

**EMERGING CENTRIFUGAL TECHNOLOGY
IN SHALE HYDRAULIC FRACTURING
WASTE MANAGEMENT: A U.S.-FRANCE-
CHINA SELECTED ENVIRONMENTAL
COMARATIVE ANALYSIS**

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I. INTRODUCTION

As world energy use continues to increase, newly discovered natural gas shale plays in the United States, France, and China will become vital in satisfying future demand.¹ As a result, production from shale formations is one of the most rapidly expanding trends in international oil and gas exploration and production.² Hydraulic fracturing is the current technology of choice for developing most shale gas reserves. A key aspect of successful shale exploration and production is drilling waste management.³ Drilling waste is generally composed of liquid and solid components, including water, caustic soda, various acids, methanol, and salt.⁴ Many commentators have expressed

1. See GROUND WATER PROTECTION COUNCIL & ALL CONSULTING, *Modern Shale Gas Development in the United States: A Primer*, DEP'T OF ENERGY, 3 (Apr. 2009), http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/Shale_Gas_Primer_2009.pdf [hereinafter *Modern Shale Gas Primer*] (United States); Geraldine Amiel, *France Cancels Shale-Gas Permits Over Fracking Impasse*, WALL ST. J. (Oct. 4, 2011), available at <http://online.wsj.com/article/SB10001424052970204612504576608983814069012.html> (France); Vinod Dar, *Emerging International Shale Gas: Poland and China Lead*, SEEKING ALPHA (Jan. 14, 2011), <http://seekingalpha.com/article/246623-emerging-international-shale-gas-poland-and-china-lead> (China).

2. *Modern Shale Gas Primer*, *supra* note 1, at 1; see Vinod Dar, *Emerging International Shale Gas: Poland and China Lead*, SEEKING ALPHA (Jan. 14, 2011), <http://seekingalpha.com/article/246623emerging-international-shale-gas-poland-and-china.lead>.

3. *Modern Shale Gas Primer*, *supra* note 1, at 1.

4. MINORITY STAFF OF H.R. COMM. ON ENERGY AND COMMERCE, 111TH CONG., *CHEMICALS USED IN HYDRAULIC FRACTURING* 5–6 (2011), <http://democrats.energycommerce.house.gov/sites/default/files/documents/Hydraulic%20Fracturing%20Re>

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serious concerns about the environmental impact of shale gas exploration and production, including hydraulic fracturing and how it will affect water supplies.⁵

The current approach to using hydraulic fracturing for shale development may be exemplified by three countries: (1) the U.S., (2) France, and (3) China. The U.S., through various state schemes, has utilized a combined approach ranging from variable bans to near laissez-faire approaches.⁶ France has elected to ban the use of hydraulic fracturing for shale development.⁷ China has given oil and gas exploration and production developers de facto free reign to utilize hydraulic fracturing.⁸

Shale gas in the United States is regulated through the same network of federal and state laws that control the production and exploration of conventional oil and gas.⁹ Each individual state with oil and gas production typically has its own regulatory agency that controls the granting of well permits in that state and enforces state environmental laws.¹⁰ These state agencies have broad powers in order to regulate drilling, well

port%204.18.11.pdf.

5. See Danny Hakim & Nicholas Confessore, *Cuomo Will Seek to Lift Ban on Hydraulic Fracturing*, N.Y. TIMES, June 30, 2011, <http://www.nytimes.com/2011/07/01/nyregion/cuomo-will-seek-to-lift-drilling-ban.html> (noting interested persons in New York).

6. See James E. Goddard, *Hydraulic Fracturing of Shale Formations and the Protection of Groundwater*, 6 TEX. J. OIL GAS & ENERGY L. 435, 443–55 (2011) (discussing the various state laws on hydraulic fracturing operations in Arkansas, Colorado, Louisiana, Michigan, Montana, New Mexico, New York, North Dakota, Ohio, Oklahoma, Pennsylvania and Wyoming).

7. Tara Patel, *France Vote Outlaws “Fracking” Shale for Natural Gas, Oil Extraction*, BLOOMBERG (July 1, 2011), <http://www.bloomberg.com/news/2011-07-01/france-vote-outlaws-fracking-shale-for-natural-gas-oil-extraction.html>; Michael Ricciardi, *France Becomes First Nation to Ban “Fracking”*, REUTERS (July 12, 2011), <http://www.reuters.com/article/2011/07/12/idUS5879120720110712>.

8. David Lee Smith, *Fracking Woes Could Help China Blow Past Us*, THE MOTLEY FOOL (Dec. 23, 2011), <http://www.fool.com/investing/general/2011/12/23/fracking-woes-could-help-china-blow-past-us.aspx>.

9. *Modern Shale Gas Primer*, supra note 1, at 25.

10. *Id.*; J. Daniel Arthur et al., *An Overview of Modern Shale Gas Development in the United States*, ALL CONSULTING, 12 (2008), <http://www.all-llc.com/publicdownloads/ALLShaleOverviewFINAL.pdf>.

design and location, waste disposal, wildlife impacts, and pollution.¹¹ On the federal level, agencies like the Environmental Protection Agency, the Bureau of Land Management, and the U.S. Forest Service manage oil and gas development on federally-owned land and administer federal environmental laws.¹² Federal agencies can also grant primary jurisdiction for implementing federal environmental laws to states by approving of state programs that adopt similar standards to federal ones.¹³

In France, production and development of oil and gas is largely regulated by a department within the Ministry of Economy, Finance and Industry, whose mandate is to “define and put into operation the energy policy of France and the supply of raw materials.”¹⁴ Wastewater treatment requirements are defined and regulated by the Ministries of Health, Environment and Agriculture.¹⁵ In conjunction with French agencies, European Union directives also regulate environmental quality including wastewater management.¹⁶ Many wastewater treatment projects in France utilize activated sludge or aerated lagoon processes.¹⁷

In China, development and exploration of shale formations are nominally under the jurisdiction of the Ministry of Environmental Protection (“MEP”).¹⁸ A set of environmental protection laws passed by the Chinese National People’s Congress theoretically control all aspects of actions that affect

11. *Modern Shale Gas Primer*, *supra* note 1, at 25; Arthur, *supra* note 10, at 12.

