



## **RECOMMENDED PRACTICES: Pre-Drill Water Supply Surveys**

# RECOMMENDED PRACTICES:

## Pre-Drill Water Supply Surveys

### 1.1 Purpose

These recommended practices address relevant considerations and guidelines for Pre-Drill Water Supply Surveys and support the Marcellus Shale Coalition's (MSC) guiding principles. For the purposes of this document a water supply is defined as any water source such as a groundwater well, spring, pond, stream, or lake used for human consumption, or for agricultural, commercial, industrial, or other legitimate beneficial uses.

### 2.1 General

The objective of a Pre-Drill Water Supply Survey and associated water sampling is to establish a baseline for conditions that exist prior to initial oil or gas drilling activities, or to update water quality conditions prior to drilling new wells on an existing pad. Groundwater typically contains various natural constituents not associated with human activity. The presence and concentration of any constituent may vary over time due to many factors, including but not limited to water usage, pump depth, seasonal recharge and water level variability, well age, meteorological events, temperature, and barometric pressure changes. For example, there are areas throughout the United States where naturally occurring methane gas is present in aquifers frequently used as water supplies for private landowners. This has been well documented for decades in portions of the Appalachian basin (refer to the MSC's Recommended Practice for Responding to Stray Gas Incidents for further information on this subject). Therefore, it is important for both the operator and the water supply owner to understand the concentrations of constituents in, and other characteristics associated with, water supplies located in the area of planned drilling activities.

A Pre-Drill Water Supply Survey and associated water sampling should be conducted on all identified water supplies within a given area of the well pad surface location. The State Regulatory Agency (SRA) may have guidelines or regulations regarding the sampling distances. An oil and gas company may choose to sample beyond the area specified by the SRA, in accordance with the oil and gas company's internal sampling guidance. Sampling decisions may be based on hydrology, geology, aquifer characteristics or any number of other factors. Water supplies such as wells, springs, and ponds should be evaluated. Consideration should also be given to sampling water supplies that are not currently in use, as they could be put into use in the future.

Consider sampling and laboratory analyses prior to any earth disturbance for site construction or drilling related activities. Consider performing another round of sampling and analysis prior to additional drilling related activities if significant time elapses between these activities. Authorization to access and sample the water supply(ies) for a property must be obtained from the property owner.

### 3.1 Initial Survey

Water supplies within the selected area of the well pad surface location should be identified during initial water supply inventorying activities or subsequent surveys. The following tools may be utilized to identify water well, pond, and spring locations: regulatory databases; topographic and aerial maps; windshield surveys; and property tax rolls. Each water supply should be given a unique identifier.

The owner and/or user (*e.g.*, resident or tenant) of the water supply should then be contacted to schedule the initial survey using, any methods that may be prescribed by the SRA (*e.g.*, certified mail, direct contact). Operators should inform the water supply owners and/or residents that any and all information/data collected can be provided to the owner/ occupant upon request and to the SRA (if required by state regulations) and, as such, the information could be disclosed as public information upon inquiry to the SRA.

With the assistance of the water supply owner or resident, locate the water supply(ies) and sampling location(s). Use GPS (preferably NAD83 datum)

to determine and record the latitude and longitude of each water supply. For each water supply, conduct a survey or interview with the water supply owner or resident and document available basic water supply information (*e.g.*, if the supply is a water well obtain the depth, year drilled, casing type, treatment, historical water quality issues). Prepare a plan view sketch or digital aerial map to document the location of the water supply (and sampling point), residence, septic system, adjacent surface water bodies, mine influenced water seeps and any other pertinent features. Photograph all notable features, such as the wellhead, spring location, sample point, etc. Note the approximate distances between features on the sketch/map. For informational purposes, Appendix A contains an example site visit form to help illustrate information that should be collected during each sampling event.

