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**HISTORICAL ANALYSIS OF OIL AND GAS WELL
PLUGGING IN NEW YORK: IS THE REGULATORY
SYSTEM WORKING?**

RONALD E. BISHOP

ABSTRACT

The aim of this work was to evaluate New York State's regulatory program for plugging inactive oil and gas wells. Analysis of reports from the Division of Mineral Resources, Department of Environmental Conservation, reveals that three-fourths of the state's abandoned oil and gas wells were never plugged. Inadequate enforcement efforts have resulted in steady increases of unplugged oil and gas wells abandoned since 1992. Further, no program exists or is proposed to monitor abandoned wells which were plugged. These results strongly suggest that comprehensive reform and increased agency resources would be required to effectively regulate conventional oil and gas development in New York. Industrial expansion into shale oil and gas development should be postponed to avoid adding stress to an already compromised regulatory system.

Keywords: oil, gas, plugging, regulatory, New York, fracking

New York's oil and gas industry is just nine years from its bicentennial, since the pilot project, a natural gas well near Fredonia, was drilled in 1821. Now, there is a dedicated and sophisticated Bureau of Oil and Gas Permitting and Management (BOGPM), established as a unit of the Division of Mineral

Resources (DMN) within the state Department of Environmental Conservation (DEC) in 1983. State guidance documents and regulations have undergone multiple updates, including those newly proposed in 2011 to accommodate concerns peculiar to the extraction of oil and gas from unconventional reservoirs such as shale. But before state regulators adopt new rules to permit expansion of the industry into shale oil and gas development, we should evaluate how the regulatory system has managed petroleum development so far. Few aspects of the regulatory system are as cogently diagnostic as New York's record on plugging abandoned oil and gas wells.

BACKGROUND

Abandoned Wells Issue

With great attention paid these days to proper oil and gas well construction, appropriate control of chemicals and wastes, and other production issues, post-production plugging and cleanup has received relatively little notice. But as production from the first oil and gas wells declined, this was recognized as an important issue. New York became the first state to require the plugging of abandoned wells in 1879 [1]. No particular state entity existed to monitor compliance or enforce the plugging law, but an 1882 amendment to it offered half of any fines collected to informants who reported violations [1]. From that time forward, regulating this aspect of the petroleum industry has posed a unique challenge.

Scope of the Problem

The number of abandoned oil and gas wells in New York State is not definitely known. The Historic Well Survey of 1988, included in that year's DMN annual report, established a baseline of 42,322 oil and gas wells of unknown status [2], while the Plugged Wells Estimate of 1993, included in that year's annual report, identified 13,070 wells which were known to have been plugged [3]. For their external review in 1994 by the Interstate Oil and Gas Compact Commission, BOGPM staff estimated that 61,000 wells had been developed historically, but the agency had no records on 30,000 of them [4]. Of the wells on record, 12,857 were active and about 18,000 were known to not be plugged. Therefore, of 48,000 abandoned oil and gas wells total, 13,000 were plugged and approximately 35,000 were not plugged as of 1994 [4]. It should be noted that this report represented an improvement in the BOGPM's accounting for oil and gas wells since the Historic Wells Survey of 1988, reducing the approximate number of "unknown status" wells from 42,000 to 35,000 over that six-year period.

Well Accounting Issues

Accounting for abandoned oil and gas wells is complicated by the fact that New York's BOGPM maintains more than one system for recording them. For example, the 2005 DMN annual report reported on (a) inactive oil and gas wells, (b) known, unreported wells and (c) "other, known orphan wells" [5], which summed to fewer than 9,000 wells, far short of the 35,000 unplugged, abandoned wells noted above. Annual reports from 2002 onward suggest that the locations of fully half of the state's orphan abandoned oil and gas wells are unknown, and from the 2009 annual report, "Most of the [abandoned] wells date from before New York established a regulatory program" [6]. Thus it appears that state regulators have given up on old wells for which location or operational data are missing; for clarity, I will call them "forgotten." Abandoned oil and gas wells in known locations, but for which the BOGPM lacks current ownership data, dominate the Priority Plugging List [7]. Although some of these wells have been plugged with the use of agency or external funds, most have not. Therefore, I refer to this group as "generally ignored." The primary focus of the BOGPM, then, is on those inactive wells for which all information is actionable; I call them "standing inventory." The boundaries that delimit these groups are not always clear, but the fresh discovery of a "forgotten" well typically results in its transfer to the "generally ignored" category, and the loss of ownership information may move a well from "standing inventory" to "generally ignored." Plugging oil or gas wells results in their removal from the state's accounting, although they are still abandoned structures; one might call them "forsaken."

