reduce fresh water demand by decreasing the total volume of water needed.

We are trying new techniques and tools in our fracturing operations to optimize our water usage.



### Protection

We protect water resources, minimizing our impact on surface and ground water resources where we work.

Working with environmental organizations, we have developed StreamSmart to provide industry leading practices ensuring effective sedimentation and erosion control.

We are also engaging in research projects to ensure well bore integrity.



### Innovation

We will pursue innovative technologies that provide new means for water treatment or new alternative water sources.

We will take a leadership role in pursuit of new drilling and completions technologies directed at reduction in water use.



# FRESHWATER NEUTRAL REPORT

This report details how we calculate freshwater neutral. It's an approach that begins with total water use and compares it to our reductions through use of alternative sources, operational off sets and conservation projects.



**SWN**  
Southwestern Energy®

2016  
**ACHIEVING  
FRESHWATER NEUTRAL**

**ECH<sub>2</sub>O**®  
energy conserving water

# ACHIEVING FRESHWATER NEUTRAL

In 2016, Southwestern Energy achieved its goal of becoming freshwater neutral.

It sounds simple: For every gallon of fresh water we use in our operations, we return a gallon of fresh water to the environment.

Achieving freshwater neutrality, however, is more complicated. It takes considerable time, effort and innovative thinking.

We call our program ECH<sub>2</sub>O — Energy Conserving Water (H<sub>2</sub>O). This report outlines our individual freshwater neutrality projects and the methods we use to calculate the results.

**ECH<sub>2</sub>O Includes Four Areas of Focus**

 <p><b>PROTECTION</b> Wellbore Integrity Right Products Program StreamSmart</p>	 <p><b>REDUCTION</b> New Completion Designs Recycle/Reuse Program Alternatives to Fresh Water</p>
 <p><b>INNOVATION</b> New Completion Technologies New Water Treatment Technologies</p>	 <p><b>CONSERVATION</b> Improve Water Quality Replenish Water Volumes</p>

As one of the largest producers of natural gas in the continental United States, we are committed to responsibly managing the

water used in our operations. SWN's ECH<sub>2</sub>O imperative proves responsible development can coincide with protecting fresh water, reducing water use, and encouraging innovation in water management, treatment and alternative sources.

Our voluntary efforts to achieve freshwater neutral are unprecedented in the oil and gas industry. We are unaware of another energy company that has achieved, or even set its sights, on such an ambitious goal.

While no single report can fully capture the essence of the scope of the work underway at SWN, we hope this document will show that our projects are restoring the natural beauty and improving the water quality of rivers and waterways. The benefits to wildlife have exceeded our initial expectations, and the projects are revitalizing tourism, recreation and community pride.

To view a short video that captures the program's environmental and community benefits, please visit [www.swn.com](http://www.swn.com)

Note that the contamination of these waterways did not result from SWN's — or any other company's — oil and gas operations. Rather, the projects are mitigating historical environmental issues caused decades ago by mining, dam construction and erosion.

Finally, this achievement was only possible in the collaboration with environmental groups, community leaders and governmental agencies that partnered with SWN and provided technical expertise and local knowledge and rallied local political support.

## OUR CONSERVATION PROJECT PARTNERS

Arkansas Game and Fish Commission

Borough of Blossburg

DCNR Bureau of Forestry

Ducks Unlimited

Hillside Rod and Gun Club

National Turkey Foundation

The Nature Conservancy

Pennsylvania Department of Environmental Protection

Susquehanna River Basin Commission

Tioga County Concerned Citizens Committee

Tioga County Conservation District

Trout Unlimited

U.S. Army Corps of Engineers

U.S. Fish & Wildlife Service

West Virginia Department of Environmental Protection

# CALCULATING FRESHWATER NEUTRAL

In 2012 we set a goal for SWN to become freshwater neutral by the end of 2016. Achieving this goal required a strategy for reducing our freshwater use, use of alternative water, and conservation projects that would offset the fresh water we use in each of our operating areas: Fayetteville Shale, Northeast Appalachia, and Southwest Appalachia.

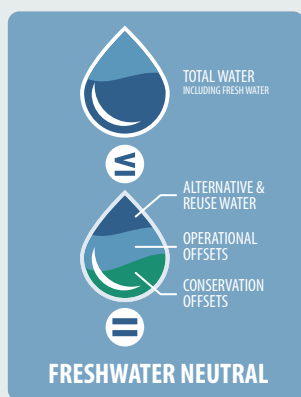
This report details how we calculate freshwater neutral. It's an approach that begins with total water use and compares it to our reductions through use of alternative sources, operational offsets and conservation projects, each of which are described in later pages.

## Freshwater Neutral Formula

When the **Total Water Used** in our operations is less than or equal to

the sum of **Alternative & Reuse Water, Operational Offsets, and Conservation Offsets** for each of our operating areas,

we will have achieved **Freshwater Neutral**.



Our conservation projects offset our fresh water use. They were selected, in many cases with help from The Nature Conservancy, to provide significant impact and benefit to the environment.

It was important to us that the value of our projects would be determined by a credible expert. Our conservation projects are reviewed and evaluated by LimnoTech, a recognized technical expert in water protection and restoration. They calculate the beneficial volume for each project in gallons.

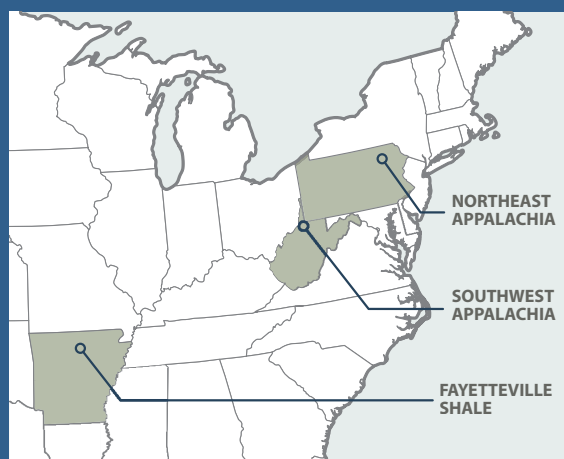
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<http://www.limno.com/>