### 4.1 Water Sampling

Water samples should be obtained by a properly trained and experienced independent third party. The sampling should be performed in accordance with any applicable state and federal regulations and requirements, and in accordance with all appropriate sample collection, preservation, handling, and chain-of-custody procedures. For more information, please refer to the MSC's [Pre-Drill Water Supply Sampling Fact Sheet](#)

Sampling should be conducted as close to the water supply source as is practical, and when possible, prior to any treatment system or storage tank. Whenever the sample cannot be collected prior to the treatment system/storage tank, the sampler should note this as part of the sample collection documentation. Note that during sampling processes it is not recommended to be invasive. The existing water collection system configuration should not be modified.

If the property owner refuses to allow the operator access to conduct the water sampling, the operator should send a refusal notice to the water supply owner confirming that access was refused. The refusal notice should include the following:

- The operator's intention to drill or alter an oil or gas well.
- The desire to conduct a Pre-Drill Water Supply Survey.
- The name of the person who requested and was refused access to conduct the survey and sampling, and the date of the request and refusal.
- The operator should note that certain landowner rights may be affected if access to conduct the Pre-Drilling or Pre-alteration Survey is withheld. For example, in Pennsylvania, the presumption established under 3218(c) of Act 13 may be void.
- The name and address of the well operator, and the address of the SRA if required, to which the water supply owner or resident may respond.

The SRA may require a copy of this refusal notice as well. In addition, if a tenant at the property (not the owner) refuses access/sampling, the property owner should be notified regarding the attempt to assist in resolving access.

### 4.2 Sample Analyses

Water samples should be analyzed by an SRA certified laboratory using appropriate analytical methods (such as relevant EPA methods, ASTM methods, or methods listed in *Standard Methods for the Examination of Water and Wastewater*). For parameters that have a primary or secondary Maximum Contaminant Level (MCL) for public water systems, the laboratory should be instructed to provide a laboratory reporting limit no greater than the published MCL. The following parameters should be considered.

### 4.3 Parameters

Beyond the following list, additional parameters may be appropriate based on location and specific conditions and may be added at the discretion of the operator. Further, operators should check the requirements of the SRA to determine if additional parameters are required. Appendix B provides the list of parameters along with their respective MCLs (for those parameters that have an MCL). The USEPA primary and secondary MCLs have been established for treated drinking water at the delivery point of public water systems. Although MCLs are commonly used as a benchmark for private water supplies, it should be noted that the USEPA and the SRAs do not have authority to regulate private drinking water wells.

Alkalinity	Xylene
Ethylene Glycol	Aluminum
pH (field and/or lab)	Arsenic
Specific Conductance	Barium
Total Dissolved Solids	Boron
Total Suspended Solids	Calcium
Chloride	Chromium
Sulfate	Copper
Bromide	Lead
Hardness	Lithium
Nitrate as N	Iron
MBAS/ Surfactants	Magnesium
Turbidity**	Manganese
Dissolved Methane*	Potassium
Dissolved Ethane	Selenium
Dissolved Propane	Sodium
Benzene	Strontium
Toluene	Vanadium
Ethylbenzene	Zinc
Total Petroleum Hydrocarbons***	

\* If the Pre-Drill field screening or sampling laboratory results show levels of methane that warrant further investigation, the operator should consider collecting a carbon isotopic sample for analysis.

\*\* If Turbidity exceeds 10 NTU, the operator should consider collecting samples for dissolved metals analysis.

\*\*\* Include Total Petroleum Hydrocarbons in oil producing regions.

### 4.4 Reporting

A report documenting the Pre-Drill Water Supply Survey and associated analytical results of the predrill sampling should be prepared. The report should be provided to the water supply owner and where required, to the SRA. Additionally, some SRAs may have a required regulatory reporting deadline that must be met. In the case where a tenant resides at the property (not the owner), the owner should be advised that the results should be shared with said tenant(s). The report may contain the following information:

- The location of the water supply and the name of the water supply owner
- The date of the survey, the name of the certified laboratory and the name of the independent third party who conducted the survey
- A description of where and how the water sample was collected
- A description of the type and age, if known, of the water supply, and treatment, if any
- The name of the oil or gas well operator, and the name of the associated well pad
- The results of the laboratory analysis

Consider including references that the water supply owner and/or resident may use to interpret analytical data such as publicly available guidance documents from regulatory agencies. For more information, please refer to the MSC's [Tips on Understanding Your Water Test Results](#).