12. *Modern Shale Gas Primer*, *supra* note 1, at 25.

13. *Id.*; Arthur, *supra* note 10, at 12.

14. GLOBAL LEGAL GROUP, THE INTERNATIONAL COMPARATIVE LEGAL GUIDE TO: GAS REGULATION 2011 89 (2011).

15. See FRANCIOUS BRISSAUD, WASTEWATER RECLAMATION AND REUSE IN FRANCE 2–3 (2007).

16. See Directive 2008/98, of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives, 2008 O.J. (L 312/3) 1.

17. BRISSAUD, *supra* note 15, at 7.

18. John Richardson, *China’s Authorities Crack Down on Polluting Chemical Producers: Time to Get Tough*, ICIS (May 16, 2008), <http://www.icis.com/Articles/2008/05/19/9124322/chinas-authorities-crack-down-onpolluting-chemical-producers.html>.

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the environment.¹⁹ However, enforcement of these laws is still weak.²⁰ In fact, the MEP has only 2,200 employees nationwide, as compared to 18,000 employees of the EPA.²¹

The true power to regulate and enforce Chinese environmental statutes falls to local officials.²² These officials are reluctant to act because they often have a personal financial stake in local businesses.²³ On the other hand, local enforcement in the U.S. stems from citizen suits, thereby buttressing EPA oversight.²⁴ Such citizen suits require only that the citizen show that violations of environmental law have lessened the aesthetic and recreational values that the citizen derives from natural resources.²⁵ In contrast, Chinese litigants must identify their precise harms, assign a monetary value to them, and demonstrate a direct causal link to the defendant's behavior.²⁶

This article (1) compares selected U.S., French, and Chinese environmental law, which applies to shale plays; (2) elucidates current drillsite waste management technologies; and (3) posits solutions to shale development waste disposal through the use of new centrifugal drillsite technology.

19. See generally Standing Committee of the National People's Congress, *Law of the People's Republic of China on Appraising of Environmental Impacts*, Oct. 28, 2002 (Adopted at the 30th Meeting of the Standing Committee of the Ninth National People's Congress on October 28, 2002); see also Zhonghua Renmin Gongheguo Shuiwuran Fangzhifa Shishixice (Approved by the State Council on July 12, 1989, promulgated by Decree No. 1 of the State Bureau of the Environment Protection on July 12, 1989).

20. Wang Canfa, *Chinese Environmental Law Enforcement: Current Deficiencies and Suggested Reforms*, 8 VT. J. ENVTL. L. 159 (2007).

21. Alex Wang, *The Role of Law in Environmental Protection in China: Recent Developments*, 8 VT. J. ENVTL. L. 195, 200 n.22 (2007).

22. Wang Canfa, *Chinese Environmental Law Enforcement: Current Deficiencies and Suggested Reforms*, 8 VT. J. ENVTL. L. 159, 171 (2007).

23. Elizabeth C. Economy, *The Great Leap Backward? The Cost of China's Environmental Crisis*, 86 FOREIGN AFFAIRS 38, 39 (2007).

24. Michael D. Axline, *Constitutional Implications of Injunctive Relief Against Federal Agencies in Environmental Cases*, 12 HARV. ENVTL. L. REV. 1, 1-2 (1988).

25. See *Friends of the Earth, Inc. v. Laidlaw Env'tl. Servs.*, 528 U.S. 167, 183 (2000).

26. Patti Goldman, *Public Interest Environmental Litigation in China: Lessons Learned From the U.S. Experience*, 8 VT. J. ENVTL. L. 251, 255-57 (2007).

II. SHALE PLAY GEOGRAPHY, GEOGRAPHY AND ECONOMICS

A. Introduction

The U. S., France, and China all contain significant shale plays. In the U.S., the major known shale plays include the Bakken, Barnett, Eagle Ford, Haynesville, and Marcellus.²⁷ In France, the major shale play is the Paris Basin, which covers roughly half of the nation.²⁸ In China, the major shale plays include the so-called “Southern Area,” which includes the Sichuan Basin, and the Northern Area, including the Songliao Basin.²⁹

B. U.S. Shale Plays

As stated, the major known shale plays in the U.S. are the Bakken, Barnett, Eagle Ford, Haynesville, and Marcellus.³⁰ The Marcellus shale play is the largest and most widely recognized gas field in the United States.³¹ The Marcellus stretches across a number of northeastern states, including Ohio, New York, and West Virginia, encompassing an area the size of Greece.³²

27. *Modern Shale Gas Primer*, *supra* note 1, at ES-1 to -2.

28. See Vinod Dar, *Will the Bakken Be as Inspiring as the Barnett?*, Seeking Alpha (Jan. 18, 2011), <http://seekingalpha.com/article/246972-will-the-bakken-be-as-inspiring-as-the-barnett> (last visited Feb. 25, 2012).

