

New York State (NYS) Casing Regulation Recommendations

Report to:
Natural Resources Defense Council (NRDC)

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1. Executive Summary

Purpose of this Analysis:

This analysis responds to Natural Resources Defense Council's (NRDC) request for a review of the New York State (NYS) Oil and Gas Well Casing Regulations. NRDC requested a technical review of the existing regulatory language to determine if NYS's casing requirements are best practice and protective of the environment. NRDC's request follows up on a conclusion drawn in the 2009 University of California Hastings College of the Law Oil and Gas Exploration and Production Report (University of California Report) that NYS had "*disappointingly sparse*" oil and gas well casing regulation. The University of California Report concluded that NYS regulations "*provide very little guidance for the construction of well casing*" and that "*the only substantive requirements are that the operator set the surface casing below freshwater levels and cement the casing to the surface. The regulatory regime is silent on the use of intermediate or production casing, and requires no pressure testing or cement setting times. For environmental protection, the statute instructs operators to prevent the pollution of water. Thus, New York's casing and drilling requirement is well outside the norm.*" NRDC requested that Harvey Consulting, LLC. verify if this conclusion is correct, and if so, make specific technical recommendations for improving NYS's casing regulations.

Analysis Approach

This analysis compares NYS's oil and gas casing regulations against casing regulations of four other states that have decades of experience and expertise in US domestic oil production (Texas, Alaska, California and Pennsylvania). The analysis is divided into four main categories of casing (conductor, surface, intermediate and production). An analysis of each class of casing is provided with summary conclusions drawn for potential improvements to NYS's casing regulations. Each casing string serves a different function, and warrants specific recommendations. This analysis applies only to onshore wells typical of those that may be drilled in NYS.

Due to recent proposals for extensive development in NYS's Marcellus Shale formation, NRDC is particularly interested in how the NYS Department of Environmental Conservation's (NYSDEC) casing requirements may apply to wells drilled into the Marcellus Shale. Thus, this analysis will comment specifically on casing standards relevant to that formation.

This analysis is intended solely to be a technical review and recommendation for areas where NYS's casing regulations may warrant improvement. Areas requiring legal review are identified for NRDC Legal Counsel.

Specific recommendations that are made in this analysis are highlighted in a blue text box. Many recommendations apply to more than one type of casing. To avoid repetition, recommendations are stated once, with an explanation as to which casing section the recommendations.

Overall Summary of Analysis Findings

NYS uses a combined approach of regulations, guidance documents, and permit stipulations to define and implement NYS oil and gas well casing requirements. The University of California Report is correct in identifying the limited regulatory language for oil and gas casing requirements found in the New York Codes Rules and Regulations (NYCRR), Chapter V, Resource Management Services, Subchapter B, Mineral Resources; however, the University of California Report did not examine the NYS guidance documents and permit stipulations used to regulate oil and gas wells. Combined, NYS's regulations, guidance documents, and permit stipulations are more technically robust than the University of California Report concluded. However, this analysis recognizes that there is a legal difference between a regulation,

guidance document, and permit stipulation, particularly in the ability to enforce guidance documents and permit stipulations that may not have solid roots in law or regulation. Thus, the most significant recommendation made in this report is that NRDC Legal Counsel should examine whether there is a need to codify guidance and permit stipulation requirements in regulation to strengthen NYS's ability to implement and enforce casing standards. Additionally, this report recommends new language that could be considered for the NYCRR based on Texas, California, Alaska and Pennsylvania casing regulations.

The value of local knowledge and experience cannot be emphasized enough when determining casing requirements for oil and gas wells. An agency must have a thorough understanding of the local geology, pressures, freshwater aquifer locations, and other site specific considerations unique to a development area. Any amendment to the NYCRR should include an extensive review of local practices, consultation with industry experienced in drilling the area, and a thorough examination of successful casing programs that have produced safe, high-quality wells, along with a review of poor-quality casing programs in order to glean lessons that can be applied in the future. The recommendations listed below are based on generally accepted good engineering practices and are indicative of state regulations where most of the US's oil and gas is produced. Local NYS casing experience and expertise should be sought and included in any final regulatory recommendation.

Recommendations to consider for amending the NYCRR are summarized below:

1. include casing requirements specific to wells drilled into the Marcellus Shale as the development pace continues to intensify in NYS;
2. include NYS's Casing and Cementing Practices and Fresh Water Aquifer Supplementary Permit Conditions;
3. include standard Good Engineering Practices (GEP) and Best Available Technology (BAT) language. This applies to all types of casing;
4. specify centralizer type according to American Petroleum Institute (API) Specification 10D and require additional centralizers in high angle or horizontal deviated wellbores. This applies to surface, intermediate and production casing;
5. clearly state that casing installation, cement methods must be designed and implemented to prevent vertical migration of fluids or gases behind casing during drilling, stimulations, or well operation. This applies to all types of casing;
6. require a 72-hour compressive strength standard of 1,200 psi for the cement mixture in the zone of critical cement, and require conformity with the API free water separation standard of no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B. Provide a provision for the NYSDEC to set more stringent local standards if needed for pollution prevention, and establish quantitative temperature limits for cement mixing water. This applies to surface, intermediate and production casing;
7. require operator certification that cement standards have been met on each well. This applies to all types of casing;
8. require casing and cementing record keeping for casing and cementing operations similar to the California Code of Regulations (CCR) at 14 CCR §1724. This applies to all types of casing;
9. specify casing and cementing program application content, similar to the Alaska Administrative Code (AAC) requirement at 20 AAC §25.030(a). This applies to all types of casing;

10. require the operator to perform a casing pressure test on all wells drilled to demonstrate that a surface pressure of at least 50% of the required working pressure of the blowout preventer (BOP) can be achieved. This applies to a casing that a BOP is installed on;
11. require a formation integrity test. This applies to surface and intermediate casing;
12. add a cement chemical and physical degradation standard similar to the Pennsylvania Code (Pa. Code) at 25 Pa. Code §78.85(a). This applies to all cement used;
13. add a requirement to report and repair defective casing, or take the well out of service similar to the Pennsylvania Code at 25 Pa. Code §78.86. This applies to all casing types;
14. add a casing standard in gas storage areas similar to the Pennsylvania Code at 25 Pa. Code §78.75, if there are sufficient well/gas storage intersection areas in NYS to warrant this additional requirement;
15. add a casing standard in coal development areas similar to the Pennsylvania Code at 25 Pa. Code §78.75, if there are sufficient coal seam intersection areas in NYS to warrant this additional requirement;
16. require casing and cement quality, cementing methods, testing, record keeping and reporting. This is especially true of the Marcellus Shale, where experience in Pennsylvania shows that industry recommends installing intermediate casing to provide an additional protective barrier in the wellbore, and to provide additional structural integrity;
17. clearly explain under what circumstances NYS will require intermediate casing to be set, what minimum requirements should be included in design and installation, and what the unique circumstances are that warrant additional NYS review and approval. Examples of how this regulatory goal was achieved in Texas, California, Alaska and Pennsylvania are provided in this report;
18. increase the amount of cement required to a minimum of 600' behind production casing similar to Texas regulation at 16 TAC Part 1 §3.13;
19. require production casing testing and minimum overlap length standards similar to the California Code of Regulations at 14 CCR §1722;
20. add a cement quality, testing, and remedial repair standard similar to the Alaska Administrative Code (AAC) requirements at 20 AAC §25.030; and
21. add a casing quality and amount standard similar to the Pennsylvania Code at 25 Pa. Code §78.84 and §78.71.

2. Casing Types and Function

Casing is metal pipe that is installed in oil and gas wells to serve many structural and safety functions, it:

- maintains wellbore structural integrity (so the hole does not cave in);
- isolates water zones from oil and gas production zones;
- contains well pressure during drilling, oil and gas production, and remedial well work (e.g. fractures, stimulations);
- isolates formations that contain different pressures;
- provides the structure and location to install blowout preventers, wellhead equipment, and hanging production tubing; and

- serves an important environmental protection function by preventing aquifer contamination and containing well blowouts or leaks that could result in oil spills or gas venting.

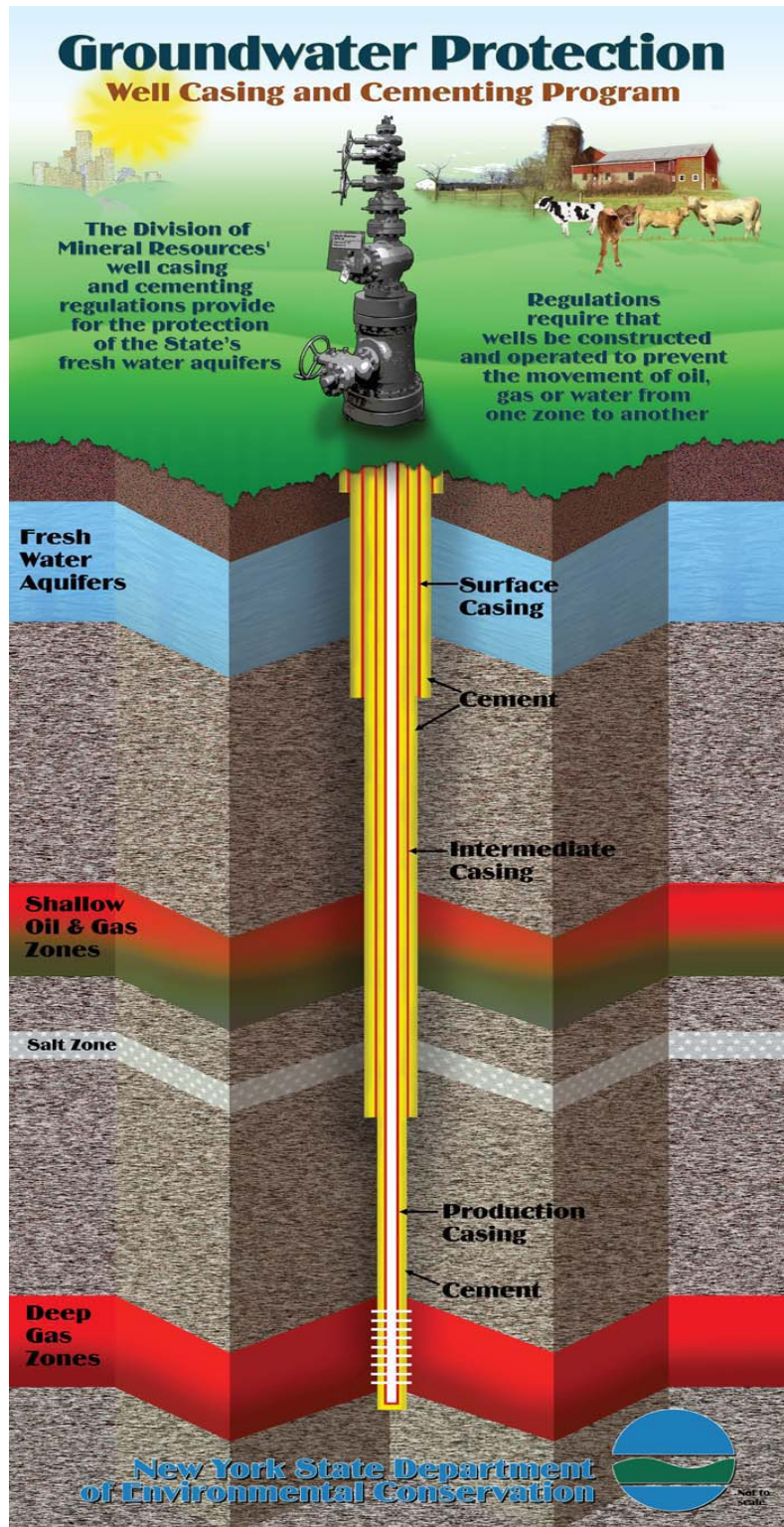
Multiple sections of casing are attached to create longer pipe sections (commonly referred to as a “casing string,” or a “string of pipe”).