## FRESHWATER NEUTRAL BY DIVISION

IN MILLIONS OF GALLONS



### FAYETTEVILLE SHALE

<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>197.0</b>
Reuse/Alternative Water	137.0
Conservation Offset	+ 1269.6
Operational Offset Water	+ 8.9
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 1415.5</b>
<b>FRESHWATER NEUTRAL</b>	<b>197.0 ≤ 1415.5</b>
	TOTAL WATER REUSE & OFFSETS

### NORTHEAST APPALACHIA

<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>310.8</b>
Reuse/Alternative Water	74.9
Conservation Offset	+ 568.0
Operational Offset Water	+ 20.1
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 663.0</b>
<b>FRESHWATER NEUTRAL</b>	<b>310.8 ≤ 663.0</b>
	TOTAL WATER REUSE & OFFSETS

### SOUTHWEST APPALACHIA

<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>217.4</b>
Reuse/Alternative Water	24.8
Conservation Offset	+ 355.7
Operational Offset Water	+ 9.7
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 390.2</b>
<b>FRESHWATER NEUTRAL</b>	<b>217.4 ≤ 390.2</b>
	TOTAL WATER REUSE & OFFSETS

# FAYETTEVILLE SHALE

Even before SWN launched ECH<sub>2</sub>O, our Fayetteville Shale Division was pursuing creative solutions for water management.

Our operations in Arkansas' Fayetteville Shale have been our biggest water user, and they were the first to become freshwater neutral in 2015 — one year sooner than the company overall. The program supported improving results across the field. In coordination with other operational measures as we refined our water management practices — focusing on reusing produced water and reducing overall water use, the productivity of our natural gas wells also improved.





Reduced Water Required for Operations

**TOTAL WATER USED**

**197**

MILLION GALLONS PER YEAR

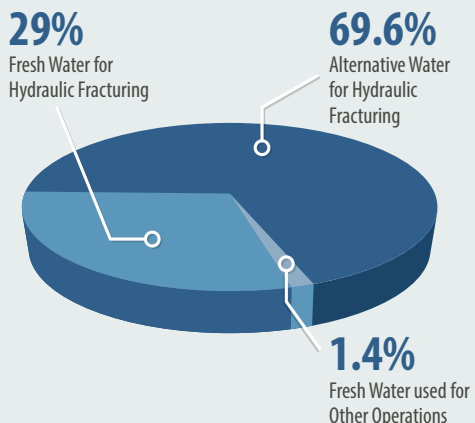
Increased Recycling of Flowback and Produced Water

**ALTERNATIVE WATER USED**

**137**

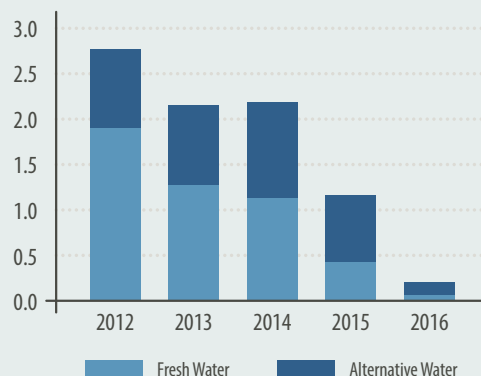
MILLION GALLONS PER YEAR

**WATER USE IN THE FAYETTEVILLE SHALE**



By using water more efficiently in hydraulic fracturing, we have lowered costs, saved time and consumable materials, and reduced traffic from water delivery trucks. The Fayetteville team cut the water required for hydraulic fracturing per foot of completed lateral (CLAT) from an average of 1,265 gallons in 2012, to 885 gallons in 2015 — a reduction of 30 percent in four years.

**DOWNHOLE WATER FOR HYDRAULIC FRACTURING IN BILLIONS OF GALLONS**



The Fayetteville team adopted a robust reuse and recycling water program for flowback and produced “alternative” water in our operations. Replacing much of the fresh water we used with alternative water resulted in lower costs, significant environmental benefits and a sharp reduction in produced water volumes that we previously disposed of in permitted injection wells.

From 2012 to 2015, we cut our freshwater use for hydraulic fracturing operations by 77 percent, from 1.9 billion gallons to 427 million gallons over the three-year period.

Channel and Habitat Restoration  
**ARCHEY FORK**  
 CONSERVATION OFFSET

Reforestation of Floodplain & Upland Areas  
**UPPER LITTLE RED RIVER TRACT 1 & TRACT 2**  
 CONSERVATION OFFSET

**126**

MILLION GALLONS/YEAR  
 TOTAL OFFSET VOLUME

**ADDITIONAL STREAMFLOW CONTRIBUTING TO IMPROVED HABITAT**

**126** x **100** = **126**  
Million Gal/Yr SWN OFFSET      Percent COST SHARE      Million Gal/Yr OFFSET VOLUME

After severe flooding in 1982 devastated Clinton, Arkansas, at the confluence of the Little Red River's Archey and South Forks, the U.S. Army Corps of Engineers broadened a three-mile stretch of the Archey Fork from its natural width of 80 feet to about 800 feet. The flood-control project cut the river's flow to little more than a trickle in summer months and changed its natural course. During high flow events, the river strongly eroded stream banks and filled with sediment that threatened water quality in the downstream reservoir, which provides drinking water for 250,000 Arkansas residents. The changes also degraded the aquatic habitat and isolated the population of the endangered yellowcheek darter fish between the two forks of the river.

SWN funded a conservation project, completed in 2015, that restored the river's channel and reconnected the two forks, while maintaining the flood capacity of the Corps' dredging project. The project, designed and constructed by The Nature Conservancy, incorporated a natural channel design that allows the river to meander, riffle and pool. With the aquatic habitat restored, the yellowcheek darter population has been reunited and strengthened. The project also mitigated severe erosion zones, which resolved the water quality issues. The restoration beautified Archey Fork Park and inspired the community to build a launching area for canoes and kayaks, as well as a walking path alongside the river.

