

Managing Environmental Aspects Associated with Exploration and Production Operations Including Hydraulic Fracturing

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Managing Environmental Aspects Associated with Exploration and Production Operations Including Hydraulic Fracturing

1 Scope

1.1 General

This document provides recommended practices applicable to the planning and operation of wells, and hydraulically fractured wells. Topics covered include recommendations for managing environmental aspects during planning; site selection; logistics; mobilization, rig-up, and demobilization; and stimulation operations. Also, this document includes guidance for managing environmental aspects during well construction. This document provides recommendations for the following topics:

- a) baseline groundwater sampling;
- b) source water management;
- c) material selection;
- d) transportation of materials and equipment;
- e) storage and management of fluids and chemicals;
- f) management of solid and liquid wastes;
- g) air emissions;
- h) site planning;
- i) training;
- j) noise and visual resources.

This document provides a general discussion of exploration and production operations, which does not supersede the review of applicable local, state, and federal regulatory requirements. Operators should consider available industry standards and guidance that can provide additional information.

In addition to this document, API 100-1 contains recommended practices for well construction and fracture stimulation design and execution as it relates to well integrity, groundwater protection and fracture containment for onshore wells. The recommended practices relate to two areas: well integrity during the design and installation of well equipment, and fracture containment during the design and execution of hydraulic fracturing treatments.

1.2 Conditions of Applicability

This document provides technical guidance only, and practices included herein may not be applicable in all regions and/or circumstances. This document does not constitute legal advice regarding compliance with legal or regulatory contractual requirements, risk mitigation, or internal company policies and procedures, where applicable. Where legal or regulatory requirements are mentioned, this document is not intended to be all-inclusive. The operator is responsible for determining compliance with applicable legal or regulatory requirements.

2 Normative References

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[API Recommended Practice 68](#), *Recommended Practice for Oil and Gas Well Servicing and Workover Operations Involving Hydrogen Sulfide*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions shall apply.

3.1.1

additive

A liquid or solid chemical product used in the blending of fluid, such as those used in fracturing, drilling, and cementing.

3.1.2

anisotropy

A condition of unequal geomechanical properties along different axes or directions.

NOTE Can include differential axes of stress.

3.1.3

aquifer

A subsurface formation that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs.

3.1.4

base fluid

The primary liquid or gas component or diluent used in blended-solutions, such as those used in hydraulic fracturing.

3.1.5

catchments

A structure, such as a basin or reservoir, used for collecting or draining fluid.

3.1.6

chain of custody

Documentation of the movement, handling, and transfer of samples or data starting from the point of capture.

3.1.7

completion

The activities and methods to prepare a well for production, including casing perforation, formation preparation, and the installation of equipment to produce a well following drilling.

3.1.8

constituent

Individual chemical or component.

3.1.9**development**

The phase of the field life-cycle after exploration when an oil or gas field is determined to be economically viable.

NOTE This phase involves the construction of one or more wells and related facilities and infrastructure for the purposes of production.

3.1.10**environmental aspects**

Elements of exploration and production activities or materials or services that can interact with the environment.

3.1.11**exploration**

The phase of the field life-cycle involving the search for rock formations associated with oil or natural gas deposits, and can involve geophysical prospecting and/or exploratory drilling.

3.1.12**flowlines**

The pipe between the wellhead and the production facilities through which produced fluids flow.

3.1.13**flowback <verb>**

The act of recovering produced fluids from the formation after hydraulic fracturing operations.

3.1.14**fresh water**

Water generally characterized by having low concentrations of dissolved solids.

NOTE Multiple regulatory and legal definitions of this term exist and should be checked for applicability to a specific situation.

3.1.15**gathering lines**

Pipelines used to transport oil or gas after primary separation to a processing or compression facility or to the point of custody transfer or sale.

3.1.16**high-pressure piping**

treating iron

The temporary surface piping, valves and manifolds necessary to deliver a fluid treatment to the wellbore from the mixing and pumping equipment.

3.1.17**hydraulic fracturing**

A completion operation in which a hydraulic fracturing fluid is pumped down a well into a target formation under pressure high enough to exceed the formation fracture gradient to create fractures through which oil or gas can flow into the well bore.