A typical well is constructed by installing conductor casing, surface casing, intermediate casing, and production casing, in that order. All wells include conductor, surface and production casing. Intermediate casing may be installed depending on local conditions (e.g. to isolate a gas or water zone), future well utility or stimulation treatment methods.

The conductor casing is the largest diameter, followed by the other types of casing, decreasing in size. Each successive casing type must fit inside the one installed prior to it (telescoping construction).

Conductor casing, surface casing and intermediate casing (if used) are run from the surface of the well to its design depth. Production casing may be set from the surface of the well or may be hung off the bottom of the deepest casing string above it. Thus, a wellbore may have at least one, and maybe up to three sets of casing, covering a freshwater aquifer for protection. In Pennsylvania, operators are installing all four sets of casing to protect freshwater zones, ensure well safety and provide for a solid wellbore construction in Marcellus Shale wells.

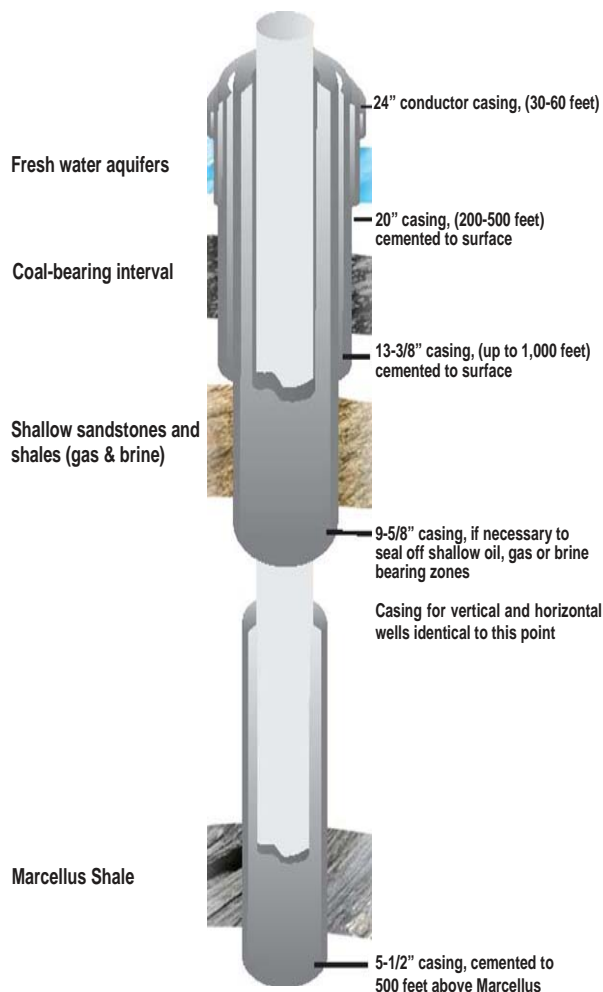
Since NRDC is particularly interested in development of the Marcellus Shale in NYS, and how casing standards in NYS may be formulated to ensure safe development of the Marcellus, a typical casing program currently recommended by NYSDEC is shown to the right.



As a comparison, a typical wellbore diagram¹ of the casing program recommended by the oil and gas industry and industry trade groups operating in the Marcellus Shale in Pennsylvania² is shown to the right. Industry recommends three sets of casing (conductor, surface, and intermediate), all cemented to the surface, putting freshwater behind three layers of casing and cement, and a fourth layer of production casing. Therefore industry's recommended casing practices and NYSDEC's recommended casing programs are similar.

In the industry recommended casing program diagram (shown to the right) intermediate casing is set at a shallow depth. Industry notes that cement is typically placed in the annular space behind the pipe all the way from the bottom of the intermediate casing (casing shoe) to surface. Cementing intermediate casing all the way to surface is possible when the intermediate casing is set at a relatively shallow depth. However, if the intermediate casing is set deeper (e.g. several thousand feet deep) it may not be possible to pump cement from the casing shoe all the way to surface. In this case, the lower section of the intermediate casing will be cemented in place by injecting cement at the casing shoe and pumping it up several hundred feet behind the lower section of the intermediate casing. This method cements the bottom section of the intermediate casing in place, ensuring that the casing will remain in place, and no drilling fluids will leak behind the casing as the well is drilled deeper. Then, production casing is installed and the production casing annulus is cemented across the Marcellus zone. Cement is also placed in the production casing annulus at least 500 feet above the top of the Marcellus zone.

Generalized casing design for a Marcellus Shale gas well to protect the environment



The casing program recommended by industry for developing the Marcellus Shale is unique to the local conditions and depths encountered in Pennsylvania. General guidelines and standards can be set in regulation for casing size, depth, cement and testing, but the specific details of a casing program must be engineered to address local conditions and safety hazards.

¹ http://www.pamarcellus.com/images/pdfs/casing_graphic-with_copy.pdf

² <http://www.pamarcellus.com/about.php>. "Founded in 2008, the Marcellus Shale Committee is an organization committed to the responsible development of natural gas from the Marcellus Shale geological formation in Pennsylvania and the enhancement of the Commonwealth's economy that can be realized by this clean-burning energy source. The members of the committee bring the strength of the Pennsylvania Oil and Gas Association and the Independent Oil and Gas Association of Pennsylvania together to address concerns with regulators, government officials and the people of the Commonwealth about all aspects of drilling and extracting natural gas from the Marcellus Shale formation."

3. Current NYS Oil and Gas Casing Requirements

NYS uses a combined approach of regulations, guidance documents, and permit stipulations to set oil and gas casing standards. NYS requires a ***Permit to Drill, Deepen, Plug Back or Convert a Well Subject to the Oil, Gas and Solution Mining Law*** (NYS Permit to Drill). When issuing a NYS Permit to Drill, the NYSDEC must determine that the applicant is in compliance with the NYCRR³ found in Chapter V, Resource Management Services, Subchapter B, Mineral Resources, including:

- Part 552 that establishes the requirements to obtain a permit;
- Part 554 that sets drilling practices and reporting standards (including casing requirements);
- Part 557 secondary recovery and pressure maintenance standards (including casing requirements); and
- Part 559 special regulations for oil and gas wells in the Bass Island pools (including casing requirements).

All wells drilled in NYS must adhere to the general requirements of Parts 552, 554, and 557. Additional, special requirements are applied to Bass Island wells.⁴ For example, NYS's Bass Island wells are subject to these additional casing requirements:

Unless the department's studies show some other requirements to be more appropriate in a particular area, the operator of a well described in subdivision (a) of this section must set surface casing to the greater depth of 450 feet from the surface or 100 feet into bedrock and must cement that casing to the surface by circulating cement, using enough excess cement to ensure cement returns. That operator must use centralizers and baskets at appropriate intervals, and the surface casing must have a minimum bursting pressure of 1,800 pounds per square inch. That operator must notify the department of the start of cementing operations at least four hours before those operations start. If a State inspector is not present during cementing operations, that operator must attach a copy of the cement ticket to the well's completion report.⁵

To ensure adequate cementing results, that operator must add material to control lost circulation to the cement used in cementing the conductor and surface casing strings. If a lost circulation zone is encountered, the operator must try to seal off that zone with lost circulation materials before pumping the cement slurry. If cement circulation is not achieved, that operator must grout the well from the surface using cement having materials to control lost circulation, to ensure a complete cement bond. If cement grouting is inadequate, the department may require a cement bond log and additional remedial measures to ensure adequacy of the bond.⁶

The use of regulations unique to an oil and gas pool is common throughout the US (also referred to as “pool rules” or “field rules”). Most states establish a standard set of default casing regulations that must be followed, unless unique circumstances warrant a special set of rules for a pool or field (“pool rules” or “field rules”). Therefore, it is important for NRDC to keep a watchful eye out for pool/field specific rules that may be adopted in the future for the Marcellus Shale, or other formations of interest to the NRDC.

³ New York State Code of Rules and Regulations

⁴ “A ‘Bass Island’ pool is a pool lying below the Tully horizon and above the base of the lowest Salina Group Salt horizon whose primary permeability results from faults or natural fractures, other than one in the Devonian shales as the department determines and other than one producing nonassociated gas with or without condensate, which is located in any of the following counties: Allgany, Genesee, Cattaraugus, Livingston, Chautauqua, Steuben, Erie, and Wyoming.”

⁵ 6 NYCRR V.B. §559.6(d)(1)

⁶ 6 NYCRR V.B. §559.6(d)(2)

Based on this report, and in particular Pennsylvania’s experience in developing the Marcellus Shale, NRDC may want to recommend that NYSDEC develop of specific casing standards for the Marcellus, rather than relying on generic NYS casing requirements. The casing program recommended by the Pennsylvania operators, and accepted by Pennsylvania, as shown in the diagram above is robust, and would be useful to adopt for NYS. This casing program requires all four sets of casing, providing extra ground water protection for horizontal wells that will sustain large fracture treatments.

Recommendation No. 1: Consider amending the NYCRR to include casing requirements specific to wells drilled into the Marcellus Shale as the development pace continues to intensify in NYS.

In addition to the NYS regulations cited above, NYS requires a permit to drill at 6 NYCRR V.B. §552, which requires operators to follow NYS’s *Casing and Cementing Practices* Guidelines.⁷ NYS’s website states that the NYS *Casing and Cementing Practices* are minimum construction standards for all wells, unless a waiver has been approved by the regional minerals manager in response to a written request and justification.⁸

However, the statement/requirement to adhere to NYS’s *Casing and Cementing Practices* is not found in NYS law or regulation. NRDC Legal Counsel will need to determine whether NYS’s *Casing and Cementing Practices* are enforceable, or whether they could be subject to challenge by industry. There may be benefit in incorporating guidance and permit stipulations within the NYS code.