*Project completed 2015*

**PROJECT PARTNER:**  
 The Nature Conservancy

**1011**

MILLION GALLONS/YEAR  
 TOTAL OFFSET VOLUME

**INCREASED FLOODPLAIN INFILTRATION**

**84** vs **1083** = **999**  
Million Gal/Yr PRE-PROJECT GRASSLAND      Million Gal/Yr REFORESTED LAND      Million Gal/Yr OFFSET VOLUME

**DECREASED RUNOFF**

**70** vs **58** = **12**  
Million Gal/Yr PRE-PROJECT GRASSLAND      Million Gal/Yr REFORESTED LAND      Million Gal/Yr OFFSET VOLUME

Over the years, much of the Upper Little Red River watershed in Arkansas was cleared for agriculture. That work replaced natural forests with tall fescue grasses that are flattened by flooding during heavy rains that overtop the riverbanks.

SWN funded two major conservation easements that committed property along the Upper Little Red River to not be developed. These easements will increase groundwater infiltration and recharge in the watershed, improve biodiversity in the upland areas, and reduce upland runoff. From 2014 to 2016, a reforestation effort planted 100,000 tree seedlings across these 260 acres.

The trees will curtail high runoff in the uplands, encourage infiltration in the overbank areas, and provide the additional benefit of reducing carbon dioxide in the environment.

*Tract 1 completed in 2014, Tract 2 completed in 2016*

**PROJECT PARTNERS:**  
 The Nature Conservancy  
 U.S. Fish and Wildlife Service  
 National Turkey Foundation

Improvement of  
Wetland Habitat  
**ED GORDON  
POINT REMOVE**  
CONSERVATION OFFSET

Water Treatment  
& Environmental Benefit  
**WATER TREATMENT  
TECHNOLOGY**  
OPERATIONAL OFFSET

**133**

MILLION GALLONS/YEAR  
TOTAL OFFSET VOLUME

**IRRIGATION SAVINGS FOR EXISTING WETLANDS**

**397** - **125** = **272**  
Acre-Foot      Acre-Foot      Acre-Foot  
PRE-PROJECT VOLUME      POST-PROJECT VOLUME

**WATER PROVIDED TO NEW WETLANDS**  
**72.7** = **72.7**  
Acre-Foot      Acre-Foot  
WATER PROVIDED TO NEW WETLANDS

**FLOODWATER CAPTURED IN FLUME DITCH**  
**63** = **63**  
Foot-Acre      Acre-Foot  
OFFSET BENEFIT

The 8,780-acre Ed Gordon Point Remove Wildlife Management Area (WMA) in Conway County, Arkansas was a wetland forested with hardwoods. The area was cleared for agriculture, and levees were constructed to prevent flooding. Now a protected conservation area, the WMA is a popular spot for duck, deer and dove hunting, and other outdoor recreation

SWN funded the renovation of 1,036 acres of wetlands within the WMA to maintain proper water levels and to produce the most food for water flow. The project manages the timing and amount of water by filling "borrow pits" with soil, which reduces the water volume required to provide optimum levels for water fowl and improves foraging habitats. Another 103 acres of scrub were converted to new wetlands, and a flume ditch with a new piping system installed to retain and distribute water to the wetlands more efficiently.

*Project completed 2016*

**PROJECT PARTNERS:**

Arkansas Game and Fish Commission  
Ducks Unlimited  
U.S. Army Corps of Engineers

**9**

MILLION GALLONS IN 2015  
TOTAL OPERATIONAL OFFSET VOLUME

**TREATED & STEAM EVAPORATED**

**8.9**  
Million Gal/2015  
OFFSET VOLUME

In pursuing freshwater neutrality, we have developed water treatment processes and technologies that treat water produced from operating wells, returning it to the environment as fresh water and offsetting our use.

In 2014 and 2015, we operated a thermal water treatment process that separated solids from the water, then distilled it through evaporation and condensation. We treated the distilled water to add minerals that were required to return the water to a nearby pond. However, this process used a large amount of energy to operate.

In 2016, we increased our efforts to identify technologies that safely and cost-effectively treat our produced water. The Fayetteville Shale returns more produced water through normal production than can be reasonably reused. Given this abundance, we have recently tested six new water treatment technologies.

We wanted a technology that was highly efficient and produced clean water vapor for release. One of these options showed promise, and we treated and evaporated 8.9 million gallons of produced water in 2016. This water was returned to the environment rather than injecting it into disposal wells. This also eliminated more than 2,100 trips by water trucks.

# FAYETTEVILLE SHALE SUMMARY

IN MILLION GALLONS

<b>Hydraulic Fracturing</b> Fresh and Reuse Water Downhole	194.1
<b>Drilling, Completions, Production, Midstream</b> Non-fracturing Operations	2.9
<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>= 197.0</b>

<b>Alternative/Reuse Water</b> for Hydraulic Fracturing	137.0
<b>Total Alternative/Reuse Water Used</b>	<b>137.0</b>
<b>Archey Fork</b> Channel and Habitat Restoration	126.0
<b>Upper Little Red River</b> Reforestation of Flood Plain and Upland Areas - Tract 1	455.1
<b>Upper Little Red River</b> Reforestation of Flood Plain and Upland Areas - Tract 2	555.6
<b>Ed Gordon Point Remove WMA</b> Improvement of Wetland Habitat	132.9
<b>Total Conservation Offset</b>	<b>+ 1269.6</b>
<b>Water Treatment Technology</b> Water Treated & Evaporated	8.9
<b>Total Operational Offset Water</b>	<b>+ 8.9</b>
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 1415.5</b>