3.1.18**hydraulic fracturing fluid**

A fluid blend that can include a base fluid, proppant, and other additives, that is expressly designed to hydraulically induce fractures in the target formation.

3.1.19**impoundment**

An earthen-bermed or excavated storage area, above- or below-grade, to store fluid used in onshore operations.

3.1.20**isotopic analyses**

An analysis of a sample for stable isotopes, usually carbon or hydrogen.

3.1.21**liquid waste****solid waste**

Any solid, semi-solid, liquid or contained gaseous material that is intended for disposal.

3.1.22**mitigation**

An action taken to offset, reduce, or compensate for an impact.

3.1.23**non-potable groundwater**

Subsurface water not suitable for consumption by humans or animals without treatment.

3.1.24**pad****well pad**

The ground surface where wells and production equipment are placed and/or operations conducted.

NOTE 1 A pad is usually constructed to provide a stable surface for equipment used in exploration and production (E&P) activities.

NOTE 2 Several wells can be located on one pad to reduce the overall surface disturbance.

3.1.25**potable groundwater**

Subsurface water suitable for consumption by humans or animals with or without treatment.

3.1.26**primacy**

A legal authority granted to a state by the federal government that allows state agencies to implement federal regulatory programs with federal oversight.

3.1.27**primary containment**

The tanks, pipes, vessels, or containers that first come in contact with the material.

3.1.28**produced water**

Any type of water produced from oil and gas wells.

3.1.29**produced fluid**

Fluids recovered from a well that can contain a combination of produced water, oil, gas, and additives.

3.1.30**production**

The phase of the field life-cycle that occurs after successful exploration and development and during which hydrocarbons are economically recovered from an oil or gas field.

3.1.31**project area**

The area of exploration or development that includes one or more well pads and well sites.

**Documents**

Document Sharing Hub

3.1.32**proppant**

Natural, treated, or man-made particles pumped into a formation during a hydraulic fracturing operation to keep fractures open.

3.1.33**receptor**

People, organisms, environs, or facilities that are susceptible to the potential effects of exposure.

3.1.34**reuse**

The act of using fluid or material again, with or without processing.

3.1.35**secondary containment**

Material, equipment, facilities used to limit the spread or discharge of fluids that are inadvertently released from primary containment.

3.1.36**slickwater**

A type of water-based hydraulic fracturing fluid that uses friction reducing additives for the purpose of reducing injection pump pressures.

3.1.37**sodium adsorption ratio****SAR**

Ratio of the concentration of sodium ions $[Na^+]$ to the concentration of calcium $[Ca^{2+}]$ and magnesium $[Mg^{2+}]$ ions, expressed in meq/L, as calculated in the following equation.

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}] + [Mg^{2+}])}}$$

3.1.38**stakeholders**

A person, entity, or organization that is materially affected by the outcome of an operational activity at a site or a regulatory, policy or management decision.

3.1.39**surface water**

A body of water naturally open to the atmosphere.

3.1.40**total dissolved solids****TDS**

The dry weight of dissolved material, organic and inorganic, contained in water and usually expressed in parts per million.

3.1.41**total petroleum hydrocarbons**

A concentration or mass of petroleum hydrocarbon constituents in a given amount of media.

3.1.42**waste water**

Water that has been used in an application and contains constituents no longer useful.

3.1.43**water rights**

Legal access and authority to use a water source designated to a user.

3.1.44**well site**

The area surrounding and contiguous to a single or multiple-well pad.

3.2 Acronyms and Abbreviations

BMP	best management practice
BTEX	benzene, toluene, ethylbenzene, xylenes
CFR	<i>Code of Federal Regulations</i>
DOT	Department of Transportation
E&P	exploration and production
EPA	Environmental Protection Agency
LPG	liquid petroleum gas
PPE	personal protection equipment
QA/QC	quality assurance/quality control
MS/MSD	matrix spike/matrix spike duplicate
SAR	sodium absorption ratio
SDWA	Safe Drinking Water Act
SMP	stormwater management plan
SDS	safety data sheet [formerly known as a material safety data sheet (MSDS)]
SOP	standard operating procedure
SPCC	spill prevention, control, and countermeasures
TDS	total dissolved solids
UIC	underground injection control
VOC	volatile organic compound

4 Planning

4.1 Planning and Design Considerations

Planning and design for exploration, development, and production operations is essential to managing the environmental aspects effectively and should be started at the conceptual stages of site development. Planning allows the operator to better anticipate issues and events prior to execution of the drilling and completions including hydraulic fracturing operations. Planning also allows for consideration of external factors that may not be obvious to the operator when conceptualizing the project. During the planning process, a single point of contact should be established who has overall responsibility for the project and can direct individual leads for the various activities.