Photo by: Department of Labor, www.dol.gov

NYS also applies *Fresh Water Aquifer Supplementary Permit Conditions* to drilling in primary aquifer areas, *Wildcat Supplementary Permit Conditions* to wells drilled in new, unfamiliar areas, and/or high pressure areas, and *Notification and Reporting Requirements*.⁹ These conditions and stan applied as part of a final permit to drill and are enforced by NYS.

Recommendation No. 2: Consider amending the NYCRR to include NYS’s Casing and Cementing Practices and Fresh Water Aquifer Supplementary Permit Conditions.

4. Conductor Casing

Conductor casing is the first pipe set in the wellbore; it is the largest [widest?] and shortest piece of piping. Oil and gas wells are started by excavating an initial hole at the earth’s surface. This hole is called the well cellar. The well cellar is shallow (less than 6’) and is typically 6-8’ in diameter depending on the size of the wellhead equipment associated with the drilling project. Often corrugated pipe is inserted into

⁷ NYS Division’s Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

⁸ “The casing and cementing practices above are designed for typical production casing/cementing. The Department will require additional measures for wells drilled in environmentally or technically sensitive areas (i.e. primary or principal aquifers). The Department recognizes that variations to the above procedures may be indicated in site-specific instances. Such variations will require the prior approval of the Regional Mineral Resources office.” <http://www.dec.ny.gov/energy/1628.html>.

⁹ NYS Division’s Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

the well cellar and is cemented in place. Sometimes pre-fabricated “box cellars” are utilized instead of the corrugated pipe.

Once the well cellar is excavated, another hole is excavated about 60-80 feet into the ground and conductor casing is lowered in the hole (as shown in the photo above) and is cemented in place. Conductor casing is typically 20-24” in diameter. Cement is poured in the annulus (the space between the outside of the pipe and inside of the hole). Alternatively, if surface geology allows, conductor casing can be driven by mechanical percussion methods into unconsolidated strata. In this case, there is no annulus, and the casing is not cemented.

Conductor casing prevents the well cellar hole from caving in and provides a conduit for drilling fluids while drilling the next section of the well. This casing is much like a retaining wall for a house foundation.

4.1 Existing NYS Conductor Casing Requirements

NYS does not include any specific conductor casing standards in its regulations in the NYCRR. Although, NYS does require a permit to drill at 6 NYCRR V.B. §552, however, to which conductor casing and ground water protection stipulations can be attached.

NYS guidance informs the applicant that it must follow NYS’s *Casing and Cementing Practices* guidelines when designing a well; however, there is no specific language codified in the NYCRR requiring compliance with the guidance.¹⁰ NYS’s website advises the applicant that the NYS *Casing and Cementing Practices* are minimum construction standards for all wells, unless a waiver has been approved by the regional minerals manager in response to a written request and justification.

NYS *Casing and Cementing Practices* include one requirement for conductor casing:

When drive pipe (conductor casing) is left in the ground, a pad of cement shall be placed around the well bore to block the downward migration of surface pollutants. The pad shall be three feet square or, if circular, three feet in diameter and shall be crowned up to the drive pipe (conductor casing).¹¹

Additionally, NYS state places *Fresh Water Aquifer Supplementary Permit Conditions* on permits to drill, after reviewing the applicants casing program design. The *Fresh Water Aquifer Supplementary Permit Conditions* for conductor casing include more restrictive conditions for wells drilled through primary and principal aquifers. Typical conditions applied to conductor casing are posted at the NYSDEC website and include a requirement to drill the conductor casing section of the hole with air, fresh water, or fresh water based muds, which excludes synthetic muds and oil based muds from being used while drilling this shallow section of the wellbore.¹² NYS also lists procedures for ensuring the conductor pipe is cemented from top to bottom, and firmly affixed in a central location in the wellbore with a continuous, equally thick layer of cement around the pipe.¹³

¹⁰ NYS Division’s Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

¹¹ NYS Division’s Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 11.

¹² NYS Fresh Water Aquifer Supplementary Permit Conditions at 3. “Any hole drilled for conductor or surface casing (i.e., “water string”) must be drilled on air, fresh water, or fresh water mud. For any holes drilled with mud, techniques for removal of filter cake (e.g., spacers, additional cement, appropriate flow regimes) must be considered when designing any primary cement job on conductor and surface casing.” <http://www.dec.ny.gov/energy/1628.html>.

¹³ NYS Fresh Water Aquifer Supplementary Permit Conditions at 4. “If conductor pipe is used, it must be run in a drilled hole and it must be cemented back to surface by circulation down the inside of the pipe and up the annulus, or installed by another procedure approved by this office. Lost circulation materials must be added to the cement to ensure satisfactory results.” “Additionally, at least two centralizers must be run with one each at the shoe and at the middle of the string. In the event

4.2 Conductor Casing Recommendations for NYS

Texas regulations do not set specific conductor casing requirements; however, Texas does instruct the operator to use good engineering practices, which would apply to construction of this initial section of the well.

California regulations include a maximum depth standard, limiting conductor casing to 100' unless approved otherwise.

*This casing shall be cemented at or driven to a maximum depth of 100 feet. Exceptions may be granted by the appropriate Division district deputy if conditions require deeper casing depth.*¹⁴

Alaska regulations include a depth criterion requiring conductor casing to be set to a sufficient depth to provide a solid structural anchorage, designed on site specific engineering and geologic factors, and cemented in place from top to bottom.

*For onshore wells, conductor casing must be set by driving, jetting, or drilling to a depth sufficient to provide anchorage for a diverter system...however, the commission will (A) approve a different casing setting depth if necessary to permit the casing shoe to be set in a competent formation or below formations that should be isolated; or (B) authorize an operator to drill without setting conductor casing based on information from wells drilled in the immediate vicinity and other available data, if the commission determines that the absence of conductor casing will not jeopardize well control;*¹⁵

*Casing design and setting depth must be based on engineering and geologic factors relevant to the immediate vicinity, including the presence or absence of hydrocarbons, potential drilling hazards, and permafrost;*¹⁶

*If conductor casing is set by drilling or jetting, the conductor casing must be cemented by filling the annular space with cement from the shoe to the surface; if the BOPE¹⁷ is to be installed on the conductor casing, the adequacy of the cement to contain potential wellbore pressures and fluids must be demonstrated by a formation integrity test;*¹⁸

Pennsylvania regulations prohibit removal of conductor casing once set, and instruct the operator to design the conductor casing to meet best local, site-specific and industry practices.

*Use of conductor pipe. If the operator installs conductor pipe in the well, the operator may not remove the pipe.*¹⁹

that cement circulation is not achieved, cement must be grouted (or squeezed) down from the surface to ensure a complete cement bond. In lieu of or in combination with such grouting or squeezing from the surface, this office may require perforation of the conductor casing and squeeze cementing of perforations. This office must be notified (to be determined by DEC on individual well basis) hours prior to cementing operations and cementing cannot commence until a state inspector is present.”

¹⁴ 14 CCR §1722.3(a) Conductor casing

¹⁵ 20 AAC §25.030 (c)(2)

¹⁶ 20 AAC §25.030(b)(1)

¹⁷ Blowout Preventer Equipment (BOPE)

¹⁸ 20 AAC §25.030 (d)(2)

¹⁹ 25 Pa. Code §78.82

*The operator shall equip the well with one or more strings of casing of sufficient length and strength to prevent blowouts, explosions, fires and casing failures during installation, completion and operation.*²⁰

*The operator shall determine the amount and type of casing to be run and the amount and type of cement to be used in accordance with current prudent industry practices and engineering. In making the determinations, the operator shall consider the following: (1) Successful local practices for similar wells. (2) Maximum anticipated surface pressure. (3) Collapse resistance. (4) Tensile strength. (5) Chemical environment. (6) Potential mechanical damage. (7) Manufacturing standards, including American Petroleum Institute or equivalent specifications for pipe used in wells drilled below the Onondaga formation or where blow-out preventers are required.*²¹

Overall, the NYS code, guidance documents, and standard permit stipulations for conductor casing are protective of the environment and essentially equivalent in all practical purpose to other major oil and gas producing states. However, NRDC may determine it would be preferable to codify these standards in the NYCRR, providing additional legal protection to ensure compliance, as well as an ability to enforce. If that is the case, four changes could be considered for inclusion in the NYCRR for conductor casing, and these general recommendations also apply to surface, intermediate and production casing:

1. Instruct the operator to use good engineering practices (GEP) and best available technology (BAT);
2. Require the casing depth to be based on regional engineering and geologic data;
3. Incorporate NYS's ***Casing and Cementing Practices*** requirement for a cement pad, at the surface, around the conductor casing to prevent the downward migration of surface pollutants that could originate from wellhead leaks, or other remedial/operational activities at the wellhead area; and
4. Incorporate NYS's ***Fresh Water Aquifer Supplementary Permit Conditions*** for mud type and cement integrity.



Recommendation No. 3: Consider amending the NYCRR to include standard GEP and BAT language.²² This applies to all types of casing.

5. Surface Casing

Surface casing is the second casing set in the wellbore. Surface casing is set to protect ground water aquifers, provide the structure to support blowout prevention equipment and provide a conduit for drilling fluids while drilling the next section of the well. This section of the well can be hundreds to thousands of feet deep, depending on the well design and geologic formations. The drilling engineer will determine the depth of the surface casing with a few key factors in mind: (1) surface casing should stop above any significant pressure zone or hydrocarbon zone, to ensure the blowout preventer can be installed prior to

²⁰ 25 Pa. Code §78.71(a)

²¹ 25 Pa. Code §78.71(b)

²² Recommendation No. 2 above, already includes the suggestion to include NYS's Casing and Cementing Practices and Fresh Water Aquifer Supplementary Permit Conditions in NYCRR, therefore is not repeated here in Recommendation No. 3.

drilling into a pressured zone or hydrocarbons; and (2) surface casing needs to be set to provide a protective barrier to prevent hydrocarbons from contaminating drinking water aquifers when the well is drilled deeper (below the surface casing) into hydrocarbon bearing zones.

Surface casing is typically 13-20” in diameter, but size is a site-specific, well-specific function and can vary. The surface casing pipe is set into the earthen hole and the annulus is filled with cement. It is important that the casing is centered in the hole, so that an equal, continuous section of cement filling is placed from bottom to the top of the annulus. Casing centralizers are installed on the outside of the pipe to keep it centered in the hole while cement is pumped into the annulus and then sets the pipe in place. In high angle holes this is very important, because the heavy casing pipe will lie on the low side of the hole, unless casing centralizers are used to force the pipe into the center of the hole. Casing in a horizontal well that is not properly centralized, will have thinner, or possibly no cement where the pipe is near or contacts the earth wall.