**197** ≤ **1416**

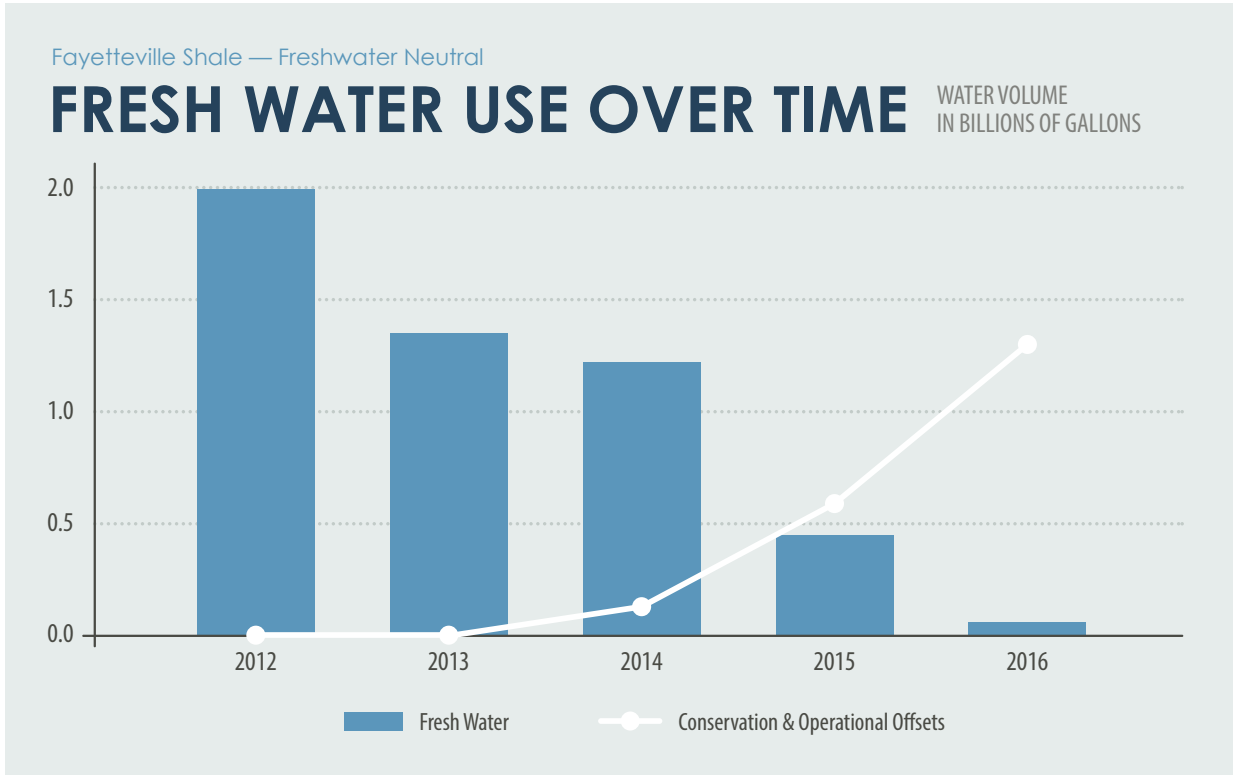
TOTAL WATER USED

TOTAL REUSE & OFFSETS

**FRESHWATER NEUTRAL  
ACHIEVED**

The Archey Fork, Upper Little Red River and Ed Gordon Point Remove returned almost 1.3 billion gallons a year to the environment, offsetting our freshwater usage. Water treatment technology also returned an additional 8.9 million gallons of

freshwater to the environment. In the graph below, the increase in these offset programs is shown by the white line. The blue bars represent our freshwater use, which declined from more than 2 billion gallons to 197 million gallons annually over four years.

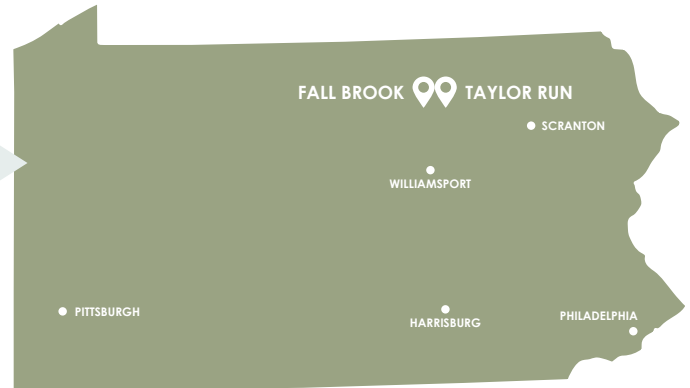


Archey Fork River

# NORTHEAST APPALACHIA

When we launched ECH<sub>2</sub>O in 2012, Northeast Appalachia was our most rapidly growing operating area.

The Marcellus Shale spans about 600 miles of Pennsylvania, and SWN leases about 270,000 acres in the northeastern part of the state. When we began drilling there in 2007, we recognized that water transportation was critical to our planning. Our operations include a water distribution system connected to centralized water storage and management facilities. This has reduced our truck traffic significantly and allows us to reuse 100% of our flowback and produced water for hydraulic fracturing.



An Abundance of Surface Water Sources

**TOTAL WATER USED**

**311**

MILLION GALLONS PER YEAR

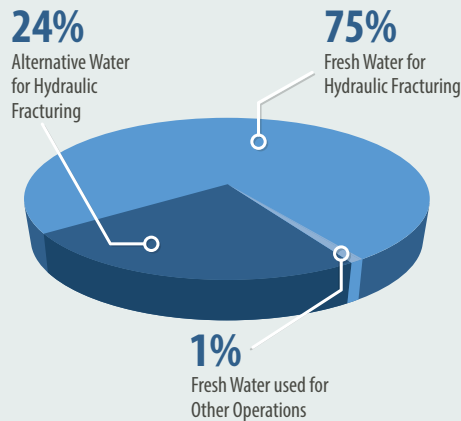
Achieved 100% Reuse of Produced Fluid

**ALTERNATIVE WATER USED**

**75**

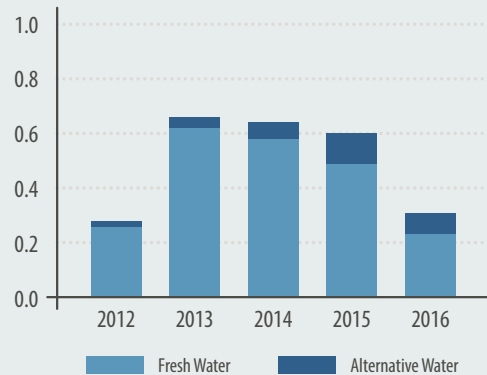
MILLION GALLONS PER YEAR

**WATER USE IN NORTHEAST APPALACHIA**



The Marcellus shale is a dry gas reservoir, and it returns only about 3 to 6 percent of the water injected during fracturing. This is far less than the Fayetteville shale, which results in less produced water after wells are completed. However, that produced water has some of the highest levels of total dissolved solids (TDS) for a shale play, ranging from 100,000 to 300,000 parts per million. This requires adding freshwater to the produced water within our centralized facilities to dilute the TDS, as well as supply the water volumes necessary for our operations.