*This document provides general guidance on recommended practices for the subject(s) addressed. It is offered as a reference aid and is designed to assist industry professionals in improving their effectiveness. It is not intended to establish or impose binding requirements. Nothing herein constitutes, is intended to constitute, or shall be deemed to constitute the setting or determination of legal standards of care in the performance of the subject activities. The foregoing disclaimers apply to this document notwithstanding any expressions or terms in the text that may conflict or appear to conflict with the foregoing.*



APPENDIX A

**SITE VISIT FORM**  
**ONE FORM FOR EACH WATER SOURCE**

Part A: GENERAL INFORMATION

Water Source ID:	O&G Well Name/No.:	Permit No.:	Well Operator:
Coordinates: (Specify Coordinate System) Lat _____ Long _____ GPS Points _____ Elevation _____ FT.			
Sampled By:	Date Sampled:	<input type="checkbox"/> N/A: No Sample (See Notes)	
Person Interviewed: <input type="checkbox"/> Owner <input type="checkbox"/> Resident <input type="checkbox"/> Tenant <input type="checkbox"/> Executor <input type="checkbox"/> Designee <input type="checkbox"/> Neighbor <input type="checkbox"/> Relative <input type="checkbox"/> Trustee <input type="checkbox"/> Other (relationship to owner): _____ (attach documentation of authorization)			
PROPERTY ADDRESS		PROPERTY OWNER MAILING ADDRESS	
Name:		Name:	
Address:		Address:	
Address:		Address:	
Phone No.:		Phone No.:	

Part B: WATER QUALITY

	Owner/Tenant Reported Quality			Survey Technician Observed Quality		
	Yes	No	N/A	Yes	No	N/A
Staining	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Odor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cloudiness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oily Film /Sheen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Effervescence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	N/A	N/A	N/A
Taste	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Color _____		
Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>			

Have there been any water quality complaints previously filed for this water supply?  Yes  No

Has the residence ever been served by public water?  Yes  No

Has the residence ever been served by public sewer?  Yes  No

If yes what was the nature and date of the complaint? \_\_\_\_\_  
 \_\_\_\_\_

**APPENDIX A**

**SITE VISIT FORM  
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**Part C: WATER SYSTEM HARDWARE**

Treatment	Pump Type
Hand	Unknown
<input type="checkbox"/> None <input type="checkbox"/> UV Light <input type="checkbox"/> Softening <input type="checkbox"/> pH Adjustment <input type="checkbox"/> Chlorination <input type="checkbox"/> Other: _____ <input type="checkbox"/> Iron Removal <input type="checkbox"/> In-line Sediment Filter <input type="checkbox"/> Charcoal Filter <input type="checkbox"/> Reverse Osmosis Yes <input type="checkbox"/> No <input type="checkbox"/> Functioning Properly	<input type="checkbox"/> None <input type="checkbox"/> Gas Piston <input type="checkbox"/> Submersible <input type="checkbox"/> Windmill <input type="checkbox"/> Jet <input type="checkbox"/> Other: _____ <input type="checkbox"/> Capacity _____ GPM Size of pump (horsepower): _____
Last date of maintenance: _____	

**Part D: WATER SOURCE INFORMATION**

Does this water source supply any other properties? \_\_\_\_\_ If yes, identify properties \_\_\_\_\_

Is the water source(s) located on the property: Yes  No  If No, please explain: \_\_\_\_\_

Number of people using this water source? \_\_\_\_\_ Gallons/day, if metered: \_\_\_\_\_

How often is treatment serviced or administered? \_\_\_\_\_

Has water source ever gone dry? Yes  No

If so under what circumstances has it gone dry: \_\_\_\_\_

How frequently does it go dry: \_\_\_\_\_

Pressure Tank Yes  No  Size of tank \_\_\_\_\_ gallons  Actual size  Estimated  Unknown

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Water Use  Domestic  Husbandry  Irrigation  Other: \_\_\_\_\_

Water source uses:  Drinking water  Cooking  Showering  Laundry  Dishwashing  Lawn care  Gardening  Not in Use

Not in Service  Future Use

Farm irrigation – How many acres? \_\_\_\_\_

Animal husbandry – if cattle (how many head?) \_\_\_\_\_

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Compass course from water source to dwelling \_\_\_\_\_ Estimated distance from water source to dwelling \_\_\_\_\_ FT.