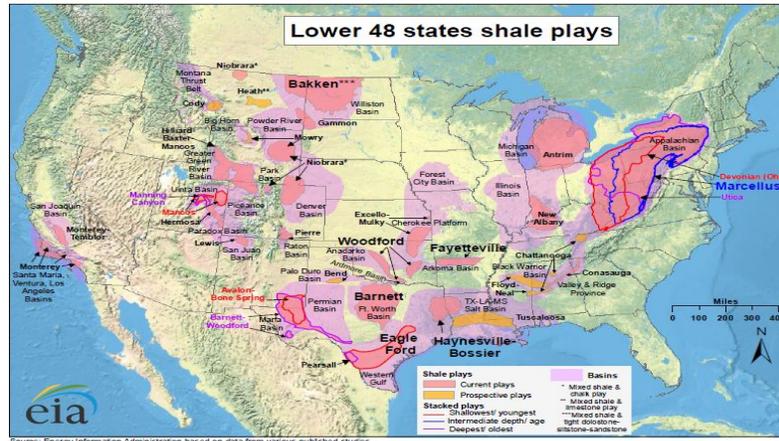
29. See Melanie Hart & Daniel J. Weiss, *China Has More Shale Gas Than We Do. Will they Embrace Environmental Safeguards on Fracking? Will We?*, THINKPROGRESS (Oct. 24, 2011, 8:23 AM), <http://thinkprogress.org/romm/2011/10/24/350356/china-shale-gas> (discussing Sichuan and Songliao basins as well as several other shale basins and including a relevant map of those basins); Jim Bai & Aizhu Chen, *FACTBOX—China’s Fledgling Shale Gas Exploration*, REUTERS (Aug. 24, 2010), <http://www.reuters.com/article/2010/08/24/china-gas-shale-idUSTOE67N00R20100824>; *China: Sinopec Confirms Gas Discovery in Songliao Basin*, ENERGY-PEDIA NEWS (July 6, 2006), <http://www.energy-pedia.com/news/china/sinopec-confirms-gas-discovery-in-songliao-basin>.

30. *Modern Shale Gas Primer*, *supra* note 1, at ES-1 to -2.

31. See Lorimer Willson, *U.S. Has 3rd Largest Natural Gas Field in the World – Which Other Countries are Included in the Top 10?*, MUNKNEE (Nov. 16, 2011), <http://www.munknee.com/2011/11/u-s-has-3rd-largest-natural-gas-field-in-the-world-which-other-countries-are-included-in-thetop-10/> (last visited Feb. 25, 2011).

32. See *Senate Panel to Meet in W. Va. on Marcellus Shale*, BUSINESSWEEK, Nov. 9, 2011, <http://www.businessweek.com/ap/financialnews/D9QTAFP00.htm> (stating that the Marcellus Shale bed is the size of Greece); *Modern Shale Gas Primer*, *supra* note 1, at 21

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Map No. 133

As the price of natural gas increases, all of these states stand to experience a high rate of activity.³⁴ Estimated recoverable reserves in the Marcellus have ranged from 1.9 trillion cubic feet (“TCF”) by a 2002 publication from the United States Geological Survey to 262 TCF by the Department of Energy’s estimation in 2009.³⁵ Though these numbers indicate

(stating and showing on map that the Marcellus Shale bed covers six states in the northeastern U.S. including Ohio, New York, West Virginia, Pennsylvania, Kentucky, and Tennessee).

33. Office of Research and Development, *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*, ENVIRONMENTAL PROTECTION AGENCY 10 (Nov. 2011), http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/upload/hf_study_plan_110211_final_508.pdf.

34. Cf. Timothy J. Considine, et al., PENNSYLVANIA STATE UNIVERSITY COLLEGE OF EARTH AND MINERAL SCIENCES DEPARTMENT OF ENERGY AND MINERAL ENGINEERING, *THE PENNSYLVANIA MARCELLUS NATURAL GAS INDUSTRY: STATUS, ECONOMIC IMPACTS AND FUTURE POTENTIAL* 28–29, fig. 15, available at <http://eidmarcellus.org/wp-content/uploads/2011/07/Final-2011-PA-Marcellus-Economic-Impacts.pdf> (highlighting the economic benefits from development of the Marcellus basin in Pennsylvania primarily and by implication all other states with Marcellus drilling operations).

35. See Russell Gold, *Gas Producers Rush to Pennsylvania: Promising Results There Spur Investment*, INVESTORVILLAGE, (Apr. 2, 2008), <http://investorvillage.com/smbd.asp?mb=2234&mn=101279&pt=msg&mid=4468651>; *Modern Shale Gas Primer*,

enormous reserves of natural gas, current technology may only be able to unlock a fraction of these estimates.³⁶ Access to the Marcellus shale play was limited for a time, as New York enacted a complete moratorium on hydraulic fracturing while data on environmental and health concerns was compiled.³⁷ Recently the moratorium has been lifted in places where contamination to drinking water is unlikely, though areas near major watersheds are still protected as a general precaution.³⁸

Where the Marcellus shale formation is one of the most recognized and largest fields in the United States, the Bakken shale may be the most prolific and profitable. Stretching out over an area covering parts of Montana, North Dakota and up into Canada, the Bakken shale play presents an entirely different set of operational hurdles than other fields. (see Map No. 1). Extreme weather and a lack of pipeline or other resource transportation infrastructure has been a major limiting agent in Bakken production. Estimated recoverables in the Bakken formation vary depending on the source, though the United States Geological Survey reported estimates of 3.0 to 4.3 billion barrels of oil recoverable.³⁹ As an oil rich field, the Bakken is currently attractive due to the high value margin of oil as opposed to natural gas.⁴⁰ Toreador Resources Corporation,

supra note 1, at 17,21.

36. See S.S. Suthersan, *Hydraulic and Pneumatic Fracturing*, REMEDIATION ENGINEERING: DESIGN CONCEPTS, ch. 9, para. 9.3.1 (1999), <http://www2.bren.ucsb.edu/~keller/courses/esm223/SuthersanCh09HydraulicFracturing.pdf> (noting that hydraulic fracturing has only made “25 to 30% of the U.S. oil reserves economically viable.”); *Marcellus Shale*, DEPARTMENT OF ENVIRONMENTAL CONSERVATION, <http://www.dec.ny.gov/energy/46288.html> (last visited Feb. 23, 2012) (“Geologists estimate that the entire Marcellus Shale formation may contain up to 489 trillion cubic feet of natural gas throughout its entire extent. It is not yet known how much gas will be commercially recoverable from the Marcellus in New York.”).

37. See Hakim & Confessore, *supra* note 5.

38. See *Id.*

39. *3 to 4.3 Billion Barrels of Technically Recoverable Oil Assessed in North Dakota and Montana's Bakken Formation—25 Times More than 1995 Estimate*, U.S. GEOLOGICAL SURVEY (Apr. 10, 2008), <http://www.usgs.gov/newsroom/article.asp?ID=1911>.