The cement is allowed to harden and must be integrity tested (e.g. hardness, continuity, and proper seal). There is no blowout preventer (BOP) equipment in place while the surface hole is drilled and the surface casing is installed, because until the surface casing is installed, and cemented in place, there is insufficient casing or cement in the ground to anchor the BOP equipment. If shallow gas is encountered while drilling, the surface casing is vented to atmosphere through a diverter valve.

Once the surface casing is cemented in place, the blowout preventer is installed at the surface and is attached to the surface casing. The surface casing serves as a solid anchor in the ground holding the blowout preventer in place in the event high pressures are encountered as the well is drilled deeper into hydrocarbon bearing zones.

5.1 Existing NYS Surface Casing Requirements

NYS includes specific surface casing standards in its regulations in the NYCRR, including:

1. Pollution Prevention:

*Surface casing shall be run in all wells to extend below the deepest potable fresh water level.*²³

*The drilling, casing and completion program adopted for any well shall be such as to prevent pollution.*²⁴

*Pollution of the land and/or of surface or ground fresh water resulting from exploration or drilling is prohibited.*²⁵

*On all wells where rotary tools are employed, and the subsurface formations and pressures to be encountered have been reasonably well established by prior drilling experience, the operator shall have the option of either running surface casing as provided in section 554.1(b) of this Part or of cementing the production casing from below the deepest potable fresh water level to the surface. In areas where the subsurface formations and pressures to be encountered are unknown or uncertain, surface casing shall be run as provided in section 554.1(b) of this Part.*²⁶

²³ 6 NYCRR V.B. §554.1(d)

²⁴ 6 NYCRR V.B. §554.1(a)

²⁵ 6 NYCRR V.B. §554.1(b)

²⁶ 6 NYCRR V.B. §554.4(a)

2. Cementing Method:

When surface casing is utilized, it shall be cemented by the pump and plug or displacement method with sufficient cement to circulate to the top of the hole. Drilling shall not be resumed until the cement has been permitted to set in accordance with prudent current industry practices.²⁷

3. Testing:

On all wells where cable tools are employed, the surface casing shall be tested by bailing to insure a shutoff before drilling below the casing point proceeds.²⁸

NYS requires a permit to drill at 6 NYCRR V.B. §552, to which stipulations can be attached. NYS also requires the operator to file a **Well Drilling and Completion Report** listing information on the size, grade and type of casing and cement used.

NYS guidance informs the applicant that it must follow NYS's **Casing and Cementing Practices** guidelines when designing a well; however, there is no specific language in the regulation requiring compliance with the guidance.²⁹ NYS's website states that the NYS **Casing and Cementing Practices** are minimum construction standards for all wells, unless a waiver has been approved by the regional minerals manager in response to a written request and justification.

NYS **Casing and Cementing Practices** include several requirements for surface casing:

1. Pollution Prevention:

Surface casing shall not extend into zones known to contain measurable quantities of shallow gas. In the event that such a zone is encountered before the fresh water is cased off, the operator shall notify the Department and, with the Department's approval, take whatever actions are necessary to protect the fresh water zone(s).³⁰

2. Depth:

Surface casing shall extend at least 75 feet beyond the deepest fresh water zone encountered or 75 feet into competent rock (bedrock), whichever is deeper. However, the surface pipe must be set deeply enough to allow the BOP stack to contain any formation pressures that may be encountered before the next casing is run.³¹

3. Casing Quality:

All surface casing shall be a string of new pipe with a mill test of at least 1,100 pounds per square inch (psi). Used casing may be approved for use, but must be pressure tested before drilling out the casing shoe or, if there is no casing shoe, before drilling out the cement in the bottom joint of casing. If plain end pipe is welded together for use, it too must be pressure tested. The minimum pressure for testing used casing or casing joined together by welding, shall be determined by the Department at the time of permit application. The appropriate Regional Mineral Resources office staff will be notified six hours prior to making the test. The results will be entered on the drilling log.³²

4. Cement Quality:

The operator shall test or require the cementing contractor to test the mixing water for ph and

²⁷ 6 NYCRR V.B. §554.4(b)

²⁸ 6 NYCRR V.B. §554.3(a)

²⁹ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

³⁰ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>, at 3.

³¹ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 2.

³² NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 4.

temperature prior to mixing the cement and to record the results on the cementing ticket. The cement slurry shall be prepared according to the manufacturer's or contractor's specifications to minimize free water content in the cement. After the cement is placed and the cementing equipment is disconnected, the operator shall wait until the cement achieves a calculated compressive strength of 500 psi before the casing is disturbed in any way. The WOC³³ time shall be recorded on the drilling log.³⁴

5. Cementing Method:

The pump and plug method shall be used to cement surface casing. The amount of cement will be determined on a site specific basis and a minimum of 25% excess cement shall be used, with appropriate lost circulation materials, unless additional excesses are specified by the Department.³⁵

Prior to cementing any casing strings, all gas flows shall be killed and the operator shall attempt to establish circulation by pumping the calculated volume necessary to circulate. If the hole is dry, the calculated volume would include the pipe volume and 125% of the annular volume. Circulation is deemed to have been established once fluid reaches the surface. A flush, spacer or extra cement shall be used to separate the cement from the bore hole spacer or extra cement shall be used to separate the cement from the bore hole fluids to prevent dilution. If cement returns are not present at the surface, the operator may be required to run a log to determine the top of the cement.³⁶

Cement baskets shall be installed appropriately above major lost circulation zones.³⁷

6. Use of Centralizers to Center Casing in Hole:

The diameter of the drilled surface casing hole shall be large enough to allow the running of centralizers in recommended hole sizes.³⁸

Centralizers shall be spaced at least one per every one hundred-twenty feet; a minimum of two centralizers shall be run on surface casing.³⁹

7. Record Keeping and Variances:

When requested by the Department in writing, each operator must submit cement tickets and/or other documents that indicate the above specifications have been followed. The casing and cementing practices above are designed for typical surface casing cementing. The Department will require additional measures for wells drilled in environmentally or technically sensitive areas (i.e. primary or principal aquifers). The Department recognizes that variations to the above procedures may be indicated in site specific instances. Such variations will require the prior approval of the Regional Mineral Resources office staff.⁴⁰

NYS state places **Fresh Water Aquifer Supplementary Permit Conditions** on permits to drill, after reviewing the applicants casing program design. The **Fresh Water Aquifer Supplementary Permit Conditions** for surface casing include more restrictive conditions for wells drilled through primary and

³³ Waiting on Cement (WOC)

³⁴ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 8-10.

³⁵ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 7.

³⁶ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>, at 6.

³⁷ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 5.

³⁸ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 1.

³⁹ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 5.

⁴⁰ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

principal aquifers. Typical conditions applied to surface casing are posted at the NYS website and may include:

1. Pollution Prevention:

If multiple fresh water zones are known to exist or are found or if shallow gas is present, this office may require multiple strings of surface casing to prevent gas intrusion and/or preserve the hydraulic characteristics and water quality of each fresh water zone. The permittee must immediately inform this office of the occurrence of any fresh water or shallow gas zones not noted on the permittee's drilling application and prognosis. This office may require changes to the casing and cementing plan in response to unexpected occurrences of fresh water or shallow gas, and may also require the immediate, temporary cessation of operations while such alterations are developed by the permittee and evaluated by the Department for approval.⁴¹

2. Drilling Mud Type:

Any hole drilled for conductor or surface casing (i.e., "water string") must be drilled on air, fresh water, or fresh water mud. For any holes drilled with mud, techniques for removal of filter cake (e.g., spacers, additional cement, appropriate flow regimes) must be considered when designing any primary cement job on conductor and surface casing.⁴²

3. Depth:

A surface casing string must be set at least 100' below the deepest fresh water zone and at least 100' into bedrock. If shallow gas is known to exist or is anticipated in this bedrock interval, the casing setting depth may be adjusted based on site-specific conditions provided it is approved by this office. There must be at least a 2½" difference between the diameters of the hole and the casing (excluding couplings) or the clearance specified in the Department's Casing and Cementing Practices, whichever is greater.⁴³

4. Use of Centralizers to Center Casing in Hole:

Additionally, cement baskets and centralizers must be run at appropriate intervals with centralizers run at least every 120'.⁴⁴

5. Cement Method:

Cement must be circulated back to the surface with a minimum calculated 50% excess. Lost circulation materials must be added to the cement to ensure satisfactory results.⁴⁵

In the event that cement circulation is not achieved on any surface casing cement job, cement must be grouted (or squeezed) down from the surface to ensure a complete cement bond. This office must be notified (to be determined by DEC on individual well basis) hours prior to cementing operations and cementing cannot commence until a state inspector is present. In lieu of or in combination with such grouting or squeezing from the surface, this office may require perforation of the surface casing and squeeze cementing of perforations. This office may also require that a cement bond log and/or other logs be run for evaluation purposes. In addition, drilling out of and below surface casing cannot commence if there is any evidence or indication of flow behind the surface casing until remedial action has occurred. Alternative remedial actions from those described above may

⁴¹ NYS Fresh Water Aquifer Supplementary Permit Conditions at 6.

⁴² NYS Fresh Water Aquifer Supplementary Permit Conditions at 3.

⁴³ NYS Fresh Water Aquifer Supplementary Permit Conditions at 5.

⁴⁴ NYS Fresh Water Aquifer Supplementary Permit Conditions at 5.

⁴⁵ NYS Fresh Water Aquifer Supplementary Permit Conditions at 5.