Are there any other water sources on the property? Yes  No  If yes, how many? \_\_\_\_\_

Provide all water source ID(s) \_\_\_\_\_

Are you aware of any abandoned water source (s) on the property? \_\_\_\_\_ If yes, where \_\_\_\_\_, when \_\_\_\_\_

Are you aware of any inactive (not currently used) water source (s) on the property? \_\_\_\_\_ If yes, where \_\_\_\_\_, when \_\_\_\_\_

Water Source Type:  Water Well

Driven Well:     Drilled Well:     Dug Well:     Is it Artesian:  Yes  No  
 Other: \_\_\_\_\_  
 Reported total well depth: \_\_\_\_\_ FT.    Well casing diameter: \_\_\_\_\_ IN.    Aboveground top of casing / casing stick up \_\_\_\_\_ FT.  
 Missing/damaged pit-less adaptor    Yes     No     Unknown

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Depth to water (if accessible): \_\_\_\_\_ FT.    Reported pump depth \_\_\_\_\_ FT.    SWL/Depth to water taken before sampling \_\_\_\_\_ FT. & taken after sampling \_\_\_\_\_ FT.  
 If measured what was the method of measurement: \_\_\_\_\_  
 Combustible Gas Reading of Well Headspace: \_\_\_\_\_ (if accessible)  
 Is the Well Vented?  Yes  No

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Date Drilled: \_\_\_\_\_    Drilling Company: \_\_\_\_\_  
 Is the well located inside the house  or outside the house     Where is the well located (e.g., cellar, in the middle of the driveway, crawl-space, in the middle of the back yard)? \_\_\_\_\_

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Is a driller log available for the subject water well?    Yes     No

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Water Source Type:  Spring

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Discharge Pipe    Yes     No     Seep/Ground Surface Flow    Yes     No     Spring House    Yes     No     Underground Vault    Yes     No

**PART D: DESCRIPTION OF WATER SOURCE (check all that apply)**

Water source open to the environment  
 Water source open to surface water  
 Source buried  
 Cover flush with ground  
 Water source covered and secured  
 Loose, missing, or damaged cover (circle one if applicable)  
 Evidence of insects, spiders, animals (circle one if applicable)  
 Any cracked or damaged well casing/spring vault (circle one if applicable)  
 Additional storage or holding tank/coyote system (circle one if applicable) & Size of Holding Tank \_\_\_\_\_ gallons  
 Evidence of erosion of surrounding landscape  
 Other: \_\_\_\_\_

## APPENDIX A

### SITE VISIT FORM ONE FORM FOR EACH WATER SOURCE

**PART E: DESCRIPTION OF AREA SURROUNDING WATER SOURCE (check all that apply) Show locations on site sketch and provide approximate distance & compass course. Document housekeeping conditions. Information to be gathered through technician observation or landowner interview (Attach photos.)**

- Ground sloping toward water source.
- Water source down-slope of septic system (approximate distance in feet.) \_\_\_\_\_
- Signs of failing septic, soggy ground, foul odor (circle all that apply and approximate distance in feet.) \_\_\_\_\_

**Close Proximity to: (check all that apply, list approximate distance and compass direction)**

√	Item	~feet	√	Item	~feet	√	Item	~feet	√	Item	~feet
✓	<i>Example</i>	<i>15 SE</i>	□	Garden		□	Agricultural field		□	Orchard	
□	Greenhouse		□	Junk yard		□	Dumping area		□	Landfill	
□	Field with livestock		□	Barn		□	Barnyard		□	Other outbuilding	
□	Equipment storage		□	Maintenance areas		□	Garage		□	Pipeline	
□	Current mining activities		□	Historic mining activities		□	Salt storage area		□	Salted roadway	
□	Fuel storage tanks? Are tanks:		□	AST(s)		□	UST(s)				
□	Industrial Land Use		List type of use:								
□	Other:										