40. See *Exposure to Best Oil Resource Play in U.S.*, HAMECK OIL CO., <http://www.hameckoil.com/wp-content/uploads/2011/06/Brigham-Divide-Curve-and-Oil->

Paris Basin Shale Oil

Bakken analogy summary



TOREADOR

	Paris Basin Shale Oil	Bakken
TOC	0 - 12% (avg. 5%)	0 - 40% (avg. 10%)
Tmax	445°C	445°C
Source Rock	Type II	Type II
Organic Matter	Marine plankton + anaerobic bacteria	Marine plankton + anaerobic bacteria
Quartz Content	26% - 58%	20% - 68%
Depositional environment	Marine and oxygen restricted	Marine and oxygen restricted
Competent Layer	<i>Banc de Roc</i>	<i>Middle Bakken</i>
Net Thickness	1 - 40 meters (4 - 130 feet)	2 - 20 meters (7 - 66 feet)
Porosity	Up to 12%	8 - 12%
Permeability	Up to 5mD	0.05 - 0.5 mD
Oil Gravity API	38°	42°

Source: Company estimates based on analysis of publicly available data

Graph No. 1⁴¹

which owns a substantial amount of leases in the Paris Basin shale, has presented data illustrating the many similarities between the geology of the Bakken formation and the Paris Basin shale.⁴² (see Graph No. 1).

The Barnett shale is the birthplace for modern shale exploitation. Directional drilling and hydraulic fracturing were pioneered in the Barnett to great success. During the past decade, Barnett became the testing ground for many of the techniques used around the United States today.⁴³ Not only has

to-Gas-Margins.pdf (comparing the economic advantages of Bakken oil versus natural gas from other regions).

41. Published with permission from Toreador Resources Corporation.

42. Unconventional Oil 2010 Conference Presentation, *Paris Basin Shale Oil*, TOREADOR (Oct. 12, 2010), http://www.toreador.net/images/presentations/Toreador_Unconventional_Oil_2010.pdf.

43. See Russell McLendon, *Big Frack Attack: Is Hydraulic Fracturing Safe?*, MOTHER NATURE NETWORK (Dec. 10, 2010), <http://www.mnn.com/earth-matters/translating-uncle-sam/stories/big-frack-attack-is-hydraulic-fracturing-safe>

the Barnett been a testing ground for technology, but also important for observing the cultural impact from urban drilling. From an efficiency standpoint, the Barnett shale is also the highest producer of gas, with a proven recoverable greater than 2.35 TCF of gas and estimates ranging from 27-30 TCF.⁴⁴

C. French Shale Plays

In France, the major shale play is the Paris Basin. (see Map No. 2 below).

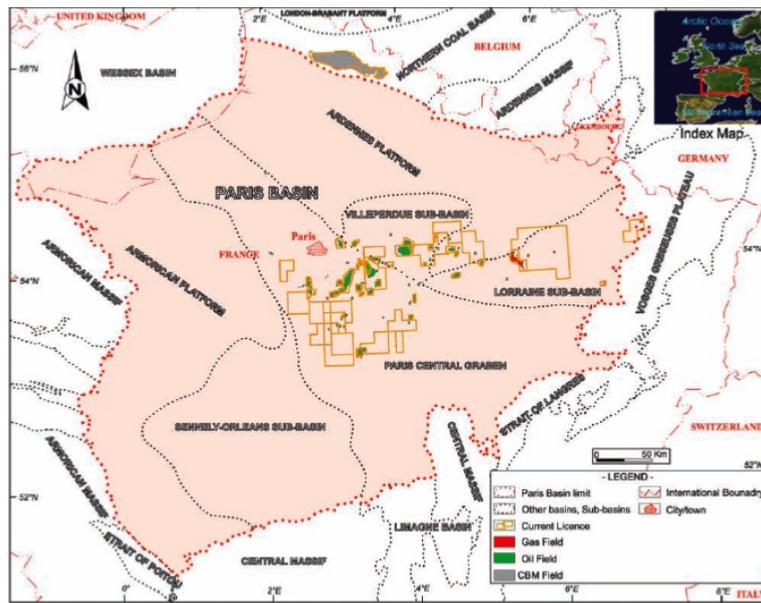


Figure 1 Location and hydrocarbon activity map of the Paris Basin (compiled from IHS data as of July 2008).

Map No. 245

The Paris Basin extends from Paris and central France east,

(discussing the role of the Barnett shale as a testing ground for hydraulic fracturing).

44. THE PERRYMAN GRP., BOUNTY FROM BELOW: THE IMPACT OF DEVELOPING NATURAL GAS RESOURCES ASSOCIATED WITH THE BARNETT SHALE ON BUSINESS ACTIVITY IN FORT WORTH AND THE SURROUNDING 14-COUNTY AREA 27 (2007).

45. Used with permission.

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with some of the best prospects lying in the Champaign region.⁴⁶ In fact, it is very likely that oil reserves could be tapped underneath the Eiffel Tower, though, as discussed below, fracking has been banned in France.⁴⁷ The Paris Basin shale is important because the play is oil rich, close to market, and located in a stable economic environment.⁴⁸ As stated above, the geology of the Paris Basin is often compared to the U.S. Bakken formation in the United States. Sources disagree on the potential of the Paris Basin, and whether it could produce similarly to the Bakken, but cumulative production of conventional wells has been about 285 million bbls.⁴⁹ Though, like the U.S. Bakken, the Paris Basin could benefit greatly from directional drilling and hydraulic fracturing techniques.

Hydraulic fracturing techniques have been banned in France.⁵⁰ Politically, the process has been highly controversial, with a number of large lease permits going out to producers in 2010 only to be halted in mid 2011 based on fears about the practices effect on drinking water.⁵¹ With New York partially lifting its moratorium and EPA research on the horizon, it remains to be seen whether France will lift its ban in the future, however, other European countries with shale potential, like Poland, will explore their own resources.⁵²

46. Anita Elash, *Old World Oil, New World Techniques*, GLOBE ADVISOR (Jan. 13, 2011), <https://secure.globeadvisor.com/servlet/ArticleNews/story/gam/20110113/RBBWBVERMILLION1207ATL#>.