**DOWNHOLE WATER FOR HYDRAULIC FRACTURING IN BILLIONS OF GALLONS**



Our Northeast Appalachia team reuses 100 percent of the flowback and produced water the field returns to us. We have also collaborated with other oil and gas operators, treatment companies and water recyclers to expand the reuse of third-party water as well. These efforts have reduced our freshwater consumption, benefiting the environment and reducing our hauling and disposal costs.

Acid Mine Drainage  
Reclamation

**FALL  
BROOK**

CONSERVATION OFFSET

**450**

MILLION GALLONS/YEAR  
TOTAL OFFSET VOLUME

**VOLUME OF WATER TREATED**

**857** = **450.4**  
Gal/Minute      Million Gal/Yr  
SWN OFFSET      OFFSET VOLUME

The water of the Upper Tioga River, in north central Pennsylvania, for many years has been plagued by excessive concentrations of metals and acidity from acid mine drainage (AMD) seeping to the surface from long-abandoned coal mines. The AMD has polluted the Upper Tioga River and several tributaries, which took a heavy toll on the river's aquatic life.

In 2014, SWN joined the Pennsylvania Department of Environmental Protection, the Tioga County Conservation District, the Tioga County Concerned Citizens Committee and several other organizations in the Fall Brook AMD Reclamation project to improve water quality. The project consisted of collecting and treating multiple sources of AMD in the Fall Brook watershed. The process adjusts the acidity of the water and removes aluminum, iron and manganese, and returns clean water back to the river. Recent tests show drastically improved water quality, and native brook trout have been observed once again in portions of the Tioga River benefitting from this project.

*Project completed 2016*

**PROJECT PARTNERS:**

Borough of Blossburg  
DCNR Bureau of Forestry  
Hillside Rod and Gun Club  
Pennsylvania Department of Environmental Protection  
Susquehanna River Basin Commission  
Tioga County Concerned Citizens Committee  
Tioga County Conservation District

Dam Removal  
& Stream Restoration

**TAYLOR  
RUN**

CONSERVATION OFFSET

**118**

MILLION GALLONS/YEAR  
TOTAL OFFSET VOLUME

**VOLUME OF WATER CONTRIBUTING  
TO IMPROVED HABITAT**

**117.6** x **100** = **117.6**  
Million Gal/Yr      Percent      Million Gal/Yr  
SWN OFFSET      COST SHARE      OFFSET VOLUME

Taylor Run is a high-gradient, clear water tributary to the Tioga River that historically provided habitat for Eastern Brook trout, a native of cold water streams in Pennsylvania. Two low-water dams, were constructed in the late 1800s for water supply, before being abandoned. Eventually, excessive sediment built up between the dams, preventing fish from swimming downstream. Superstorm Sandy washed out the dams in 2012, and made stream conditions worse.

SWN joined a project team to remove the dams' remnants and clean up sediment in the former reservoir areas. The project restored the river to a natural condition in which the brook trout can once again migrate upstream and down. To assist with stabilizing the restored channel we added seedlings and native plants to improve the riparian buffers and restore the area's overall appearance.

*Project completed 2016*

**PROJECT PARTNERS:**

Borough of Blossburg  
Tioga County Conservation District



# NORTHEAST APPALACHIA SUMMARY

IN MILLION GALLONS

<b>Hydraulic Fracturing</b> Fresh and Reuse Water Downhole	307.6
<b>Drilling, Completions, Production, Midstream</b> Non-fracturing Operations	3.2
<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>= 310.8</b>

<b>Alternative/Reuse Water</b> for Hydraulic Fracturing	74.9
<b>Total Alternative/Reuse Water Used</b>	<b>74.9</b>

<b>Fall Brook</b> Acid Mine Drainage Reclamation	450.4
<b>Taylor Run</b> Dam Removal and Stream Restoration	117.6
<b>Total Conservation Offset</b>	<b>+ 568.0</b>

<b>Treated Water</b> Recycled to Other Operations and Third-Party Vendors	20.1
<b>Total Operational Offset Water</b>	<b>+ 20.1</b>
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 663.0</b>