**ADDITIONAL REMARKS & COMMENTS:**

**PART F: SAMPLING**

SAMPLED	SAMPLING POINT LOCATION (be specific with regard to location of sample)
<input type="checkbox"/> Before Treatment <input type="checkbox"/> After Treatment <input type="checkbox"/> No Treatment <input type="checkbox"/> Not Sure  _____	<input type="checkbox"/> Inside Faucet with aerator (e.g., kitchen, bathroom, etc.): _____ <input type="checkbox"/> Inside Faucet without aerator (e.g., kitchen, bathroom, etc.): _____ <input type="checkbox"/> Pressure Tank <input type="checkbox"/> Overflow/Discharge Pipe <input type="checkbox"/> Outside Faucet: _____ <input type="checkbox"/> Wellhead <input type="checkbox"/> Seep <input type="checkbox"/> Spring <input type="checkbox"/> Surface Water (sampled at coordinates in Part A) <input type="checkbox"/> Other: _____

Please provide sampling point coordinates only if the sample point location is different from the water source location in Part A:

Sampling point coordinate: (Specify Coordinate System) Lat \_\_\_\_\_ Long \_\_\_\_\_ GPS Points  
 \_\_\_\_\_ Elevation \_\_\_\_\_ FT.

SAMPLING EQUIPMENT:  Existing well pump  Sampling pump  Bailer  Other: \_\_\_\_\_

PURGING METHOD (as applicable):

Was the water source purged before sampling? Yes  No  If yes, volume purged (gal.) \_\_\_\_\_ time purged (min) purged \_\_\_\_\_  
 rate purged: \_\_\_\_\_ If no, why? \_\_\_\_\_

**FIELD ANALYSES:**

Test	Measurement	Units
Turbidity		
pH		
Conductivity		
Temperature		
ORP		
Cold Water Cap		
Jar Headspace		
DO		
Other		

Notes:

Chain of custody attached?  Yes  No Name of Certified Laboratory: \_\_\_\_\_

**PART G: PLAN SKETCH and PHOTOGRAPHS** *(use additional pages as necessary)* Show compass course and provide approximate distance.

**Sampler/Interviewer**

Sign _____	Print _____	Date _____
Company Name: _____		

**Interviewee**

Sign _____	Print _____	Date _____
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## Appendix B

### Summary of Aqueous Pre-drill Constituents, Maximum Concentration Limits, Analytical Methods, and Holding Times

Constituent	MCL <sup>1</sup>	Units <sup>2,3</sup>	EPA Methods for Water Analysis <sup>4</sup>	EPA Waste: SW-846 <sup>4</sup>	Standard Methods for the Examination of Water and Wastewater, 23rd Edition <sup>4</sup>	Other	Holding Times (with proper preservative)
<b>Conventional Analyses</b>							
Alkalinity	--		310.1	--	2320B		14 days
Ethylene Glycol	--		--	8015 Modified	--		14 days
pH (field and/or lab)	6.5-8.5 SU <sup>5</sup>		150.1, 150.2	9040, 9041	4500-H+-B		Immediately (15 minutes)
Specific Conductance			120.1	9050	2510B		28 days
Total Dissolved Solids	500 <sup>5</sup>		160.1	--	2540C		7 days
Total Suspended Solids	--		160.2	--	2540D		7 days
Chloride	250 <sup>5</sup>		300.0, 300.1	9056, 9212, 9250, 9251, 9253	4110B, 4500Cl-B,C,D,E		28 days
Sulfate	250 <sup>5</sup>		300.0, 300.1	9035, 9036, 9038, 9056	4110B, 4500-SO42 Cor D		28 days
Bromide	--		300.0, 300.1	9056	4110B		28 days
Hardness	--		130.1, 130.2, 200.7 (calc)	6010, 6020 (calc)	2340 B or C		6 months
Nitrate as N/Nitrite as Nitrate	10/1		300.0, 300.1, 352.1, 353.2	9056, 9210	4110B, 4500-NO3 B		48 hours
MBAS/ Surfactants	0.05 <sup>5</sup>		425.2	--	5540C		48 hours
Turbidity	--		180.1	--	2130B		48 hours
<b>Dissolved Gases</b>							
Dissolved Methane	--	ug/L		--	RSK SOP-175, ASTM D8028-17		14 days
Dissolved Ethane	--	ug/L		--	RSK SOP-175, ASTM D8028-17		14 days
Dissolved Propane	--	ug/L		--	RSK SOP-175, ASTM D8028-17		14 days
<b>Volatile Organic Compounds</b>							
Benzene	0.005	mg/L	624.1, 524.2	8260			14 days
Toluene	1	mg/L	624.1, 524.2	8260			14 days
Ethylbenzene	0.7	mg/L	624.1, 524.2	8260			14 days
Xylene	10	mg/L	624.1, 524.2	8260			14 days
<b>Total Metals</b>							
Aluminum	0.2 <sup>5</sup>	mg/L	200.7, 200.8	6010, 6020			6 months
Arsenic	0.01	mg/L	200.7, 200.8	6010, 6020 3113, 3114			6 months
Barium	2	mg/L	200.7, 200.8	6010, 6020 3111, 3113, 3120			6 months
Boron	--	mg/L	200.7, 200.8	6010, 6020			6 months
Calcium	--	mg/L	200.7, 200.8	6010, 6020 3111, 3120, 3500			6 months
Chromium	0.1	mg/L	200.7, 200.8	6010, 6020 3113, 3120			6 months
Copper	1	mg/L	200.7, 200.8	6010, 6020			6 months