Before site construction begins, logistics and timing for the following should be taken under careful consideration:

- a) site selection (see Section 5);
- b) local, state, and federal legal and regulatory requirements including relevant permitting for the project;
- c) community outreach and engagement (see [API 100-3](#));
- d) spill prevention, control, and response (see Section 6);
- e) logistics (see Section 7);
- f) baseline ground water sampling (see Section 8);
- g) source water management (see Section 9);
- h) material selections associated with hydraulic fracturing (see Section 10);
- i) transportation of materials and equipment (see Section 11);
- j) mobilization, rig-up, and demobilization (see Section 12);
- k) storage and management of fluids and additives on-site (see Section 13);
- l) management of solid and liquid wastes (see Section 14);
- m) employee training (see [API 75L](#));
- n) job safety analysis (JSA).

These activities are likely to vary depending on the complexity, scope, and size of the project and are likely to evolve as conditions change. The items listed above should be re-evaluated to optimize environmental management. See 4.2 for more information.

4.2 Project Life-cycle Considerations

As part of project planning, operators should recognize that most, if not all, drilling, completion, and production activities will change as a project progresses from the exploration phase to the development phase to the production phase. Planning for several, isolated exploration wells has considerably different technical, environmental, safety, and business challenges compared to planning for an extensive multi-well, multi-location development program coincident with design and installation of centralized oil and gas gathering and processing facilities. Planning decisions should be appropriate for the phase of the project; however, operators should weigh the short-term benefits of planning

decisions made during the exploration phase versus potential longer-term benefits of planning decisions that more readily accommodate project success and growth into the development and production phases.

Many of the project activities supporting drilling, completions and production will likely change out of necessity as the project grows from exploration to development and production. For example, a single local water source and off-site commercial waste disposal can be appropriate for an exploration well. Alternatively, plans during development may change to accommodate multiple water sources, including treated and reused water, and possible on-site waste disposal.

4.3 General Documentation

4.3.1 Documentation is a critical component of any well-planned and well-executed project. Operators should seek and follow legal advice to develop their document preparation and retention procedures.

4.3.2 General principles that apply to documentation processes include the following.

- a) Retain final versions of documentation used in the preparation of permit applications, copies of permit applications, copies of approved permits, and any variances.
- b) Retain final versions of documentation used in the preparation of reports in compliance with a permit or other regulatory approval. These may include environmental studies, consultant reports, laboratory reports, and professional or legal opinions.
- c) Retain approvals of variances or waivers from regulatory requirements.
- d) Retain documentation involved in any legal, regulatory, or compliance action.

4.3.3 Many regulatory agencies specify document retention requirements (including, but not limited to training records, inspection records, and plans, etc.) within their regulations or their permits and operators must comply with those requirements. For materials not directly addressed by such requirements, operators should seek legal advice regarding retention of materials.

4.4 Self-assessment and Follow-up

Operators should develop procedures for and implement routine walk-throughs and self-assessments of operations. These procedures should include tracking the findings to completion and resolution, documentation, and possible communication. The procedures may address the appropriate level of communication and document retention.

5 Site Selection and Considerations

5.1 General

The selection of a project area, and ultimately the well site, is an important step that can have implications for subsequent project stages. The examination of a particular project area should involve a thorough review of both short and long term factors related to operational, health and safety, land, infrastructure, logistical, and community considerations. In selecting a site, operator should consider suitability for drilling activities as well as future and ongoing production needs, and how the site will be integrated into existing or future field operations. Operators should also consider any environmental (sensitive habitat or protective species) and social aspects in site selection. A local evaluation of these factors should be made before a well site is selected. This may require on-site surveys as well as consultations with landowners and other local interests. The objective of this process should be to, as reasonably practicable, select project areas that promote successful and safe operations while reducing potential local disturbances.