Practical Significance

Why would abandoned wells matter to anyone? As if to answer this question, DMN annual reports from 2002 and 2003 presented case studies with photographs of individual abandoned oil and gas wells [8, 9]. One case involved an old gas well that discharged brine at a rate of five gallons per minute into a wetland near Rome, killing over an acre of vegetation [8]. Another involved the entire village of Rushville, on the border between Ontario and Yates Counties, where two dozen unplugged abandoned wells were responsible for widespread emanation of gas from the soil, so that methane accumulated to explosive levels in some structures [8]. Plugging or excavation of abandoned wells on school properties in Allegany and Wyoming Counties cost those school districts thousands of dollars [8]. Further, abandoned wells have been found leaking oil into creeks and wetlands in Steuben and Allegany Counties, and into residential ponds and lawns in Allegany and Cattaraugus Counties [9]. These case studies provide evidence that many abandoned petroleum wells across New York leak fluids to the ground surface.

This issue is by no means limited to New York. In a 1987 report, the U.S. Environmental Protection Agency (EPA) estimated that, of about 1.2 million abandoned oil and gas wells nationwide, approximately 200,000 (17%) were portals for pollution to reach the surface [10], and in 1989 the U.S. General Accounting Office reported that the number of improperly abandoned wells was increasing [11].

Long-Term Instability

Abandoned wells leak because well casings deteriorate over time, and once-depleted rock formations repressurize with oil, gas, and brines [12–14]. Dusseault and coworkers showed that because temperature, pressure, and salt concentrations all tend to increase with depth, steel pipe and concrete degradation occurs most rapidly in the deepest segments of abandoned wells, where the damage is most difficult to detect. They estimated that essentially all unmaintained well bores lose integrity over a 50-year time frame, and further, that deep rock structures frequently repressurize [12]. One industry study of offshore oil and gas wells determined that half of the well casings studied began to leak in just 15 years [13]. A more recent industry study of oil and gas projects in Alberta, Canada, found leaks in just over 4 percent of the wellbores, including some which were plugged before abandonment [14]. A possible explanation for the lower percentage of leaks found in the onshore wells might be that they were more actively maintained. That is, the Canadian projects were more consistently monitored for sustained casing vent flow and external gas migration, and were more aggressively re-grouted when these problems were discovered [14]. Ongoing maintenance, then, is required to keep old wellbores stable. Therefore, to be effective, the state's oil and gas regulatory program must not only ensure that abandoned wells are properly plugged, but must also periodically inspect and, when necessary, repair the plugged wells.

Economic Impact

The cost of plugging abandoned oil and gas wells varies for different situations, but two contract awards cited in DMN's 2008 annual report provide some context [15]. One contract was for \$190,000 to plug 45 wells in Allegany County, an average cost of \$4,222 per well, and the other was for \$150,000 to plug 25 wells in Cattaraugus County, or \$6,000 per well. At about \$5,000 per abandoned well, plugging the 4,722 wells on the BOGPM's current priority plugging list [7] would cost \$23.6 million. And on this basis, finding and plugging the 35,000 unplugged, abandoned wells which were estimated in 1994 would cost at least \$175 million.

In the agency's defense, the DEC began to amass an "Oil and Gas Fund" in 1981 to pay for the plugging of priority oil and gas wells, but in 1993 the Legislature appropriated \$1 million of that fund for general expenditures, and

changed state law to prevent the use of collected fines for plugging activities [4]. The DMN never accumulated that much money again; the plugging fund balance at the end of 2009 was \$209,000 [6].

Difficulty of Enforcement

What is involved in enforcing compliance with the state's oil and gas plugging laws? This question is nuanced, according to Louis W. Allstadt, a former senior oil and gas company executive [16]:

Very little attention is paid to the end of the life of an oil or gas well. I think you will find that it is rare for the larger companies to plug and abandon their older wells. Rather, at some point, a smaller company with lower overheads and less expensive operating costs will offer to buy the old wells at a price that gives the original company a better return than continued operations. The original company uses the cash to finance new investments. The buying company operates with lower costs because they spend less on maintenance and safety items and they have fewer well-qualified people to pay. The chain may end there or continue through smaller and ever lower cost operators who do no preventive maintenance at all, do the bare minimum of repairs to keep the well going and eventually walk away, maybe after plugging the hole as cheaply as possible and maybe not plugging at all.