**311 ≤ 663**

TOTAL WATER USED

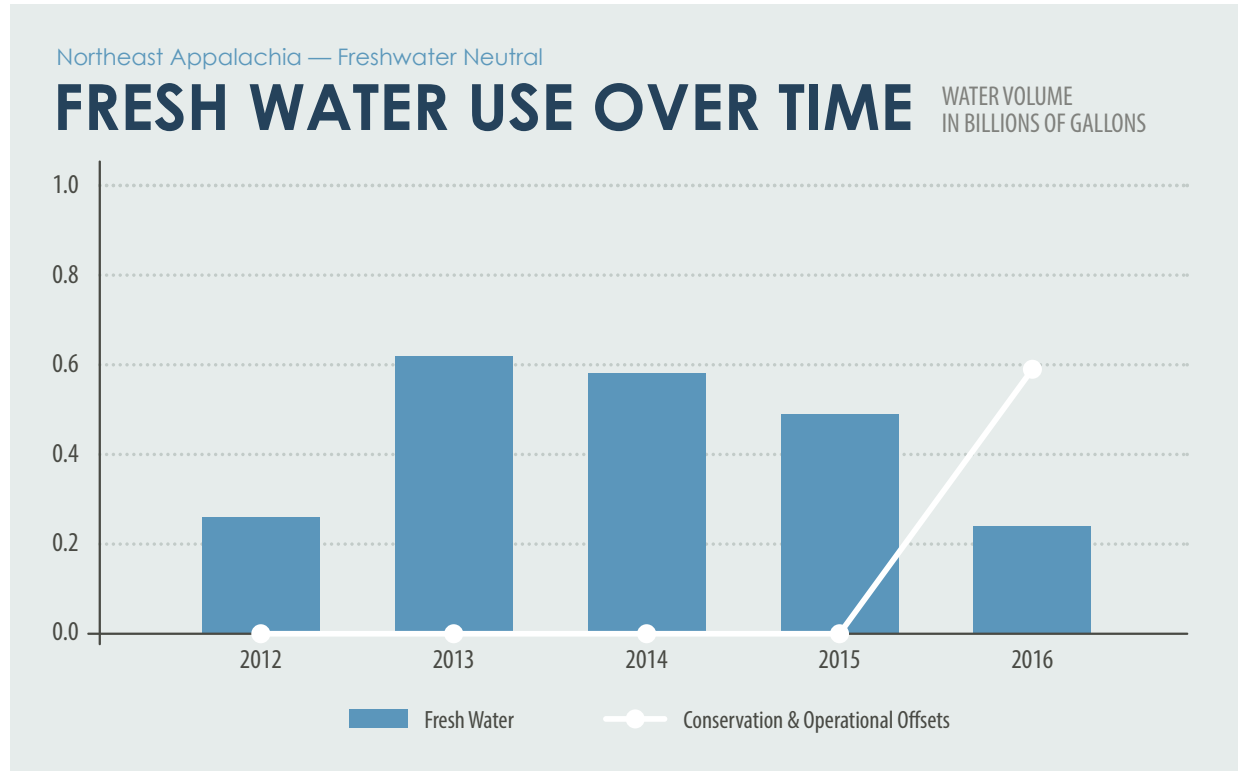
TOTAL REUSE & OFFSETS

**FRESHWATER NEUTRAL  
ACHIEVED**

## 13 Northeast Appalachia

We achieved freshwater neutrality in the region in May of 2016 with the completion of the Fall Brook and Taylor Run projects. These two programs created more than 500 million gallons of fresh water benefit annually to the local environment. In addition, 20 million gallons of alternative water was recycled by

our operations from other oil and gas operators and third-party vendors. The combined 588 million gallons a year, shown as the white line in the graph below, offsets our total freshwater use in Northeast Appalachia, which declined by more than 50 percent during the past three years.





Tioga River

## SOUTHWEST APPALACHIA

SWN has made a concerted effort to reuse the produced water in our well completions.

In early 2015, we became the operator of almost 322,000 acres of natural gas- and oil-producing properties in West Virginia and southwestern Pennsylvania. At the time, the area had no central facilities for produced or flowback water, which was trucked to disposal wells in Ohio. We began reusing produced water in our well completion operations and sharing the excess with other operators for their completions. This practice reduced our water disposal costs by \$3.7 million and the fresh water used in completions by SWN and others. Like Northeast Appalachia, the produced water rate is between 3 percent and 6 percent of the water used.



West Fork River



Establishing Contacts & Building Partnerships

**TOTAL WATER USED**

**217**

MILLION GALLONS PER YEAR

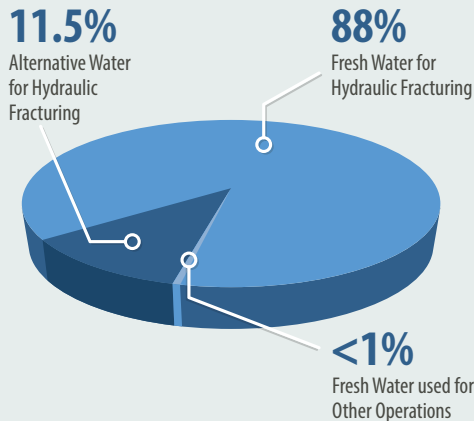
Improvements in Friction Reducers

**ALTERNATIVE WATER USED**

**25**

MILLION GALLONS PER YEAR

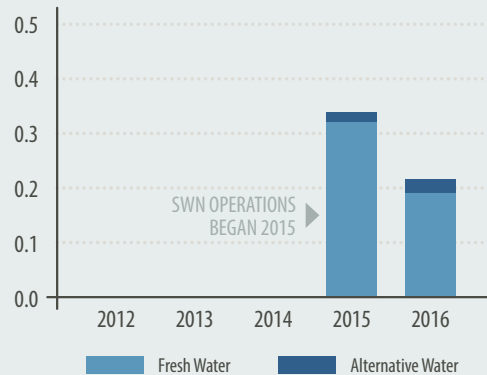
WATER USE IN SOUTHWEST APPALACHIA



When we took over the acreage, none of the flowback and produced water was reused. Our water reuse now consists of 11.5 percent of the hydraulic fracturing volume.

Typically, a conservation project takes about two years to implement — establishing partnerships in a new area, identifying projects in the same watershed as our operations, obtaining permits and bids and completing construction. Because of our previous conservation projects in Pennsylvania and Arkansas, we quickly established relationships with the West Virginia Department of Environmental Protection (WVDEP) and the Canaan Valley Institute, which led to a project that could meet our schedule needs.

DOWNHOLE WATER FOR HYDRAULIC FRACTURING IN BILLIONS OF GALLONS



As we expand our operations in West Virginia and perform completion field trials, we are using more sand per foot of completed lateral. Even though our fresh water volume per lateral has increased, we have improved our reductions, which has lowered water volumes in the stages of the fracturing process from as much as 462,000 gallons to 336,000 gallons per stage. Our focus on water used helps us minimize the fresh water we use, reducing the amount of water to be offset.

Dam Removal and Aquatic  
Habitat Restoration

**WEST FORK  
RIVER**

CONSERVATION OFFSET



**356**

MILLION GALLONS/YEAR  
TOTAL OFFSET VOLUME

**VOLUME OF WATER CONTRIBUTING  
TO IMPROVED HABITAT**

$$\begin{array}{rcccl} \mathbf{533.4} & \times & \mathbf{66.7} & = & \mathbf{356} \\ \text{Million Gal/Yr} & & \text{Percent} & & \text{Million Gal/Yr} \\ \text{SWN OFFSET} & & \text{COST SHARE} & & \text{OFFSET VOLUME} \end{array}$$

Since the early 1900s, a 75-mile stretch of the West Fork River in West Virginia has been obstructed by a series of dams that were built for local drinking water. We joined with the U.S. Fish and Wildlife Service to remove three dams and modify a fourth to allow aquatic life passage.

The dams created impoundments on the river, slowing the flows, producing pond-like conditions — increasing water temperature and retention times that collect nutrients and organic matter, providing an environment in which algae and aquatic plants flourish.