Well pads should be planned with safety—worker, community, and environment—as a first priority. Site selection should also be made with an understanding of prevailing regulatory requirements, surface and mineral lease requirements, and subsurface geology in the area to the extent practical. Important factors in final site selection and potential impacts associated with certain locations may include: visual aesthetics, noise, vehicle traffic, emissions (dust and odors), lighting, erosion control, material use, existing land use and habitat, and management of hydrocarbons and produced water.

5.2 Site Plan

The site selection process should include an initial review of potential well pad locations by reviewing various public and private geographic information system (GIS) and mapping websites to evaluate major surface features, such as topography; water bodies and drainages; roads and other infrastructure; and current land ownership and use. Prospective well pad locations should also be investigated in the field by key project staff to confirm the site characteristics observed during the initial review and begin location design. In some jurisdictions, field reconnaissance of prospective well pads with federal, state, and/or local regulatory staff and/or the surface owner is required as part of the well permitting process. During the field reconnaissance, a general layout of the well site (well pad, ingress/egress, equipment location, impoundments, storage areas, etc.) can be staked and surveyed.

After the well pad location has been selected and surveyed, a site plan should be drafted for use by the project team in planning and permitting. The site plan should be used in developing other planning and operational documents.

5.3 Surface Considerations

5.3.1 Site selection for E&P activities warrants careful evaluation and planning to reduce surface disturbances. Larger well pads required for multiple wells and horizontal fracture stimulation, ultimately reduce the overall surface disturbance when compared to multiple single-well pads. These multi-well pads should be sized to accommodate the additional drilling and fracturing equipment and larger production facilities necessary for higher volumes of produced fluids. These larger well pads can result in additional localized impacts during construction, drilling, fracturing, well completion, and production operations that should be considered and mitigated as appropriate. As soon as practicable, temporary equipment can be removed and excess areas may be reclaimed, restored, or returned to other uses, reducing the location size and overall footprint. See [API 51R](#) for further information on appropriate reclamation practices.

5.3.2 In choosing a project area, operators should consider the following.

- a) Encourage regional cooperation among operators to create plans for reducing surface disturbance (for example, developing shared infrastructure such as access roads, navigation channels, facilities, etc.).
- b) Pre-plan and adequately size infrastructure and facilities to accommodate current and future production, to reduce disturbance at a location to a single occurrence.
- c) Evaluate aspects and potential impacts of drilling multiple wells on a well pad.
- d) Evaluate topographic, population, protected areas and hazards, zoning and other data to locate sensitive or high-exposure areas [such as churches, schools, hospitals, residential areas, surface waters, fresh water wells, flood zones, active fault areas, threatened and endangered plants and animals (including habitat), protected bird habitat, wetlands, archaeological, recreational, biological, or scenic areas]. Where feasible, the project area should be located away from these sensitive areas. This planning must comply with applicable regulatory setback and spacing requirements.
- e) Use existing roads and rights-of-way to the maximum extent possible to also include pipelines, utilities, and other infrastructure. Where new infrastructure or pipelines may be needed, consider potential impacts of routes, property rights acquisition needs, and construction requirements.

- f) Consult with the land owner and/or surface tenant to understand present and future uses of affected and adjacent land.
- g) Reduce construction of facilities in floodplain areas. Certain jurisdictions have specific regulations regarding construction in floodplains and setbacks from water courses and water supply wells.
- h) Reduce the amount of surface terrain alteration to reduce potential environmental and visual effects.
- i) Reduce well pad locations requiring construction practices such as cut and fill in areas that can pose possible soil stability concerns and potentially increase stormwater run-on and run-off. Coverage under a construction stormwater permit may be required. Consideration should be given to stock-piling topsoil, if feasible. Subsurface soil conditions should be considered for adequate foundation support of the drilling rig, buildings, pumps, engines, tanks, and equipment used during hydraulic fracturing operations.
- j) Position equipment and materials at the well pad to reduce the risk of spills migrating offsite and affecting soil, vegetation, and water.