In conventional fields these selling/buying cycles might start when the field is 20-30 years old and run for another 20-30 years. By the time these wells are abandoned, the casings have been subjected to corrosive fluids for many years. When it costs too much to repair versus what might be produced, the well is abandoned. Whether it is plugged before it is abandoned depends on the final operator. In tight shale this could all take place over a much shorter time period and the abandoned wells could increase quickly [16].

Hence, inspecting low-production oil and gas projects and tracking well ownership through multiple transfers pose particular challenges to state regulators, and may help to explain how many owners have avoided plugging their abandoned wells. This problem would be exacerbated by shorter-lived projects, and indeed, industry analysts have presented evidence that tight shale gas wells decline much more quickly than oil and gas wells in conventional deposits, with shale gas projects exhibiting half-lives of about eight years [17, 18].

Therefore, with state regulators proposing to permit dramatic expansion of the oil and gas industry into extraction from shale, the principal aim of this study is to answer the question: "How successful has New York's oil and gas regulatory program been, especially since the 1994 review, with respect to post-production plugging?"

METHODS

Data Sources

Most data for this investigation came from annual reports by the DEC's Division of Mineral Resources. Reports that were accessible from the DEC's web site included those from 1994 through 2010 [19]. Reports from 1985 through 1993 were obtained by Freedom of Information Law (FOIL) request from the DEC. Other data came from the 1994 New York State Review (STRONGER review) [4] and the New York State priority plugging list [7]. These documents constitute the entire body of publicly available records on this topic in the State of New York.

Categories of Inactive Wells

As stated in the introduction, the primary focus of the BOGPM appears to be the "standing inventory" of oil and gas wells declining to zero commercial production, for which complete location and owner information is currently available. That subset of inactive wells represents all that are detailed in the DMN annual reports, and forms the main substance of the Results section, below.

Influence of Shut-in Wells

The results below are expressed in terms of oil and gas wells that had been reported as "inactive," defined as having zero commercial production. An oil or gas well may be considered inactive either because it is depleted or because it is shut in. From 1966 to 1990, no distinction was made in DMN annual reports between depleted and shut-in wells. Since 1991, shut-in wells have been consistently identified as those that may be capable of producing oil or gas, but are not connected to pipelines or for some other reason are temporarily sealed to prevent product loss. Shut-in wells are not required to be plugged, even though they are inactive. Therefore, a summary of shut-in application approvals by year was requested from the BOGPM. The agency claimed to have no responsive records, but informed me that "269 shut-in applications are currently approved" [20]. Hence, the number of inactive oil and gas wells in each year's standing inventory may include some which were not required to be plugged at the time, but no data are available to resolve that question for individual years.

Influence of "Other" Plugged Wells

In DMN annual reports, data for well plugging included oil, gas, and "other regulated wells." The other regulated wells included salt solution and stratigraphic geothermal wells, and their numbers were expressly stated in only eight of the reports, from 2003 through 2010. These "other" plugged wells ranged from 12 to 55 per year, with mean and median averages of 26.5 and 24,

respectively. To maintain consistency of data handling across the entire 39 years reported, the more conservative median average of 24 wells was subtracted from the raw “plugged” data for each year from 1971 through 1992, and the actual number of “other” plugged wells was subtracted from the raw “plugged” data prior to plotting and analysis. This modest correction is supported by data from the salt solution mining section of the DMN 1995 annual report, which indicated that 167 wells were plugged in the seven-year period from 1988 through 1994 (average of 24 wells per year) for a single salt solution project (Tully Valley) [21].

RESULTS

The yearly data for inactive and plugged wells are summarized in Table 1, and a plot of inactive oil and gas wells and corrected plugged wells by year shows the results of Table 1 graphically (Figure 1).

Trend Analysis

The results shown in Figure 1 indicate that New York has maintained a significant standing inventory of inactive oil and gas wells, a fraction of which have been plugged each year. Over time, this standing inventory tended to increase, except for the period 1990-1992. That period, when the inventory decreased, coincided with Pennzoil’s closing out its Chipmunk Field operations in Cattaraugus County; it unilaterally plugged 629 wells in 1990, contributing to a record 937 wells plugged that year [22]. The inventory then increased steadily from 1992 through 2010, approximately doubling over that 18-year period. Hence, for most of their recorded history, New York regulators’ efforts to enforce plugging laws have not kept pace with the number of oil and gas wells that needed to be plugged.

To evaluate what would be required for the BOGPM to prevent an increase in unplugged wells, we need to know how many oil and gas wells become newly inactive each year. When I requested this information, the agency responded that its records are not structured to provide it: one would have to simultaneously monitor every well in the database and observe when each one was first reported to have zero production [20]. Nevertheless, the annual decline of oil and gas wells to zero production can be deduced from the trends shown in Figure 1.