The dams impeded fish movement and by removing them, the upstream and downstream river lengths were reconnected, significantly expanding the habitat for fish and as many as 25 different species of freshwater mussels, including two endangered species. Boulders, woody debris and bank protection were placed in the stream for stabilization and habitat enhancement.

*Project completed 2016*

**PROJECT PARTNER:**

U.S. Fish and Wildlife Service

# SOUTHWEST APPALACHIA SUMMARY

IN MILLION GALLONS

<b>Hydraulic Fracturing</b> Fresh and Reuse Water Downhole	215.4
<b>Drilling, Completions, Production, Midstream</b> Non-fracturing Operations	1.6
<b>TOTAL WATER USED</b> INCLUDING FRESH WATER	<b>= 217.4</b>

<b>Alternative/Reuse Water</b> for Hydraulic Fracturing	24.8
<b>Total Alternative/Reuse Water Used</b>	<b>24.8</b>

<b>West Fork River</b> Dam Removal and Aquatic Habitat Restoration	355.7
<b>Total Conservation Offset</b>	<b>+ 355.7</b>

<b>Treated Water</b> Recycled to Other Operations and Third-Party Vendors	9.7
<b>Total Operational Offset Water</b>	<b>+ 9.7</b>
<b>TOTAL REUSE &amp; OFFSETS</b>	<b>= 390.2</b>

**217 ≤ 390**

TOTAL WATER USED

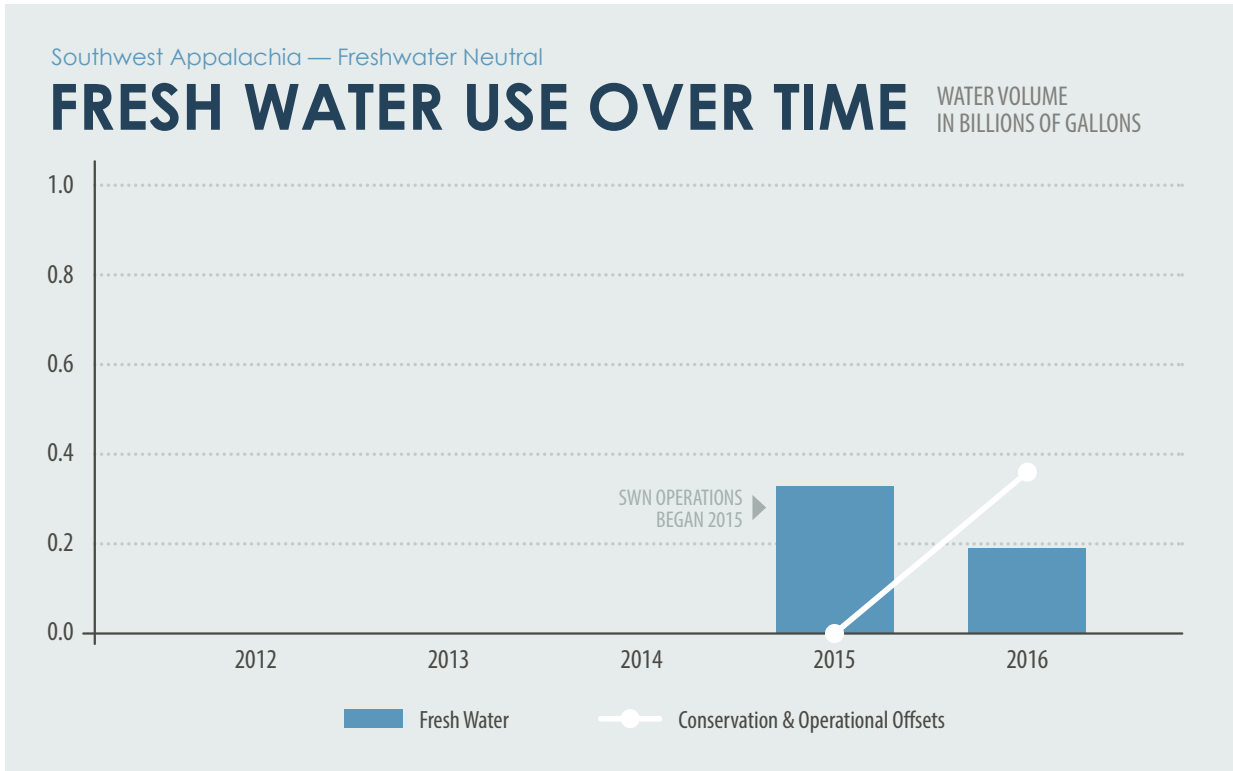
TOTAL REUSE & OFFSETS

**FRESHWATER NEUTRAL  
ACHIEVED**

Our Southwest Appalachia division had the shortest time for meeting our freshwater neutrality mandate. By completing the West Fork River dam removal and habitat restoration project, we met the goal less than two years after we became the operator of the leases in the area. As shown by the white line in the graph below, the project added 356 million gallons of water annually, exceeding the amount of fresh water we used, as shown by the blue bars.

cleanup of a tributary to the Cheat River, one of the 10 most endangered rivers in the nation. Acid mine drainage from two collapsed mines in the mid-1990s destroyed all aquatic life for 16 river miles. The WVDEP is building a treatment facility for about half of the acid mine discharge flowing into the Cheat. With SWN's funds, WVDEP can build an acid mine drainage water collection pipeline for the remaining 630 million gallons a year, which will be piped to the facility, treated and discharged back into the Cheat.