Detailed guidance for site selection considerations is provided in [API 51R](#).

5.4 Consideration of Visual Resources

5.4.1 General

Visually-significant resources designated through federal, state, and local processes are values shared by the general population. They include parks, historic places, preserves, refuges, landmarks, wild and scenic areas, etc. In addition to shared, visually-significant resources, local stakeholders value the natural beauty of the places where they live, work, and play. An operator should understand the potential impact from construction and operation activities and incorporate design and siting measures to reduce the potential visual impacts.

The visual impacts from operations at any particular site are generally minor and short-term, and vary with topography, vegetation, and distance to the viewer. Site-specific impacts can be greater with multi-well pads because the locations are generally larger than a single well pad, but the cumulative impact of a large-scale operation is reduced. Horizontal drilling provides flexibility to locate well pads in low impact areas and use of multi-well pads will reduce the visual impacts.

5.4.2 Design and Siting Measures

5.4.2.1 General

Design and siting measures are the simplest and most effective methods for avoiding or reducing potential impacts to visual resources. Operators should work with affected stakeholders to identify and/or map potential areas of high visual sensitivity and consider opportunities to reduce visual disturbance. Opportunities to reduce potential visual impacts can be incorporated into pre-construction planning, construction, and operational phases of the site. Design and siting measures can include screening, relocation, camouflage or disguise, low profile equipment, project scale, non-reflective materials, painting and color schemes, and lighting controls.

5.4.2.2 Screening

Screens are objects that conceal other objects from view. Screens may be natural or artificial and may be constructed of soil, rocks, bricks, or almost anything opaque. Vegetation can function as a screen when a sufficient density is employed. In natural settings it is generally better to employ natural materials, while in urban settings designers may employ a broader range of materials.

5.4.2.3 Relocation

A facility component may be relocated to another place within the site to take advantage of the mitigating effects of topography and vegetation.

5.4.2.4 Camouflage/Disguise

Colors and patterns of color can conceal an object or its identity and its disguise may take many forms. Painting and color schemes should blend with the existing areas. The use of non-reflective materials can reduce reflected light into surrounding areas.

5.4.2.5 Low Profile

Long-term facilities and equipment, such as tanks and compressors, should be placed to reduce potential visual impacts. Reducing the height of an object reduces its profile and visibility.

5.4.2.6 Project Scale

Downsizing/reducing the number, area, or density of equipment on-site can reduce their visibility.

5.4.2.7 Lighting

Lighting should be the minimum necessary for safe working conditions, security, and for public safety, and should be sited to reduce off-site light migration, glare, and sky glow light pollution. Mitigation should be considered when the impacts on receptors are significant and when such impacts cannot be avoided by design, scheduling, and siting measures. During night time operations, the use of barriers, such as wind walls, should be considered.

5.5 Noise Considerations

5.5.1 Noise is best mitigated by distance—the further from receptors, the lower the impact. The second level of noise mitigation is direction. Directing noise-generating equipment away from receptors greatly reduces associated impacts. Timing also plays a key role in mitigating potential noise impacts. Scheduling the more significant noise-generating operations during daylight hours provides for tolerance that may not be achievable during the evening hours.

5.5.2 Drilling and completion, including hydraulic fracturing, operations should be planned with these noise-related considerations. When possible, attention to the location of the access road may mitigate potential noise impacts associated with trucking and the hydraulic fracturing operations. When feasible, the well site and access road should be located as far as practical from occupied structures and places of assembly. Noise levels generated by vehicles depend on a number of variable conditions, including vehicle type, load, and speed, nature of the roadway surface, road grade, topography, and ground condition. Traffic noise mitigation measures may include modification of speed limits and restricting or prohibiting truck traffic on certain roads. Engaging stakeholders that can be potentially affected by noise impacts will result in nearby parties being better informed about the nature, character, and frequency of the noise disturbance.

5.5.3 Other examples of noise mitigation techniques that can be considered with regard to operations include:

- a) placing tanks, trailers, topsoil stockpiles, or hay bales between the noise sources and receptors;
- b) using noise reduction equipment such as hospital-grade industrial mufflers, exhaust manifolds, or other high-grade baffling;
- c) properly maintaining equipment;

- d) limiting operating hours of activities such as pipe cleaning, running casing, and laying down pipe to reduce disturbance to stakeholders;
- e) locating or orienting high-pressure discharge pipes and other equipment away from noise receptors;
- f) installing noise walls or noise barriers.