A stable standing inventory would indicate that plugging rates matched the entry of inactive wells into the DMN database. Plugging rates would have to be lower than the entry of inactive wells into the database for the inventory to increase, and conversely, plugging rates would have to exceed the entry of inactive wells into the database for the inventory of unplugged wells to decrease. Average annual values derived from these trend parameters are shown in Table 2.

Table 1. Annual Plugging Data for Abandoned Oil and Gas Wells in New York

Year	Inactive ^a	Number plugged (raw)	Correction	Number plugged (corrected)
1996 ^b	4500	N.A.	N.A.	N.A.
1967	4600	N.A.	N.A.	N.A.
1968	4450	N.A.	N.A.	N.A.
1969	1009	N.A.	N.A.	N.A.
1970	1350	N.A.	N.A.	N.A.
1971 ^c	1567	418	-24	394
1972	1619	573	-24	549
1973	1484	544	-24	520
1974	1862	622	-24	598
1975	1883	553	-24	529
1976 ^d	1825	442	-24	418
1977	1820	455	-24	431
1978	1864	352	-24	328
1979	2020	117	-24	93
1980	1900	119	-24	95
1981	2128	184	-24	160
1982	2304	262	-24	238
1983	2431	90	-24	66
1984	2296	182	-24	158
1985	2519	269	-24	245
1986	2468	471	-24	447
1987	2543	417	-24	393
1988 ^e	2348	322	-24	298
1989	2620	260	-24	236
1990 ^f	2707	961	-24	937
1991 ^g	2069	376	-24	352
1992	1502	244	-24	220
1993 ^h	1642	263	-24	239
1994 ⁱ	1887	248	-24	224

Table 1. (Cont'd.)

Year	Inactive ^a	Number plugged (raw)	Correction	Number plugged (corrected)
1995	1784	219	-24	195
1996 ^j	2215	233	-24	209
1997 ^k	1974	187	-24	163
1998	2169	169	-24	145
1999 ^l	1748	138	-24	114
2000 ^m	2190	131	-24	107
2001 ⁿ	2259	79	-24	55
2002 ^o	2272	146	-24	122
2003 ^p	2379	142	-15	127
2004	2526	145	-39	106
2005 ^q	2658	150	-55	95
2006 ^r	2871	213	-22	191
2007 ^s	2460	192	-31	161
2008	3071	221	-12	209
2009	3043	240	-24	216
2010 ^t	3169	178	-14	164

^aOil and gas wells reported to have zero commercial production.

^bEarliest official records.

^cEarliest plugging records.

^dEarliest reporting of "shut-in" gas wells.

^eEstimated 42,32 wells of unknown status.

^fRecord high number of wells plugged.

^g"Shut-in" wells first referred to as "inactive."

^hTotal plugged wells reported as 13,070.

ⁱTotal unplugged wells estimated at 35,000 [4].

^j96 newly discovered abandoned wells.

^k200 newly discovered abandoned wells.

^l270 newly discovered abandoned wells.

^m220 newly discovered abandoned wells.

ⁿ150 newly discovered abandoned wells.

^oFirst mention of priority plugging list.

^pFirst explicit reporting of "other" plugged wells.

^q2117 Known wells unreported.

^r1103 Known wells unreported.

^s822 Known wells unreported.

^tLast available annual report.

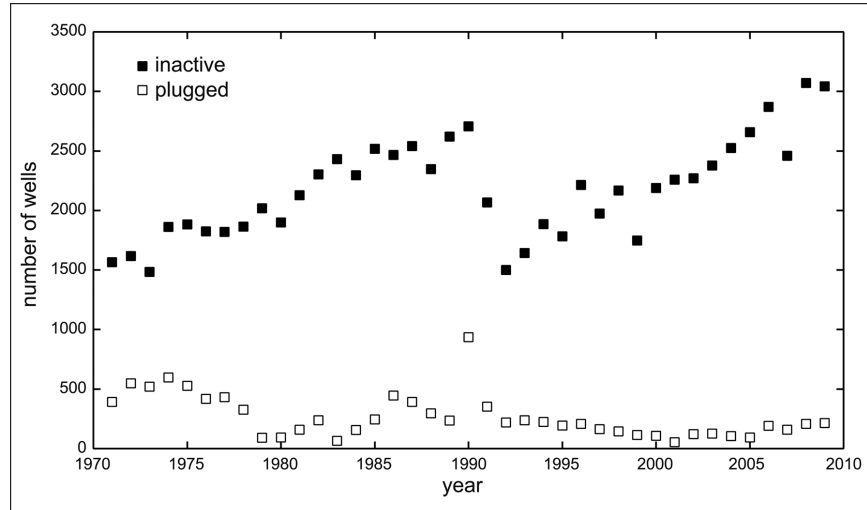


Figure 1. Annual reports of standing inventory of inactive wells (filled squares) and plugged inactive wells (open squares) by year reported, 1971-2010. Data taken from Table 1.