*be approved by this office on a case-by-case basis provided site-specific conditions form the basis for such proposals.*⁴⁶

6. Casing Quality Method:

*Pipe must be either new API graded pipe with a minimum internal yield pressure of 1,800 psi or reconditioned pipe that has been tested internally to a minimum of 2,700 psi. If reconditioned pipe is used, an affidavit that the pipe has been tested must be submitted to this office before the pipe is run.*⁴⁷

7. State Inspector to Oversee Stimulation Operations:

*This office must be notified (to be determined by DEC on individual well basis) hours prior to any stimulation operation. Stimulation may commence without the state inspector if the inspector is not on location at the time specified during the notification.*⁴⁸

8. Recordkeeping:

*The operator must complete the "Record of Formations Penetrated" on the Well Drilling and Completion Report, providing a log of formations, both unconsolidated and consolidated, and all water and gas producing zones.*⁴⁹

NYS state places **Wildcat Supplementary Permit Conditions** on permits to drill, for new, unique or high pressure areas. Typical conditions NYS may apply for surface casing are posted at the NYS website and may include:

1. Pressure Testing:

*The BOP, choke manifold and surface casing must be tested to a minimum of 1000 psi prior to drilling out the surface casing shoe, unless the Department grants a waiver in response to a written request from the operator which demonstrates to the Department's satisfaction that: a) the well is proposed as a deep wildcat that will be drilled through an established, shallow, low pressure pool and b) the well will have an intermediate casing string that is the first string intended for well control purposes. When intermediate casing is used, the BOP, choke manifold and intermediate casing must be tested to at least the maximum anticipated shut-in surface pressure plus a 5% safety factor prior to drilling out the intermediate casing shoe. A representative of this office must be notified six (6) hours prior to each test and a department representative may be present during the test. If the Department representative is not on location at the agreed time, the test may proceed with the results of the test and the name of the witness being noted in the driller's log.*⁵⁰

5.2 Surface Casing Standard Recommendations for NYS

Overall, NYS's surface casing requirements are fairly robust, when the NYCRR, guidance documents, and standard stipulations are combined. However, similar to the recommendations outlined above in the conductor casing section, NYS's regulations may benefit from codifying guidance and standard stipulations.

Additionally, other state regulations examined in this report point to possible improvements and refinements. Because each state's surface casing regulations are very extensive, they are not repeated here

⁴⁶ NYS Fresh Water Aquifer Supplementary Permit Conditions at 7.

⁴⁷ NYS Fresh Water Aquifer Supplementary Permit Conditions at 5.

⁴⁸ NYS Fresh Water Aquifer Supplementary Permit Conditions at 8.

⁴⁹ NYS Fresh Water Aquifer Supplementary Permit Conditions at 9.

⁵⁰ NYS Wildcat Supplementary Permit Conditions at 5.

in entirety. Rather, selected regulations are listed below where a state has a more stringent, or more detailed, regulation that may benefit NYS.

Texas regulations that may benefit NYS include:

1. Use of Centralizers to Center Casing in Hole:

*Centralizers. Surface casing shall be centralized at the shoe, above and below a stage collar or diverting tool, if run, and through usable-quality water zones. In nondeviated holes, pipe centralization as follows is required: a centralizer shall be placed every fourth joint from the cement shoe to the ground surface or to the bottom of the cellar. **All centralizers shall meet API spec 10D specifications. In deviated holes, the operator shall provide additional centralization**⁵¹ [emphasis added].*

Like Texas, NYS requires a centralizer at every fourth joint (every 120'). However NYS does not specify an industry standard for centralizers; Texas requires the American Petroleum Institute Specification (API) 10D. Texas also requires additional centralizers to be used in deviated holes. In high angle or horizontal holes, the casing pipe drops by gravity to the lowside of the hole making cementing difficult under the low side of the pipe. Additional centralizers placed around casing in a deviated wellbore helps to centralize the pipe in the hole, and allows a concentric cement barrier to be pumped around the casing.

Recommendation No. 4: Consider amending the NYCRR to specify centralizer type according to American Petroleum Institute (API) Specification 10D and require additional centralizers in high angle or horizontal deviated wellbores. This applies to surface, intermediate and production casing.

2. Prevent Vertical Migration of Fluids or Gas Behind Pipe:

*It is the intent of all provisions of this section that casing be securely anchored in the hole in order to effectively control the well at all times, all usable-quality water zones be isolated and sealed off to effectively prevent contamination or harm, and all potentially productive zones be isolated and sealed off to prevent vertical migration of fluids or gases behind the casing. When the section does not detail specific methods to achieve these objectives, the responsible party shall make every effort to follow the intent of the section, using good engineering practices and the best currently available technology.*⁵²

Like Texas, NYS sets objectives for the protection of drinking water aquifers and sets cement method and integrity standards; however, Texas regulations go the extra step of overtly stating that **all usable-quality water zones be isolated and sealed off to effectively prevent contamination or harm, and all potentially productive zones be isolated and sealed off to prevent vertical migration of fluids or gases behind the casing.** NYS regulations do not specifically state the goal of preventing vertical migration of fluids or gases behind casing.

Recommendation No. 5: Consider amending the NYCRR to clearly state that casing installation and cement methods must be designed and implemented to prevent vertical migration of fluids or gases behind casing during drilling, stimulations, or well operation. This applies to all types of casing.

⁵¹ 16 Texas Administrative Code (TAC) Part 1 §3.13(b)(2)(F)

⁵² 16 TAC Part 1 §3.13(a)

3. **Cement Quality:**

Surface casing strings must be allowed to stand under pressure until the cement has reached a compressive strength of at least 500 psi in the zone of critical cement before drilling plug or initiating a test. **The cement mixture in the zone of critical cement shall have a 72-hour compressive strength of at least 1,200 psi.** ...In addition to the minimum compressive strength of the cement, **the API free water separation shall average no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B.** The commission may require a better quality of cement mixture to be used in any well or any area if evidence of local conditions indicates a better quality of cement is necessary to prevent pollution or to provide safer conditions in the well or area⁵³ [emphasis added].

Compressive strength tests. Cement mixtures for which published performance data are not available must be tested by the operator or service company. Tests shall be made on representative samples of the basic mixture of cement and additives used, using distilled water or potable tap water for preparing the slurry. The tests must be conducted using the equipment and procedures adopted by the American Petroleum Institute, as published in the current API RP 10B. **Test data showing competency of a proposed cement mixture to meet the above requirements must be furnished to the commission prior to the cementing operation.** To determine that the minimum compressive strength has been obtained, operators shall use the typical performance data for the particular cement used in the well (containing all the additives, including any accelerators used in the slurry) at the following temperatures and at atmospheric pressure. (i) **For the cement in the zone of critical cement, the test temperature shall be within 10 degrees Fahrenheit of the formation equilibrium temperature at the top of the zone of critical cement.** (ii) **For the filler cement, the test temperature shall be the temperature found 100 feet below the ground surface level, or 60 degrees Fahrenheit, whichever is greater**⁵⁴ [emphasis added].

Texas and NYS both set a cement compressive strength standard of 500 psi for the final cement bond; however, Texas includes an additional standard requiring the cement mixture in the zone of critical cement to have a 72-hour compressive strength rating of at least 1,200 psi. This places a quality standard on the type of cement mix purchased.

Additionally, Texas requires API free water separation to average no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B, and the commission may require a better quality of cement mixture to be used in any well or any area if evidence of local conditions indicate a better quality of cement is necessary to prevent pollution or to provide safer conditions in the well or area.

While NYS requires the operator to test and record the temperature of the mixing water, NYS does not set a temperature quality standard like Texas.

Recommendation No. 6: Consider amending the NYCRR to require a 72-hour compressive strength standard of 1,200 psi for the cement mixture in the zone of critical cement, and the requirement to conform with the API free water separation standard of no more than six milliliters per 250 milliliters of cement tested in accordance with the current API RP 10B. Provide a provision for the commission to set more stringent local standards if needed for pollution prevention, and establish quantitative temperature limits for cement mixing water. This applies to surface, intermediate and production casing.

⁵³ 16 TAC Part 1 §3.13(b)(2)(C)

⁵⁴ 16 TAC Part 1 §3.13(b)(2)(D)

4. Record Keeping and Reporting:

*Cementing report. Upon completion of the well, a cementing report must be filed with the commission furnishing complete data concerning the cementing of surface casing in the well as specified on a form furnished by the commission. **The operator of the well or his duly authorized agent having personal knowledge of the facts, and representatives of the cementing company performing the cementing job, must sign the form attesting to compliance with the cementing requirements of the commission**⁵⁵ [emphasis added].*

NYS requires the operator to file a **Well Drilling and Completion Report** listing information on the size, grade and type of casing and cement used. In addition, NYS's guidance documents state it can demand cementing records from the operator; however, Texas regulations go one step further and demand the operator to certify, under penalty of law that every cement job is in compliance.

Recommendation No. 7: Consider amending the NYCRR to require operator certification that cement standards have been met on each well. This applies to all types of casing.

California regulations that may benefit NYS include:

1. Recordkeeping and Reporting:

Required Well Records. The operator of any well drilled, redrilled, deepened, or reworked shall keep, or cause to be kept, an accurate record of each operation on each well including, but not limited to, the following, when applicable: (a) Log and history showing chronologically the following data: (1) Character and depth of all formations, water-bearing strata, oil- and gas-bearing zones, lost circulation zones, and abnormal pressure zones encountered. (2) Casing size, weight, grade, type, condition (new or used), top, bottom, and perforations; and any equipment attached to the casing...(4) Casing pressure tests and pressure tests of the casing-tubing annulus, including date, duration, pressure, and percent bleed-off. (5) Hole sizes. (6) Cementing and plugging operations, including date, depth, slurry volume and composition, fluid displacement, pressures, calculated or actual fill, and downhole equipment... (9) Water shutoff and lap tests of casing, including date, duration, depth, and results. Records to Be Filed with the Division. Two true and reproducible copies of the well summary, core record, and history, and all electrical, physical and chemical logs, tests and surveys run, including mud logs shall be filed with the Division within 60 days after the completion, plugging and abandonment, or suspension of operations of a well⁵⁶

California requires extensive recordkeeping and reporting for casing and cementing installation on each well. NYS's **Well Drilling and Completion Report** form requires some of this information, but not all. NYS's guidelines announce these records can be demanded, but do not require them on a routine basis.

Recommendation No. 8: Consider amending the NYCRR to require casing and cementing record keeping for casing and cementing operations similar to the California Code of Regulations at 14 CCR §1724. This applies to all types of casing.

⁵⁵ 16 TAC Part 1 §3.13(b)(2)(E)

⁵⁶ 14 CCR §1724 and 14 CCR §1724.1

Alaska regulations that may benefit NYS include:

1. Casing and Cementing Program Application Contents:

A complete proposed well casing and cementing program must be submitted with an application for a Permit to Drill (Form 10-401). Unless modified or altered by pool rules established under 20 AAC §25.520, a well casing and cementing program must be designed to: (1) provide suitable and safe operating conditions for the total measured depth proposed; (2) confine fluids to the wellbore; (3) prevent migration of fluids from one stratum to another; (4) ensure control of well pressures encountered; (5) protect against thaw subsidence and freezeback effects within permafrost; (6) prevent contamination of freshwater; (7) protect significant hydrocarbon zones; and (8) provide well control until the next casing is set, considering all factors relevant to well control including formation fracture gradients, formation pressures, casing setting depths and proposed total depth.⁵⁷

Both NYS and Alaska require the operator to describe its casing and cementing program in its application to drill, however, Alaska's application content requirements establish specific criteria for the application content, where, NYS does not.