47. Tara Patel, *Toreador Plans to Drill in Paris Basin for Shale Oil Starting Next Month*, BLOOMBERG (Dec. 15, 2010), <http://www.bloomberg.com/news/2010-12-15/toreador-plans-to-drill-in-paris-basin-for-shale-oil-starting-next-month.html>.

48. 48. Unconventional Oil 2010 Conference Presentation, *supra* note 41, at 17.

49. *Id.* at 5.

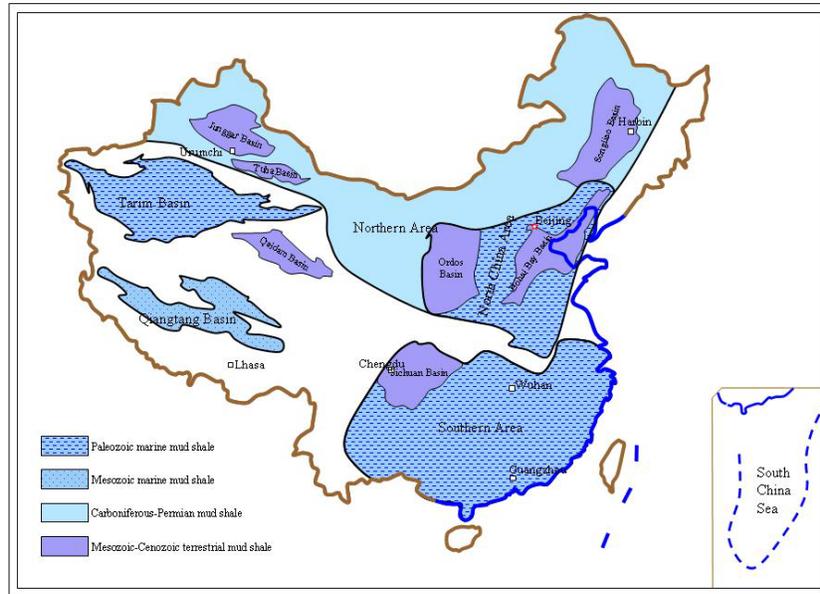
50. Ricciardi, *supra* note 7; *see also* Patel, *supra* note 7.

51. See Mamta Badkar, *France To Ban Fracking*, BUSINESS INSIDER (May 12, 2011), *available at* http://articles.businessinsider.com/2011-05-12/news/30004330_1_shale-gas-fracking-hydraulic (discussing the French government's temporary freeze on shale gas exploration permits due to concern about possible water contamination).

52. Ricciardi, *supra* note 7; Mark Strzelecki & Ladka Bauerova, *Poland Targeting Shale Gas with Exxon, Chevron to End Russian Dominance*, BLOOMBERG (June 8, 2011), *available at* <http://www.bloomberg.com/news/2011-06-07/poland-targeting-shale-gas->

D. Chinese Shale Plays

In China, the major shale plays are the Southern and Northern Formations. Map No. 3 below shows the Southern Area and the Sichuan Basin as well as the Northern Area and the Songliao Basin. (see Map No. 3 below).



Map No. 353

Shale gas resources in China consist of both marine-based areas and terrestrial basins. There are three major marine-based areas: the marine shale in the Southern China Area (Southern Area), the marine shale on the Northern China Area-Gansu Corridor (Northern Area), and the marine shale in the Tarim

with-exxon-to-end-russian-dominance.html; see also Matt Daily & Braden Reddall, *Chevron Profit Jumps with Oil, Output Growth Slow*, REUTERS (July 29, 2011), <http://www.reuters.com/article/2011/07/29/us-chevron-idUSTRE76S2YB20110729> (attributing Chevron's profit gains in part to its added interests in Romania and Poland).

53. Used with permission.

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Basin.⁵⁴ The terrestrial basins are as follows: the Songliao Basin, the Bohai Bay Basin, the Shanganning Basin, the Junggar Basin, and the Tuha Basin.⁵⁵ An in-depth analysis and compilation of geological data for the Chinese shale formations is attached:⁵⁶

<u>Area or Basin</u>	<u>Formation Age</u>	<u>Gas Bearing Area (1000 km²)</u>	<u>Thickness (m)</u>	<u>TOC (%)</u>	<u>R₀ (%)</u>	<u>Prospective Resource (10¹² m³)</u>
Southern Area	Z-J	30-50	200-300	1.0-23.49	2.0-4.0	33-76
Northern Area	O, C-P	20-25	50-180	1.0-7.0	1.5-2.5	22-38
Tarim Basin	E-O	13-15	50-100	2.0-3.0	0.9-2.4	14-22.8
Songliao Basin	C-P, K	7-10	180-200	0.5-4.57	0.9-2.0	5.9-10.5
Bohai Basin	Ek-s	5-7	30-50	1.5-5.0	1.0-2.6	4.3-7.4
Ordos Basin	C-P, T3	4-5	20-50	2.0-22.21	0.8-1.3	3.4-5.3
Junggar Basin	C-J	3-5	150-250	0.47-18.47	1.2-2.3	2.6-5.3
Tuha Basin	C-J	0.8-1.0	150-200	1.58-25.73	0.8-2.0	0.7-1.1

While shale resources in China are abundant, development of

54. Zhang Jingang et al., *Yeyanqi chengcang jili he fenbu* [Shale Gas Reserves: Mechanics and Distribution], 24 TIANRANQI GONGYE [NATURAL GAS INDUS.] 15-18 (2004) (China) [hereinafter *Shale Gas Distribution*] [translation provided by author].