Table 2. Annual Newly Inactive Oil and Gas Wells

Period	Plug rate ^a	Inventory trend	Change ^b	Newly inactive ^c
1973-1978	499/yr	Stable	0	499/yr
1979-1987	151/yr	Increasing	+92/yr	243/yr
1987-1992	444/yr	Decreasing	-208/yr	236/yr
1992-2010	161/yr	Increasing	+93/yr	254/yr

^aTotal oil and gas wells plugged/number of years in period.

^bIncrease or decrease in inventory/number of years in period.

^cPlug rate column value \pm Add/subtract column value.

The results of Table 2 indicate that since 1980, approximately 250 oil and gas wells have become newly inactive annually. Therefore, for plugging to keep pace with ongoing demand, the BOGPM would have to enforce the plugging of at least 250 wells each year. The data in Table 1 show that such an enforcement level has not been achieved since 1991.

Current Status of Abandoned Oil and Gas Wells

Summary statistics from the DMN annual reports from 2008, 2009, and 2010 indicate that 75,000 total oil and gas projects are believed to have been developed in New York, of which about 11,000 remain active [6, 15, 23]. Using these values in conjunction with the results shown in Table 1, it is possible to estimate how many oil and gas wells have been abandoned in the state, both plugged and unplugged. The data for 1994 and 2010 are presented for comparison in Table 3.

The results shown in Table 3 indicate that, while the number of plugged oil and gas wells has grown considerably since 1994, the number of unplugged abandoned oil and gas wells has increased even more. The percentage of plugged wells, out of all the abandoned wells, has slipped from 27 percent in 1994 to 25 percent currently, leaving the state with an estimated 48,000 wells that need to be plugged. At an estimated cost of \$5,000 per well, about a quarter of a billion dollars would be needed to plug all these wells, if they could be found.

CONCLUSIONS AND RECOMMENDATIONS

Since 1970, New York's Bureau of Oil and Gas Permitting and Management has failed to adequately enforce state laws that require industry operators to plug inactive oil and gas wells. As a result, three-fourths of inactive oil and gas wells remain unplugged, and the number of unplugged abandoned wells in New York continues to increase. In the last year reported, only 164 of an estimated 250 newly inactive oil and gas wells (66%) were plugged. Further, no program to monitor and maintain plugged abandoned wells exists or is proposed, in spite of evidence that plugged wells can disintegrate and leak.

Table 3. Summary of Plugged and Unplugged Abandoned Oil and Gas Wells

Year	1994 ^a	2010 ^b
Total projects	61,000	75,000
Active wells	12,857	10,707
Abandoned wells, plugged	13,070	15,912
Abandoned wells, unplugged	35,000	48,000
Total abandoned wells	48,000	64,000
Percentage plugged	27	25

^aData from STRONGER review [4] and Plugged Wells Survey [3].

^bData from 2010 DMN annual report [23], Plugged Wells Survey [3], and Table 1.

Therefore, the following actions are recommended:

1. Approval of permits for conventional oil and gas development projects in New York should be reduced by 30 percent immediately until industry compliance with inactive well-plugging requirements can be demonstrated for a minimum of three consecutive years.
2. Oil and gas well transfer requests should be suspended immediately, until the DMN can re-evaluate financial security and bonding levels which will ensure that all declining oil and gas wells are plugged when they reach zero production.
3. The state legislature should appropriate funding for the specific purpose of inspecting and plugging every well in the BOGPM standing inventory and priority plugging list.
4. New York should establish a program to register, inspect, and maintain abandoned oil and gas wells that have been plugged.
5. The New York State Bureau of Oil and Gas Regulation, Division of Mineral Resources, Department of Environmental Conservation should invite the Interstate Oil and Gas Compact Commission to conduct an updated state review.
6. Expansion of the state's petroleum industry into extraction of oil and gas from shale should be postponed until the above actions have been carried out.

Overall, the goal should be to establish a comprehensive plan for regulatory improvement, including progress on the issue of oil and gas well plugging and abandonment in New York.

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