Recommendation No. 9: Consider amending the NYCRR to specify casing and cementing program application content, similar to the Alaska Administrative Code (AAC) requirement at 20 AAC §25.030(a). This applies to all types of casing.

2. Casing Pressure Test:

A casing pressure test must be performed if BOPE is to be installed on a casing. The casing must be tested to hold a surface pressure equal to 50 percent of the required working pressure of the BOPE as specified in the Permit to Drill under 20 AAC §25.035(e)(3) or 20 AAC §25.036 (c)(3). The results of this test and any subsequent tests of the casing must be recorded as required by 20 AAC §25.070(1).⁵⁸

Alaska requires the operator to perform a casing pressure test on all wells drilled to demonstrate that a surface pressure of at least 50% of the required working pressure of the blowout preventer can be achieved. Common blowout preventer ratings range between 5,000 psi to 10,000 psi, yielding pressure tests within 2500-5000psi. Blowout preventions of higher pressure rating may be required for deeper, higher pressure, or wildcat wells. NYS's pressure testing requirement only applies to a wildcat well and only requires a minimum 1000 psi pressure rating, regardless of blowout preventer size and rating.

Recommendation No. 10: Consider amending the NYCRR to require a the operator to perform a casing pressure test on all wells drilled to demonstrate that a surface pressure of at least 50% of the required working pressure of the blowout preventer can be achieved. This applies to casing that a BOP is installed on.

3. Formation Integrity Test:

A formation integrity test must be performed if a BOPE is to be installed on a casing. The test must be performed to a predetermined equivalent mud weight, leak-off, or fracture pressure as specified in the application for the Permit to Drill. The test must be conducted after drilling out of the casing shoe into at least 20 feet but not more than 50 feet of new formation. The test results must

⁵⁷ 20 AAC §25.030(a)

⁵⁸ 20 AAC §25.030(e)

demonstrate that the integrity of the casing shoe is sufficient to contain anticipated wellbore pressures identified in the application for the Permit to Drill. The test procedure followed and the data from the test and any subsequent tests of the formation must be recorded as required by 20 AAC §25.070 (1).⁵⁹ For all casing strings on which blowout prevention equipment (BOPE) will be installed, cement may not be drilled out until sufficient compressive strength has been reached to obtain a valid formation integrity test.⁶⁰

Alaska requires the operator to perform a formation integrity test (FIT) at the casing shoe (bottom of casing string) to determine whether the wellbore will tolerate the maximum wellbore pressure anticipated while drilling the next interval. If a FIT test fails, then a cement squeeze is typically required to improve the casing/cement structural integrity before drilling deeper into the well. NYS does not require a formation integrity test.

Recommendation No. 11: Consider amending the NYCRR to require a formation integrity test. This applies to surface and intermediate casing.

Pennsylvania regulations that may benefit NYS include:

1. Cement Degradation Protection:

The operator shall use cement that will resist degradation by chemical and physical conditions in the well.⁶¹

NYS requires cement strength standards, but does not include a standard like Pennsylvania's that requires the cement formulation to resist future degradation by chemical and physical conditions that may be encountered in the wellbore over its service life. This standard would require the cement to be designed to resist naturally occurring corrosive fluids and gases, as well as stimulation or enhanced recovery fluids/gases that may be used to enhance production.

Recommendation No. 12: Consider amending the NYCRR to add a cement chemical and physical degradation standard similar to the Pennsylvania Code at 25 Pa. Code §78.85(a). This applies to all cement used.

2. Obligation to Report and Correct Defective Casing:

Defective casing or cementing. In a well that has defective, insufficient or improperly cemented casing, the operator shall report the defect to the Department within 24 hours of discovery by the operator and shall correct the defect. The operator shall correct the defect or submit a plan to correct the defect for approval by the Department within 30 days. If the defect cannot be corrected or an alternate method is not approved by the Department, the well shall be plugged under § 78.91—78.98 (relating to plugging).⁶²

Pennsylvania requires an operator to report and repair defective casing. If the casing cannot be repaired the well must be plugged and abandoned. NYS does not have an equivalent standard. This standard would be particularly helpful to apply to existing wells that may have been designed and installed using older casing and cementing standards and techniques. This would require the operator to repair or take non-compliant wells out of service.

⁵⁹ 20 AAC §25.030(f)

⁶⁰ 20 AAC §25.030(b)(2)

⁶¹ 25 Pa. Code §78.85(a)

⁶² 25 Pa. Code §78.86

Recommendation No. 13: Consider amending the NYCRR to add a requirement to report and repair defective casing, or take the well out service similar to the Pennsylvania Code at 25 Pa. Code §78.86. This applies to all casing types.

3. Casing Requirements for Drilling Through Gas Storage Areas:

In addition to the other provisions in this subchapter, a well drilled through a gas storage reservoir or a gas storage reservoir protective area shall be drilled, cased and cemented as follows: (1) An operator shall use drilling procedures capable of controlling anticipated gas flows and pressures when drilling from the surface to 200 feet above a gas storage reservoir or gas storage horizon. (2) An operator shall use drilling procedures capable of controlling anticipated gas storage reservoir pressures and flows at all times when drilling from 200 feet above a gas storage reservoir horizon to the depth at which the gas storage protective casing will be installed. Operators shall use blow-out prevention equipment with a pressure rating in excess of the allowable maximum storage pressure for the gas storage reservoir. (3) To protect the gas storage reservoir, an operator shall run intermediate or production casing from a point located at least 100 feet below the gas storage horizon to the surface. The operator shall cement this casing by circulating cement to a point at least 200 feet above the gas storage reservoir or gas storage horizon. (4) When cementing casing in a well drilled through a gas storage reservoir, the operator shall insure that no gas is present in the drilling fluids in an amount that could interfere with the integrity of the cement.⁶³

The well operator shall notify all coal owners and operators and gas storage operators of record of the proposal, by certified mail. The well operator shall state in the application that he has sent the certified mail notice to the coal owners and operators and gas storage operators of record, either simultaneously with or prior to submitting the proposal to the Department.⁶⁴

The coal owners and operators and gas storage operators of record shall have up to 15 days from their receipt of the notice to file objections or to indicate concurrence with the proposed alternative method or material. If no objections are filed within 15 days from receipt of the notice, and if none are raised by the Department, the Department will make a determination whether to allow the use of the proposed alternative method or material.⁶⁵

Pennsylvania requires specific casing standards for wells penetrating a gas storage area. NYS does not include these standards.

Recommendation No. 14: Consider amending the NYCRR to add a casing standard in gas storage areas similar to the Pennsylvania Code at 25 Pa. Code §78.75, if there are sufficient gas storage intersection areas in NYS to warrant this additional requirement.

4. Casing Requirements for Drilling Through Coal Mining Areas:

Surface and coal protective casing and cementing procedures. If the well is to be equipped with threaded and coupled casing, the operator shall drill a hole so that the diameter is at least 1 inch greater than the outside diameter of the casing collar to be installed. If the well is to be equipped with plain-end welded casing, the operator shall drill a hole so that the diameter is at least 1 inch greater than the outside diameter of the casing tube.⁶⁶

⁶³ 25 Pa. Code §78.87 (a)

⁶⁴ 25 Pa. Code §78.75(c)

⁶⁵ 25 Pa. Code §78.75 (d-e)

⁶⁶ 25 Pa. Code §78.83 (a)

*Except as provided in subsection (c), the operator shall drill to approximately 50 feet below the deepest fresh groundwater or at least 50 feet into consolidated rock, whichever is deeper, and immediately set and permanently cement a string of surface casing to that depth.*⁶⁷

*If no fresh groundwater is being utilized as a source of drinking water within a 1,000-foot radius of the well, the operator may set and permanently cement a single string of surface casing through all water zones, including fresh, brackish and salt water zones. Prior to penetrating zones known to contain, or likely containing, oil or gas, the operator shall install and permanently cement the string of casing in a manner that segregates the various waters.*⁶⁸

*The operator shall set and cement a coal protective string of casing through workable coal seams. The base of the coal protective casing shall be at least 30 feet below the lowest workable coal seam.*⁶⁹

*When a well is drilled through a coal seam at a location where the coal has been removed, the operator shall drill to a depth of at least 30 feet but no more than 50 feet deeper than the bottom of the coal seam. The operator shall set and cement a coal protection string of casing to this depth. The operator shall equip the casing with a cement basket or other similar device above and as close to the top of the coal seam as practical. The bottom of the casing shall be equipped with an appropriate device designed to prevent deformation of the bottom of the casing. The interval from the bottom of the casing to the bottom of the coal seam shall be filled with cement either by the balance method or by the displacement method. Cement shall be placed on top of the basket between the wall of the hole and the outside of the casing by pumping from the surface. If the operator penetrates more than one coal seam from which the coal has been removed, the operator shall protect each seam with a separate string of casing that is set and cemented or with a single string of casing which is stage cemented so that each coal seam is protected as described in this subsection. The operator shall cement the well to isolate workable coal seams from each other.*⁷⁰

*If the operator sets and cements casing under subsection (g) or (h) and subsequently encounters additional fresh groundwater zones below the deepest cemented casing string installed, the operator shall protect the fresh groundwater by installing and cementing another string of casing or other method approved by the Department. Sufficient cement shall be used to cement the casing at least 20 feet into the surface or coal protective casing. The additional casing string may also penetrate zones bearing brackish or salt water, but shall be run and cemented prior to penetrating a zone known to or likely to contain oil or gas.*⁷¹

*When casing through a workable coal seam, the operator shall install coal protective casing that has a minimum wall thickness of 0.23 inches.*⁷²

*The well operator shall notify all coal owners and operators and gas storage operators of record of the proposal, by certified mail. The well operator shall state in the application that he has sent the certified mail notice to the coal owners and operators and gas storage operators of record, either simultaneously with or prior to submitting the proposal to the Department.*⁷³

⁶⁷ 25 Pa. Code §78.83(b)

⁶⁸ 25 Pa. Code §78.83(c)

⁶⁹ 25 Pa. Code §78.83(g)

⁷⁰ 25 Pa. Code §78.83(h)

⁷¹ 25 Pa. Code §78.83(i)

⁷² 25 Pa. Code §78.84(c)

⁷³ 25 Pa. Code §78.75(c)

The coal owners and operators and gas storage operators of record shall have up to 15 days from their receipt of the notice to file objections or to indicate concurrence with the proposed alternative method or material.⁷⁴

If no objections are filed within 15 days from receipt of the notice, and if none are raised by the Department, the Department will make a determination whether to allow the use of the proposed alternative method or material.⁷⁵

Pennsylvania requires specific casing standards for wells while penetrating through coal seams. NYS does not include these standards.