55. *Id.*

56. Courtesy of Cai Nengzou, PetroChina Research Institute of Petroleum Exploration and Development, Beijing, P.R. China [source on file with author].

those resources has not been as prolific as in the U.S.⁵⁷ The China-U.S. development discontinuity has a number of causes.

First, the marine basin in the Southern Area (the Sichuan Basin) is considered a much older formation than the American shale formations.⁵⁸ The deeper location of this formation necessitates deeper drilling, and the associated higher cost to explore, exploit, and produce has been a major deterrence to more systematic and committed development.⁵⁹

Second, due to the age of the Southern Area Formation, the R_o ⁶⁰ value is, on average, 0.7% to 2.1% higher than the American formations.⁶¹ As a result, the TOC⁶² value is lower.⁶³ This exacerbates the higher cost of development of the Chinese shale plays, as each successful well will see less production compared to its American counterpart. Third, post formation seismic activity, mostly in the Sichuan Basin and the associated Southern Formation, has caused shifts and disconnects in the shale formation. In some extreme cases, the shale has been exposed, and a significant amount of organic hydrocarbons have

57. Li Xinjin et al., *Beimei Liefengxing Yeyanqi Tankankaiifa de Lishi* [North American Fractured Shale Gas Exploration and Development], 34 SHIYOU KANTAN YU KAIFA [OIL EXPLORATION & DEV.] 392–400 (2007) (China) [Hereinafter *North American Shale Development*] [translation provided by author].

58. *Id.*; see also Alison Tudor, *China Bets Big on Gas Technology*, WALL ST. J. (Feb. 14, 2011), available at <http://online.wsj.com/article/SB10001424052748703515504576141961147319654.html> (arguing that China's shale reserves have older and denser geologies, which make it costly to extract the gas).

59. See Nell Lukosavich, *Regional Report/ China*, 232 WORLD OIL (Dec. 2011), available at <http://www.worldoil.com/December-2011-Regional-Report-China.html> (describing the technical difficulties, including the location of deeper shale resources, that present monetary challenges to investors).

60. The levels of vitrinite reflectance are measured to determine the thermal maturity of organic matter and ultimately the age of the formation. Higher vitrinite reflectance levels will raise the R_o value, which in this case indicates that the hydrocarbons in the Southern Area Formation are past prime harvesting age.

61. *North American Shale Development*, *supra* note 57; see also *Shale Gas Distribution*, *supra* note 54.

62. Total Organic Carbon.

63. *North American Shale Development*, *supra* note 57; see also *Shale Gas Distribution*, *supra* note 54.

escaped.⁶⁴ Fourth, surface geology has significant influence on development costs. The most developed American shale formations, the Barnett, the Marcellus, and the Bakken are all located on fairly even plains,⁶⁵ whereas the major Chinese formations: the Northern and Southern Formations, are mostly located in mountainous regions.⁶⁶ Development of mountainous regions has a higher development cost due to increase cost of the necessary infrastructure (*i.e.* pipelines, roads, *etc.*).

III. OVERVIEW OF HYDRAULIC FRACTURING

Hydraulic fracturing is defined as “a mechanical method of increasing the permeability of rock, and thus increasing the amount of oil or gas produced from it. The method employs hydraulic pressure to fracture the rock.”⁶⁷ Hydraulic fracturing has become a critical process in shale gas development. The process has been utilized in more than one million wells drilled in the United States, and is gaining favor in unconventional shale plays worldwide.⁶⁸

IV. OVERVIEW OF CENTRIFUGAL TECHNOLOGY

While the use of centrifugal technology in the oil and gas industry is an emerging technology, centrifuges and related technology have existed for many years. In its simplest form, a

64. Wang Dujiao et al., *Shangyangziqiu Zhiliuxi Yeyanqi Chengzang Tiaojian* [Shale Gas Reserve Conditions in the Shang Yang Area], 29 TIANRANQI GONGYE [NATURAL GAS INDUS.] 45–50 (2009) (China) [translation provided by author].

65. Wang Lansheng et al., *Sichuanpendi Yeyanqi Chengcang Dizhi Tiaojian* [Shale Gas Reserve Conditions in the Sichuan Basin], 29 TIANRANQI GONGYE [NATURAL GAS INDUS.] 59–62 (2009) (China) [translation provided by author].

66. *Id.*

67. HOWARD R. WILLIAMS & CHARLES J. MEYERS, OIL AND GAS TERMS 275 (4th ed. 1976).

68. *Freeing Up Energy Hydraulic Fracturing: Unlocking America's Natural Gas Resources*, AMERICAN PETROLEUM INSTITUTE (July 19, 2010), http://www.api.org/policy/exploration/hydraulicfracturing/upload/HYDRAULIC_FRACTURING_PRIMER.pdf; see Adam H. Love, *Fracking: The Controversy Over its Safety for the Environment*, JOHNSON WRIGHT, (Dec. 2011), http://www.johnsonwright.net/newsletters/2011-December/Fracking-The_Controversy_Over_its_Safety_for_the_Environment.htm (discussing the worldwide trend toward the use of fracking in the petroleum industry).

centrifuge is comprised of a fixed base or frame and a rotating part in which a mixture is placed and then spun at a high speed. Capitalizing on forces such as gravity and inertia, this process separates materials of different densities, and can be an extremely efficient process in respect to drill site waste management.⁶⁹ The push to introduce centrifugal technology goes back to early 2000's but languished in Canada until 2005–2006.⁷⁰

A. *The Centrifuge Process*

Horizontal bowl centrifuges (also known as decanters) are primarily used for separating liquids from appreciable amounts of solids.⁷¹ Decanters are capable of separating more than 50% of solids from liquids on a continuous basis.⁷² Various applications of decanters include dewatering of drilling mud, cleaning of tank bottoms, waste oil cleaning, waste water treatment and sludge dewatering.⁷³ A decanter centrifuge separates solids from one or two liquid phases in one single continuous process.⁷⁴ This is done using centrifugal forces that can exceed 3000 times the force of gravity.⁷⁵

B. *Typical Applications*

As previously mentioned, typical applications of centrifugal technology include dewatering of drilling mud, cleaning of tank bottoms, waste oil cleaning, waste water treatment and sludge dewatering. During the dewatering of drilling mud process, the centrifugal dewatering rig is typically placed on site during the preproduction drilling phase, and could be described as being a parasitic loop, feeding off of the drilling rig's normally

69. Interview with Greg Warren, President of Drillsite Solids Management, LLP (Apr. 9, 2011) [on file with author].

70. *Id.*

71. *Decanters*, DOLPHIN MARINE & INDUSTRIAL CENTRIFUGES, http://www.dolphinmarine.com/decanters_new.php.