Lead	0.010 <sup>6</sup>	mg/L	200.7, 200.8	6010, 6020 3113		6 months
Lithium	--	mg/L	200.7, 200.8	6010, 6020		6 months
Iron	0.3 <sup>5</sup>	mg/L	200.7, 200.8	6010, 6020 3111, 3113, 3120		6 months
Magnesium	--	mg/L	200.7, 200.8	6010, 6020 3111, 3120, 3500		6 months
Manganese	0.05 <sup>5</sup>	mg/L	200.7, 200.8	6010, 6020 3111, 3113, 3120		6 months
Potassium	--	mg/L	200.7, 200.8	6010, 6020		6 months
Selenium	0.05	mg/L	200.7, 200.8	6010, 6020 3111, 3113		6 months
Sodium	--	mg/L	200.7, 200.8	6010, 6020 3111		6 months
Strontium	--	mg/L	200.7, 200.8	6010, 6020 3111		6 months
Vanadium	--	mg/L	200.7, 200.8	6010, 6020		6 months
Zinc	5 <sup>5</sup>	mg/L	200.7, 200.8	6010, 6020		6 months

**Notes:**

-- Not Defined

The laboratory reporting limits should be equal to or less than the MCLs.

1 - MCL - Maximum Contaminant Level - The maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system.

2 - Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million. Other units may include micrograms per liter (ug/L), which are equivalent to parts per billion.

3 - The US EPA regulates public water systems; it does not have the authority to regulate private drinking water wells.

4 - The analytical laboratory should use the most current analytical methods.

5 - Limit is a secondary drinking water standard. Secondary drinking water standards are non-enforceable guidelines regulating contaminants that may cause cosmetic or aesthetic effects in drinking water.

6 - Lead is regulated by a Treatment Technique that requires a system to control the corrosiveness of its water. This limit is an action level. This level will be effective September 2027.

**References:**

Approved Clean Water Act - Chemical Test Methods

The analytical methods promulgated under Clean Water Act section 304(h) are sometimes referred to as the "304(h)" or "Part 136" methods.

The methods measure chemical and biological pollutants in media, such as wastewater, ambient water, sediment, and biosolids (sewage sludge). These various CWA methods are tested in a variety of labs and matrices.

SW-846

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA publication SW-846, Third Edition, Final Updates I (1993), II (1995), IIA (1994), IIB (1995), III (1997), IIIA (1999), IIIB (2005), IV (2008), and V (2015).

Standard Methods

Standard Methods for the Examination of Water and Wastewater. Standard Methods is a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), 23rd edition, 2017, E.W. RICE, R.B. BAIRD, A.D. EATON, EDITORS.



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