Recommendation No. 15: Consider amending the NYCRR to add a casing standard in coal development areas similar to the Pennsylvania Code at 25 Pa. Code §78.75, if there are sufficient coal seam intersection areas in NYS to warrant this additional requirement.

6. Intermediate Casing

Intermediate casing may be set if needed to provide a transition from the surface casing to the production casing. This casing may be required for protection of oil, gas, and freshwater zones, and to seal off anomalous pressure zones, lost circulation zones, and other drilling hazards. A drilling engineer may decide to set hundreds or thousands of feet of intermediate casing to isolate unstable hole sections (to prevent collapse), isolate high or low pressure zones, or isolate geologic “thief” zones that may be prone to robbing mud from the well bore (lost circulation), put gas or saltwater zones behind pipe before drilling into the production zone, or to provide additional wellbore structure.

Intermediate casing will be smaller than the surface casing (typically less than 14” in diameter) and will be lowered in the hole, and cemented in place using similar techniques as described for the surface casing.

Intermediate casing is typically set prior to drilling through the hydrocarbon bearing zone, and may be cemented behind the entire casing string from the top of the well to the bottom of the casing shoe if the intermediate casing depth is shallow enough. Intermediate casing provides a second protective barrier across a fresh water aquifer. However, it is not possible to cement the entire intermediate casing string if it is more than a few thousand feet deep. In this case the intermediate casing strings are partially cemented in place to secure the lower section of the pipe in place. Most states specify a minimum number of feet of cement placed behind the intermediate casing (e.g. 500’).

6.1 Existing NYS Intermediate Casing Requirements

NYS does not include any specific intermediate casing standards in its regulations in the NYCRR. The general pollution prevention standard applies, as follows:

1. Pollution Prevention:

The drilling, casing and completion program adopted for any well shall be such as to prevent pollution. Pollution of the land and/or of surface or ground fresh water resulting from exploration or drilling is prohibited.⁷⁶

⁷⁴ 25 Pa. Code §78.75(d)

⁷⁵ 25 Pa. Code §78.75(e)

⁷⁶ 6 NYCRR V. B. §554.1(a-b)

NYS requires a permit to drill at 6 NYCRR V.B. §552, to which stipulations can be attached. NYS also requires the operator to file a **Well Drilling and Completion Report** listing information on the size, grade and type of casing and cement used.

NYS guidance informs the applicant that it must follow NYS's **Casing and Cementing Practices** guidelines when designing a well; however, there is no specific guidance on intermediate casing in this document. The guidelines state that:

Intermediate casing string(s) and the cementing requirements for that casing string(s) will be reviewed and approved by Regional Mineral Resources office staff on an individual well basis.⁷⁷

NYS state places **Fresh Water Aquifer Supplementary Permit Conditions** on permits to drill, after reviewing the applicants casing program design. Typical conditions applied to intermediate casing are posted at the NYSDEC website and may include:

1. **Pollution Prevention:**

If multiple fresh water zones are known to exist or are found or if shallow gas is present, this office may require multiple strings of surface casing to prevent gas intrusion and/or preserve the hydraulic characteristics and water quality of each fresh water zone. The permittee must immediately inform this office of the occurrence of any fresh water or shallow gas zones not noted on the permittee's drilling application and prognosis. This office may require changes to the casing and cementing plan in response to unexpected occurrences of fresh water or shallow gas, and may also require the immediate, temporary cessation of operations while such alterations are developed by the permittee and evaluated by the Department for approval⁷⁸ [emphasis added]

Additionally, NYS state places **Wildcat Supplementary Permit Conditions** on permits to drill, for new, unique, or high pressure areas. Typical conditions applied to intermediate casing are posted at the NYSDEC website and may include:

1. **Pressure Testing:**

When intermediate casing is used, the BOP, choke manifold and intermediate casing must be tested to at least the maximum anticipated shut-in surface pressure plus a 5% safety factor prior to drilling out the intermediate casing shoe. A representative of this office must be notified six (6) hours prior to each test and a department representative may be present during the test. If the Department representative is not on location at the agreed time, the test may proceed with the results of the test and the name of the witness being noted in the driller's log.⁷⁹

6.2 Intermediate Casing Standard Recommendations for NYS

NYS's intermediate casing requirements are not specific or detailed. In the absence of regulatory standards or guidance, an applicant must submit a proposal for intermediate casing to NYS, and then wait for approval. The quality of the permit to drill and intermediate casing requirements will be a function of the quality of the operator's initial proposal, and NYSDEC's ability to negotiate or stipulate additional requirements to attach to the permit to drill.

⁷⁷ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

⁷⁸ NYS Fresh Water Aquifer Supplementary Permit Conditions at 6.

⁷⁹ NYS Wildcat Supplementary Permit Conditions at 5.

Many of the basic principles outlined above for surface casing should also apply to intermediate casing and are readily transferable, including, but not limited to, casing and cement quality, cementing methods, testing, record keeping and reporting.

Recommendation No. 16: Consider amending the NYCRR to require casing and cement quality, cementing methods, testing, record keeping and reporting. This is especially true of the Marcellus Shale, where experience in Pennsylvania shows that industry recommends installing intermediate casing to provide an additional protective barrier in the wellbore, and to provide additional structural integrity.

A list of key intermediate casing provisions for Texas, California, Alaska and Pennsylvania is provided below, but it is hard to determine whether they compare to NYS, because NYS's requirements are not written and are currently subject to staff approval. Some of NYSDEC staff requirements for intermediate casing may mirror or include any of the other states' requirements, but the only way to verify that is to obtain copies of NYSDEC permits for wells that include intermediate casing and determine what type of requirements NYSDEC staff have included on a case-by-case basis. The lack of specificity in the NYS regulations for intermediate casing makes it impossible to conclude whether NYS's standards are sufficiently rigorous or not, since this determination is made on a case by case basis. While a permit may include site specific design and installation methods for intermediate casing, there are fundamental criteria that could be codified to clearly state when NYSDEC expects intermediate casing to be run, along with minimum technical requirements that must be met, and a list of technical issues that warrant NYSDEC staff review and approval.

Recommendation No. 17: Consider amending the NYCRR to clearly explain under what circumstances NYSDEC will require intermediate casing to be set, what minimum requirements should be included in design and installation, and unique circumstances that warrant additional NYSDEC review and approval. Examples of how this regulatory goal was achieved in Texas, California, Alaska and Pennsylvania are provided in this report.

Texas regulations that may benefit NYS include:

1. Cementing Method and Testing:

Each intermediate string of casing shall be cemented from the shoe to a point at least 600 feet above the shoe. If any productive horizon is open to the wellbore above the casing shoe, the casing shall be cemented from the shoe up to a point at least 600 feet above the top of the shallowest productive horizon or to a point at least 200 feet above the shoe of the next shallower casing string that was set and cemented in the well. (B) Alternative method. In the event the distance from the casing shoe to the top of the shallowest productive horizon make cementing, as specified above, impossible or impractical, the multi-stage process may be used to cement the casing in a manner that will effectively seal off all such possible productive horizons and prevent fluid migration to or from such strata within the wellbore.⁸⁰

When cementing any string of casing more than 200 feet long, before drilling the cement plug the operator shall test the casing at a pump pressure in pounds per square inch (psi) calculated by multiplying the length of the casing string by 0.2. The maximum test pressure required, however, unless otherwise ordered by the commission, need not exceed 1,500 psi. If, at the end of 30 minutes, the pressure shows a drop of 10% or more from the original test pressure, the casing shall be

⁸⁰ 16 TAC Part 1 §3.13(b)(3)(A)

*condemned until the leak is corrected. A pressure test demonstrating less than a 10% pressure drop after 30 minutes is proof that the condition has been corrected.*⁸¹

California regulations that may benefit NYS include:

1. Requirement for Intermediate Casing:

*Intermediate casing. This casing may be required for protection of oil, gas, and freshwater zones, and to seal off anomalous pressure zones, lost circulation zones, and other drilling hazards.*⁸²

NYS's regulations include a basic requirement to install casing to protect freshwater zones, but do not specify other reasons for setting intermediate casing to prevent well control problems and potential blowout or spill hazards. California's regulations include a list of reasons for setting intermediate casing, but are also a bit weak in that the regulation only "may" require casing in these circumstances.

Alaska regulations that may benefit NYS include:

1. Requirement for Intermediate Casing:

*One or more intermediate casing strings must be set if required for protection of oil or gas or for protection against abnormally geo-pressured strata and lost circulation zones, or if otherwise required by well conditions.*⁸³

*If the intermediate or production string is a liner, a minimum of 100 feet overlap between the outer and inner strings is required; the interval of overlap must be made pressure competent and must be pressure-tested in accordance with (e) of this section.*⁸⁴

*Casing design and setting depth must be based on engineering and geologic factors relevant to the immediate vicinity, including the presence or absence of hydrocarbons, potential drilling hazards, and permafrost.*⁸⁵

Alaska also sets general standards for when intermediate casing should be set.

2. Cementing Method:

*Intermediate and production casing must be cemented with sufficient cement to fill the annular space from the casing shoe to a minimum of 500 feet above all significant hydrocarbon zones and abnormally geo-pressured strata or, if zonal coverage is not required under (a) of this section, from the casing shoe to a minimum of 500 feet above the casing shoe; if indications of improper cementing exist, such as lost returns, or if the formation integrity test shows an inadequate cement job, remedial action must be taken.*⁸⁶

⁸¹ 16 TAC Part 1 §3.13(b)(1)(D)

⁸² 14 CCR §1722.3 (c)

⁸³ 20 AAC §25.030 (c)(4)

⁸⁴ 20 AAC §25.030 (d)(6)

⁸⁵ 20 AAC §25.030(b)(1)

⁸⁶ 20 AAC §25.030(d)(5)

3. Cement Quality Testing Requirement

If zonal coverage is required under (a) of this section, and the commission believes zonal isolation might not have been established, the commission will require a cement quality log or other method to demonstrate isolation of the zone.

For intermediate or production casing in a service well used for injection, a cement quality log or other evaluation log approved by the commission must be run to demonstrate isolation of the injected fluids to the approved interval.⁸⁷

Pennsylvania regulations that may benefit NYS include:

1. Casing Type and Cementing Practice:

The operator shall determine the amount and type of casing to be run and the amount and type of cement to be used in accordance with current prudent industry practices and engineering. In making the determinations, the operator shall consider the following: (1) Successful local practices for similar wells. (2) Maximum anticipated surface pressure. (3) Collapse resistance. (4) Tensile strength. (5) Chemical environment. (6) Potential mechanical damage. (7) Manufacturing standards, including American Petroleum Institute or equivalent specifications for pipe used in wells drilled below the Onondaga formation or where blow-out preventers are required.⁸⁸

The operator shall install casing that can withstand the effects of tension, and prevent burst and collapse during its installation, cementing and subsequent drilling and producing operations.⁸⁹

Pennsylvania's regulations for intermediate casing essentially defer to industry standards, but set some specific criteria.