72. *Id.*

73. *Id.*

74. *Id.*

75. *Id.*

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self-contained drilling fluid swirl tanks, and becoming part of the closed loop drilling rig's fluid delivery systems.⁷⁶ The centrifugal rig cleans and establishes a controlled flow of recycled drilling fluid, with specific viscosity and density as required by the rig operator, back to the closed loop and produces very dry cuttings and solids for haul off by the rig operator.⁷⁷

Centrifugal technology can be used in the cleaning of tank bottoms. During drilling, swirl tanks accumulate sedimented solids as a function of gravity and this fine silt can be vacuumed directly off of the tank bottom via pump, into the centrifugal rig for processing and disposal.⁷⁸

Waste oils in a water based fluid can be separated and recovered, as well, if the rig in place is the right size for such an operation.⁷⁹ Typically the material is pre skimmed from a stand prior to processing by the centrifuge as the specific weight of the

76. See *Rambler Metals & Mining*, PROACTIVEINVESTORS, http://www.proactiveinvestors.com/companies/sponsors_landing/376/rambler-metals-mining-0376.html (last visited Feb. 25, 2012) (noting that the mine in this situation "was fully dewatered while pre-production development" took place); Andrew K. Wojtanowicz, *Modern Solids Control: A Centrifuge Dewatering-Process Study*, 3 SPE Engineering 315 (1988), available at: <http://www.onepetro.org/mslib/servlet/onepetropreview?id=00016098&soc=SPE> (describing the technique of solids control derived from wastewater treatment involving the "centrifuge dewatering of the chemically conditioned pit content.")

77. See generally *Waste Minimization in Drilling Operations*, RAILROAD COMMISSION OF TEXAS, <http://www.rrc.state.tx.us/forms/publications/wasteminmanual/wastemindrillingops.php> (last visited Feb. 25, 2012) (Detailing multiple methods for reclaiming product and reducing waste in drilling operations).

78. See *Drilling Mud Decanter Centrifuge*, GN-DECANTER-CENTRIFUGE.COM, <http://www.gn-decanter-centrifuge.com/mud/vertical-cutting-dryer> (last visited Feb. 12, 2012); *Oilfield Refineries*, MARS TECH US.COM, <http://www.marstechusa.com/oilfield.html> (last visited Feb. 13, 2012).

79. See U.S. Centrifuge, *Wastewater Treatment*, USCENTRIFUGE.COM, www.uscentrifuge.com/wastewater-treatment.php (last visited Feb. 25, 2012) (describing centrifuge and skimming as an effective means of removing waste oil); cf. Oil Skimmers, Inc. OSI Environmental, *Why Skim?*, OILSKIM.COM, www.oilskim.com/whyskim.asp (last visited Feb. 25, 2012) (discussing skimming methods generally); New Logic Research, Inc., *Using Vibrating Membranes to Treat Oily Wastewater from a Waste Hauling Facility*, VSEP.COM, <http://www.vsep.com/pdf/OilyWastewater.pdf> (last visited Feb. 25, 2012) (discussing various waste oil removal processes including centrifuges and their relative costs and advantages).

waste oil may not present itself by “floating” on the surface in the stand.⁸⁰

Waste water management typically takes place on a very large scale and are typically carried out at large static facilities.⁸¹ The challenge this new centrifugal technology faces is creating efficient mobile versions of these static facilities.

V. SELECTED ENVIRONMENTAL REGULATIONS AND THE RELATIONSHIP BETWEEN CENTRIFUGAL TECHNOLOGY

A. *United States*

“The development and production of oil and gas in the U.S., including shale gas, are regulated under a complex set of federal, state, and local laws that address every aspect of exploration and operation.”⁸² The U.S. Environmental Protection Agency (EPA) administers most of the federal laws, while each state has one or more regulatory agencies that permit wells, including their design, location, spacing, operation, and abandonment, as well as environmental activities and discharges, including water management and disposal, waste management and disposal, air emissions, underground injection, wildlife impacts, surface disturbance, and worker health and safety.⁸³

Federal law governs most of the environmental impacts

80. See U.S. Centrifuge, *Wastewater Treatment*, USCENTRIFUGE.COM, www.uscentrifuge.com/wastewater-treatment.php (last visited Feb. 25, 2012) (describing centrifuge and skimming as an effective means of removing waste oil); Cf. Oil Skimmers, Inc. OSI Environmental, *Why Skim?*, OILSKIM.COM, www.oilskim.com/whyskim.asp (last visited Feb. 25, 2012) (discussing skimming methods generally); New Logic Research, Inc., *Using Vibrating Membranes to Treat Oily Wastewater from a Waste Hauling Facility*, VSEP.COM, <http://www.vsep.com/pdf/OilyWastewater.pdf> (last visited Feb. 25, 2012) (discussing various waste oil removal processes including centrifuges and their relative costs and advantages).

81. See U.N. Environment Programme, UN-HABITAT, *Sick Water? The Central Role of Waste-water Management in Sustainable Development*, 25 (Emily Corcoran, et al., eds. 2010), available at http://www.unep.org/pdg/sickwater_screen.pdf (discussing the large-scale infrastructure up which traditional waste water treatments rely).

82. *Modern Shale Gas Primer*, *supra* note 1, at 25.