Because Southwest Appalachia is now our fastest growing region, we will work with WVDEP this year in funding the







West Fork River

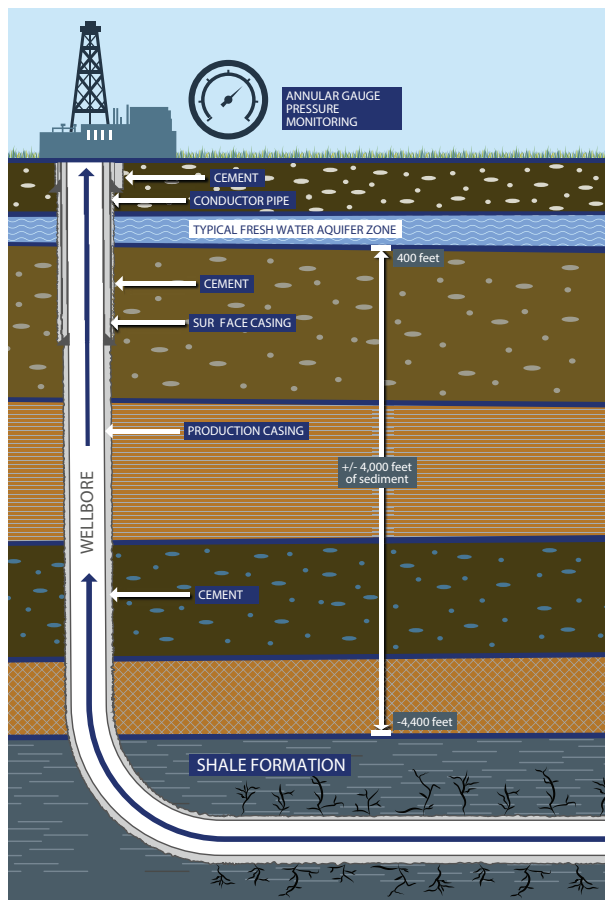
# ADDITIONAL ECH<sub>2</sub>O COMPONENTS

The reduction and conservation elements of ECH<sub>2</sub>O are critical to freshwater neutrality, so are the principles of environmental protection and innovation.

## Protection

While hydraulic fracturing takes place thousands of feet below the Earth's surface — well below any aquifer containing suitable drinking water — our wellbores pass through aquifers that provide water for drinking and agriculture. We have adopted strict programs for wellbore integrity, chemical management and other processes, such as erosion control, to protect groundwater from surface activity.

In 2012, our Strategic Solutions Division partnered with the Environmental Defense Fund (EDF) to develop a Model Regulatory Framework (MRF) that protects groundwater by establishing technical specifications for production wells. The MRF has been used by regulators in several states as a guide for developing rules governing the construction of production wells.



1 [http://www.edf.org/sites/default/files/content/Model\\_Regulatory\\_Framework\\_For\\_Hydraulically\\_Fractured\\_Hydrocarbon\\_Production\\_Wells\\_2014.pdf](http://www.edf.org/sites/default/files/content/Model_Regulatory_Framework_For_Hydraulically_Fractured_Hydrocarbon_Production_Wells_2014.pdf)

## StreamSmart®

Erosion control is critical for protecting natural water systems because it keeps sediment at our operating sites. Sediment harms streams, fish and other aquatic life by degrading water quality, altering water flow and reducing water depth. Working with the Nature Conservancy, SWN developed StreamSmart, a half-day workshop that trains our employees and contractors in effective erosion and sedimentation control. We also encourage participation from regulatory agencies and industry organizations, which may present their own learning modules. Topics include:

- The importance of water resources for human communities and natural ecosystems
- The threat that erosion and sedimentation poses to stream biodiversity and economic activities such as fishing and recreation
- Factors that contribute to erosion
- Best practices for preventing erosion

More than 600 SWN employees, as well as staff from other energy companies, consulting firms, contractors and regulatory agencies, have been trained in the StreamSmart program.

## Right Products Program

In 2013, we launched SWN's Right Products program, which assesses each chemical used in our fracturing fluid against regulatory watch lists and a range of environmental and mammalian health hazards — such as toxicity, bioaccumulation potential. Based on the assessment, each product receives a numerical score. We evaluate products with higher scores for replacement or other action to mitigate potential exposure.

In the past, determining the hazardous potential of chemical additives used in completions was challenging because vendors considered some formulas proprietary. The Right Products program avoids this problem by contracting with a neutral, third-party toxicologist who conducts the hazard assessments. The toxicologist provides us with each product's score and what components made up that score without revealing the exact percentages or chemical formula.

We have used the Right Products program to evaluate 99 percent of the chemicals we use in hydraulic fracturing, including all chemicals in our Fayetteville Shale fracturing operations. This process has enabled us to identify more environmentally-friendly alternatives for 24 chemicals we previously used.

## Innovation

In addition to the water management practices we use in the Fayetteville Shale, SWN has adopted other innovative programs:

- In Pennsylvania, we assisted **Yale University** in accessing properties near four future natural gas well sites and along their laterals for drilling groundwater monitoring wells. Yale researchers monitored the groundwater wells before we began drilling and are continuing to study them throughout site development and drilling. Data gathered will help

researchers assess if the hydraulic stimulation of the wells affects drinking water aquifers.

- We funded a study with experts at the **Colorado School of Mines** regarding underground transport of proppant in a complex fracture system. This work will help determine the optimum fluid system for hydraulic fracturing and ensure that the fluid is effective in placing proppant into fractures to deliver well performance. The study was presented at the Society of Petroleum Engineers' Hydraulic Fracturing Conference in February 2014 in The Woodlands, Texas.
- We sponsored research by the Membrane Science, Engineering and Technology Center at the University of Arkansas (part of a **National Science Foundation**-sponsored organization headquartered at the University of Colorado – Boulder) investigating the use of membrane technology for desalinating flowback water.

We are also working with our industry peers to advance policies and practices across the drilling and completion spectrum, such as the safest, most responsible and efficient means to reuse and recycle flowback and produced water. In addition, we are examining how we can work with other companies that produce non-potable water to reduce freshwater use, minimize industrial process water disposal and redirect some of it for hydraulic fracturing.

## THE FUTURE

### SWN'S ONGOING FRESHWATER NEUTRAL GOAL

While we met our freshwater neutral imperative in 2016, ECH<sub>2</sub>O's objectives remain in place. We will continue to reduce our freshwater use, explore alternative water sources, seek innovative water treatment technology and completion techniques, and partner with communities in conservation efforts.

We will maintain our ECH<sub>2</sub>O commitments as we initiate and expand operations in new plays. We will identify and review alternative water sources in each area before development, and design the infrastructure plan to maximize the efficient use of flowback and produced water, including other applicable alternative sources.

We believe our holistic approach to water management through ECH<sub>2</sub>O demonstrates our commitment to creating Value+ in the community, the economy and the environment. It is an essential part of our culture and our way of doing business.



The ability to access clean water is vital today and in the future for healthy and prosperous communities and surrounding environments.