5.6 Road Use and Transportation Considerations

5.6.1 One of the main public concerns with large-scale operations is associated with the potential impact to public and private roads by vehicles supporting exploration, development, and production operations. The following should be considered to reduce road use impacts.

- a) Review service rating [equivalent single axle loads (ESALs)] of roads that will be used in daily operations. Roads should be rated to accommodate the anticipated traffic to limit additional disturbance and new road construction.
- b) Deliver source water and produced water through pipelines to reduce long-term use of water trucks.
- c) Design and construct new roadways with potential impacts and purpose in mind. Consider sharing roads and infrastructure with other operators when feasible. Landowner input should be considered prior to construction as part of the planning process.
- d) Maintain roads under either the operator's control or as required.

5.6.2 Road use and transportation issues are discussed in more detail in Section 11. In addition, detailed guidance for lease road planning, design and construction, maintenance and reclamation, and abandonment are also provided in [API 51R](#).

5.6.3 One of the potential impacts is increased truck traffic to support high-volume hydraulic fracturing. Local authorities retain control over local roads and operators should determine if road use agreements and permits are required. Operators should develop a transportation plan that considers the following:

- a) route selection to maximize efficiency and safety;
- b) avoidance of peak traffic hours, school bus hours, community events, and overnight quiet periods;
- c) coordination with local emergency management agencies and highway departments;
- d) upgrades and improvements to roads to support the increased weight and use;
- e) advance public notice of any necessary detours or road/lane closures;
- f) adequate parking and delivery areas at the well site to avoid lane/road blockage.

5.7 Temporary Impacts

Temporary impacts such as dust, odor, and vibration during operations should be mitigated where practicable. In addition to the mitigation measures listed in 5.5, the following should be considered.

- a) Dust—use, vehicle speed restriction, watering, non-toxic chemical stabilization, mulching, and vegetation rehabilitation to control dust deposition on adjacent vegetation, introduction into water bodies, and air quality impacts.

- b) Odor—use closed tanks when practical; reduce volumes of vented gas; use natural gas engines in place of diesel engines, where feasible; discourage idling vehicles.
- c) Vibration—use same actions identified for noise control (see 5.5).

6 Spill Prevention, Control, and Response

6.1 General

The best way to avoid the potential impacts of spills is to prevent their occurrence. Operations shall be conducted in a manner that reduces the potential for releases. To accomplish this, companies shall define spill prevention, control, and response procedures in their practices. These procedures should address the following topics:

- a) transportation of materials;
- b) primary and secondary containment measures;
- c) operational procedures that reduce the potential for releases;
- d) contingency procedures in the event a spill occurs;
- e) training for well site personnel;
- f) stormwater management and control.

Each of these topics is discussed in 6.2 through 6.7.

The use of non-fresh water including non-potable groundwater, treated and untreated waste water, and reuse of produced water can require additional precautions related to storage and transportation to reduce the potential of spills.

Companies also shall consider federal, state, and local regulations when developing plans. See [API D16](#) for more information.

6.2 Transportation of Materials

Trucks and temporary piping are common methods for transporting equipment and materials. Materials must be loaded, transported, and unloaded in accordance with regulatory requirements and in a manner that is designed to prevent spillage. Temporary pipelines used to transport non-fresh water shall be designed, constructed, and operated to reduce potential piping failure and release of fluids into the surrounding environment.

Equipment transported over the highway and equipment used to transport materials shall be checked for leaks. Any open-ended lines should be properly capped before transport. Loads shall be properly secured and placarded. Containers, temporary piping, and other equipment shall be visually inspected for leaks. Discharge valves on tankers shall be inspected. Fresh water should be transported in dedicated tankers that have not previously carried other materials.

6.3 Primary and Secondary Containment

6.3.1 Impoundments can be used to store water for drilling, hydraulic fracturing, or to capture produced water. Impoundments must be designed and constructed to be fit for purpose and in accordance with regulatory requirements.