2. Fresh Water Protection:

If additional fresh groundwater is encountered in drilling below the permanently cemented surface casing, the operator shall protect the additional fresh groundwater by installing and cementing a subsequent string of casing or other procedures approved by the Department to completely isolate and protect fresh groundwater. The string of casing may also penetrate zones bearing salty or brackish water with cement in the annular space being used to segregate the various zones. Sufficient cement shall be used to cement the casing at least 20 feet into the permanently cemented casing.⁹⁰

Typically surface casing is drilled to a depth below fresh groundwater and the surface casing is set. However, in areas where fresh water aquifers are not well mapped, surface casing may be set too soon. Drilling may resume below the surface casing shoe, encountering deeper fresh water aquifers. In this case, Pennsylvania's regulations require intermediate casing to be set to ensure any additional fresh water intervals are put behind pipe and a cement barrier is placed prior to drilling into hydrocarbon bearing zones.

⁸⁷ 20 AAC §25.030(d)(7)

⁸⁸ 25 Pa. Code §78.71(b)

⁸⁹ 25 Pa. Code §78.84(a)

⁹⁰ 25 Pa. Code §78.83(f)

7. Production Casing

Production casing is the last string of casing set in the well. It is called “production casing” because it is typically set across the hydrocarbon producing zone, but alternatively could be set just above the production zone.

If production casing is set across the hydrocarbon producing zone it is called a “cased hole” completion. In this scenario, production casing is lowered into the hole and cemented in place. Explosives are lowered inside the production casing (perforation guns) to perforate holes through the pipe/cement barrier to allow oil and/or gas to enter the wellbore. In some cases a drilling engineer may elect not to set production casing. This is called an “open hole” completion.

Production casing is used to isolate hydrocarbon zones and contain formation pressure. Production casing pipe and cement integrity is very important because it is the piping/cement barrier that is exposed to fracture pressure, acid stimulation treatments, and other workover/stimulation methods used to increase hydrocarbon production.

Production casing is typically less than 9” in diameter; however, size is a site-specific, well-specific function and can vary.

7.1 Existing NYS Production Casing Requirements

NYS includes specific production casing standards in its regulations in the NYCRR, including:

1. Pollution Prevention:

The drilling, casing and completion program adopted for any well shall be such as to prevent pollution. Pollution of the land and/or of surface or ground fresh water resulting from exploration or drilling is prohibited.⁹¹

2. Cementing Method:

If it is elected to complete a rotary-drilled well and production casing is run, it shall be cemented by a pump and plug or displacement method with sufficient cement to circulate above the top of the completion zone to a height sufficient to prevent any movement of oil or gas or other fluids around the exterior of the production casing. In such instance, operations shall be suspended until the cement has been permitted to set in accordance with prudent current industry practices.⁹²

NYS requires a permit to drill at 6 NYCRR V.B. §552, to which stipulations for production casing can be attached. NYS also requires the operator to file a **Well Drilling and Completion Report** listing information on the size, grade and type of production casing and cement used.

NYS guidance informs the applicant that it must follow NYS’s **Casing and Cementing Practices** guidelines when designing a well; however, there is no specific language in the regulation requiring compliance with the guidance.⁹³ NYS’s website states that the NYS **Casing and Cementing Practices** are minimum construction standards for all wells, unless a waiver has been approved by the regional minerals manager in response to a written request and justification.

⁹¹ 6 NYCRR V.B. §554.1(a-b)

⁹² 6 NYCRR V.B. §554.4(d)

⁹³ NYS Division’s Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

NYS *Casing and Cementing Practices* include several requirements for production casing:

1. Depth:

*The production casing cement shall extend at least 500 feet above the casing shoe or tie into the previous casing string, whichever is less. If any oil or gas shows are encountered or known to be present in the area, as determined by the Department at the time of permit application, or subsequently encountered during drilling, the production casing cement shall extend at least 100 feet above any such shows. The Department may allow the use of a weighted fluid in the annulus to prevent gas migration in specific instances when the weight of the cement column could be a problem.*⁹⁴

2. Centralizers:

*Centralizers shall be placed at the base and at the top of the production interval if casing is run and extends through that interval, with one additional centralizer every 300 feet of the cemented interval. A minimum of 25% excess cement shall be used. When caliper logs are run, a 10% excess will suffice. Additional excesses may be required by the Department in certain areas.*⁹⁵

3. Cement Method:

*The pump and plug method shall be used for all production casing cement jobs deeper than 1500 feet. If the pump and plug technique is not used (less than 1500 feet), the operator shall not displace the cement closer than 35 feet above the bottom of the casing. If plugs are used, the plug catcher shall be placed at the top of the lowest (deepest) full joint of casing.*⁹⁶

4. Casing Quality:

*The casing shall be of sufficient strength to contain any expected formation or stimulation pressures.*⁹⁷

5. Cement Quality:

*Following cementing and removal of cementing equipment, the operator shall wait until a compressive strength of 500 psi is achieved before the casing is disturbed in any way. The operator shall test or require the cementing contractor to test the mixing water for pH and temperature prior to mixing the cement and to record the results on the cementing tickets and/or the drilling log. WOC time shall be adjusted based on the results of the test.*⁹⁸

6. Record Keeping and Variances:

*When requested by the Department in writing, each operator must submit cement tickets and/or other documents that indicate the above specifications have been followed. The casing and cementing practices above are designed for typical surface casing cementing. The Department will require additional measures for wells drilled in environmentally or technically sensitive areas (i.e. primary or principal aquifers). The Department recognizes that variations to the above procedures may be indicated in site specific instances. Such variations will require the prior approval of the Regional Mineral Resources office staff.*⁹⁹

⁹⁴ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 12.

⁹⁵ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 13.

⁹⁶ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 14.

⁹⁷ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 15.

⁹⁸ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html> at 16.

⁹⁹ NYS Division's Casing and Cementing Practices, <http://www.dec.ny.gov/energy/1628.html>.

7.2 Production Casing Standard Recommendations for NYS

Overall NYS's production casing requirements are fairly robust, when the NYCRR, guidance documents and standard stipulations are combined.

Additionally, other state regulations examined in this report point to possible improvements and refinements. Selected regulations are listed below, where a state has a more stringent, or more detailed regulation, that may benefit NYS.

Texas regulations that may benefit NYS include:

1. Cementing Method:

*Cementing Method. The producing string of casing shall be cemented by the pump and plug methods, or another method approved by the commission, with sufficient cement to fill the annular space back of the casing to the surface or to a point at **least 600 feet above the shoe**. If any productive horizon is open to the wellbore above the casing shoe, the casing shall be cemented in a manner that effectively seals off all such possibly productive horizons by one of the methods specified for intermediate casing in paragraph (3) of this subsection¹⁰⁰ [emphasis added].*

Texas requires an additional 100' of cement above the NYS standard for 500' for a total of 600' behind production casing. Most states require at least 500'. An additional hundred feet may be warranted in high angle wells and across high pressure zones.

Recommendation No. 18: Consider amending the NYCRR to increase the amount of cement required to a minimum of 600' behind production casing similar to Texas regulation at 16 TAC Part 1 §3.13

California regulations that may benefit NYS include:

1. Cementing Method and Testing:

Production casing. This casing shall be cemented and, when required by the Division, tested for fluid shutoff above the zone or zones to be produced. The test may be witnessed by a Division inspector. When the production string does not extend to the surface, at least 100 feet of overlap between the production string and next larger casing string shall be required. This overlap shall be cemented and tested by a fluid-entry test to determine whether there is a competent seal between the two casing strings. A pressure test may be allowed only when such test is conducted pursuant to an established field rule. The test may be witnessed by a Division inspector.¹⁰¹

Recommendation No. 19: Consider amending the NYCRR to require production casing testing and minimum overlap length standards similar to the California Code of Regulations at 14 CCR §1722.

Alaska regulations that may benefit NYS include:

1. Cementing Method, Quality and Testing:

*Intermediate and **production casing** must be cemented with sufficient cement to fill the annular*

¹⁰⁰ 16 TAC Part 1 §3.13(b)(4)(A)

¹⁰¹ 14 CCR §1722.3(d)

space from the casing shoe to a minimum of 500 feet above all significant hydrocarbon zones and abnormally geo-pressured strata or, if zonal coverage is not required under (a) of this section, from the casing shoe to a minimum of 500 feet above the casing shoe; if **indications of improper cementing exist, such as lost returns, or if the formation integrity test show an inadequate cement job, remedial action must be taken**¹⁰² [emphasis added].

For intermediate or **production casing in a service well used for injection, a cement quality log or other evaluation log approved by the commission must be run to demonstrate isolation of the injected fluids to the approved interval.**¹⁰³

If zonal coverage is required under (a) of this section, and the commission believes zonal isolation might not have been established, the commission will require a cement quality log or other method to demonstrate isolation of the zone.¹⁰⁴

Both NYS and Alaska require the operator to place at least 500' of cement behind production casing. Alaska's regulations add a quality standard, requiring remedial action in the case of poor cement quality.

Recommendation No. 20: Consider amending the NYCRR to add a cement quality, testing, and remedial repair standard similar to the Alaska Administrative Code (AAC) requirements at 20 AAC §25.030

Pennsylvania regulations that may benefit NYS include:

1. **Casing Quality and Amount:**

*The operator shall install casing that can withstand the effects of tension, and prevent burst and collapse during its installation, cementing and subsequent drilling and producing operations.*¹⁰⁵

*The operator shall determine the amount and type of casing to be run and the amount and type of cement to be used in accordance with current prudent industry practices and engineering. In making the determinations, the operator shall consider the following: (1) Successful local practices for similar wells. (2) Maximum anticipated surface pressure. (3) Collapse resistance. (4) Tensile strength. (5) Chemical environment. (6) Potential mechanical damage. (7) Manufacturing standards, including American Petroleum Institute or equivalent specifications for pipe used in wells drilled below the Onondaga formation or where blow-out preventers are required.*¹⁰⁶

Recommendation No. 21: Consider amending the NYCRR to add casing quality and amount standards similar to the Pennsylvania Code at 25 Pa. Code §78.84 and §78.71.

¹⁰² 20 AAC §25.030(d)(5)

¹⁰³ 20 AAC §25.030(d)(7)

¹⁰⁴ 20 AAC §25.030(5)

¹⁰⁵ 25 Pa. Code §78.84(a)

¹⁰⁶ 25 Pa. Code §78.71(b)