83. *Id.*

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associated with shale gas development.⁸⁴ Surface water discharges and runoff are governed by the Clean Water Act (CWA), while subsurface fluid injections are governed by the Safe Drinking Water Act (SDWA).⁸⁵ Additionally, the National Environmental Policy Act (NEPA) requires a thorough environmental impact analysis for shale gas operations occurring on federal land.⁸⁶

State regulation of the environmental practices related to shale gas development, usually with federal oversight, can more effectively address the regional and state-specific character of the activities, compared to one-size-fits-all regulation at the federal level.⁸⁷ Not only do state agencies implement and enforce federal laws; they also have their own sets of state laws to administer.⁸⁸ These state laws “often add additional levels of environmental protection and requirements.”⁸⁹ The states “have broad powers to regulate, permit, and enforce all activities—the drilling and fracture of the well,” production operations, and most important to purpose of this article, “the management and disposal of wastes.”⁹⁰ Other levels of government may impose additional regulations and restrictions, including cities, counties, tribes, and regional water authorities, affecting location and operation of wells, requiring permits, or additional approval processes.⁹¹ The entire regulatory scheme in beyond the scope of this article; therefore this article will focus on several important federal and state regulations that relate specifically to centrifugal technology.

1. Clean Water Act

The Clean Water Act (CWA)⁹² “is the primary federal law in

84. *Id.*

85. *Id.*

86. *Id.*

87. *Modern Shale Gas Primer*, *supra* note 1, at ES-3.

88. *Id.*

89. *Id.*

90. *Id.*

91. *Id.*

92. Clean Water Act, 33 U.S.C. §§ 1251–1387 (2011).

the U.S. governing pollution of surface water.”⁹³ The main objective of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters.⁹⁴ “It was established to protect water quality, and includes regulation of pollutant limits on the discharge of oil and gas-related produced water. This is conducted through the National Pollutant Discharge Elimination System (NPDES) permitting process.”⁹⁵ “Under the CWA, EPA has implemented pollution control programs such as setting wastewater standards for industry.⁹⁶ They have also set water quality standards for a variety of contaminants in surface waters.”⁹⁷ Shale gas production sites or commercial facilities “that handle the disposal or treatment of shale gas produced water must obtain permits if they intend to discharge directly into surface waters.”⁹⁸

Large facilities usually have individual NPDES permits. Discharges from some smaller facilities may be eligible for inclusion under general permits that authorize a category of discharges under the CWA within a geographical area. A general permit is not specifically tailored for an individual discharger. Most oil and gas production facilities with related discharges are authorized under general permits because there are typically numerous sites with common discharges in a geographic area.⁹⁹

Effluent limitations serve as the primary mechanism under NPDES permits for controlling discharges of pollutants to receiving waters. When developing effluent limitations for an NPDES permit, a permit writer must consider limits based on both the technology available to control the pollutants (i.e., technology-based effluent standards) and the regulations that protect the water quality standards of the receiving water (i.e.,

93. *Modern Shale Gas Primer*, *supra* note 1, at 29.

94. 33 U.S.C. § 1251.

95. *Id.*

96. *Id.*

97. *Id.*

98. *Id.* at 30.

99. *Id.*

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water quality-based effluent standards). The intent of technology-based effluent limits in NPDES permits is to require treatment of effluent concentrations to less than a maximum allowable standard for point source discharges to the specific surface water body. This is based on available treatment technologies, while allowing the discharger to use any available control technique to meet the limits.¹⁰⁰

The EPA establishes effluent limitation guidelines (ELGs) and standards for different industrial categories.¹⁰¹ “These guidelines are developed based on the degree of pollutant reduction attainable by an industrial category through the application of pollution control technologies.”¹⁰² The onshore subcategory, Subpart C, is applicable to discharges associated with shale gas development and production.¹⁰³

State agencies remain the principal organizations for enforcing water quality regulations. They have inspectors, usually located at regional offices throughout the state, which visit oil and gas well sites to ensure compliance with regulations. When a violation occurs, state enforcement and legal personnel develop the case and order compliance, in many cases also imposing penalties against the violator.¹⁰⁴

Penalties can range from fines to revocation of permits, and even to criminal sanctions in severe cases.¹⁰⁵ Such penalties are usually imposed only after hearings before a board of commissioners or other state body.¹⁰⁶ In addition to fines and penalties, companies that pollute surface or ground water must clean up or remediate the contamination they caused.¹⁰⁷

Implementing centrifugal technology allows shale gas producers to comply with the CWA and related state regulations

100. *Id.*

101. *Id.*

102. *Id.* ELGs for Oil and Gas Extraction can be found at Oil and Gas Extraction Point Source Category, 40 C.F.R. § 435 (2011).

103. 40 C.F.R. § 435.30 (2011).

104. *Id.*

105. *Id.*

106. *Id.*

107. *Id.*

by bringing them into compliance with NPDES permits, which allow a discharger to use any available control technique to meet the limits of the NPDES permit. It is inevitable that a certain lag time will exist between emerging technology and laws regulating these technologies. Thus, the limits contained in current NPDES permits are typically based on older, less efficient technologies available to the discharger. As a result, implementing highly efficient centrifugal technology will allow shale gas producers to comply with the current limits. Eventually the law will respond to emerging technology, and when combined with the serious concerns about the environmental impact of shale gas exploration and production, NPDES permits based on available treatment technologies, are likely to become more stringent. Instituting and developing centrifugal technology will allow producers to come into compliance with a stricter regulatory scheme in the future. Because inspectors visit oil and gas well sites to ensure compliance with regulations regularly, employing centrifugal technology will allow producers to stay in compliance with water regulations and avoid fines, revocation of permits, and criminal sanctions.

2. *Resource Conservation and Recovery Act*

The Resource Conservation and Recovery Act (RCRA)¹⁰⁸ was passed in 1976 to address the growing problems of the increasing volume of municipal and industrial waste.¹⁰⁹ RCRA established goals for protecting human health and the environment, conserving resources, and reducing the amount of waste.¹¹⁰ RCRA Subtitle C established a federal program to manage hazardous wastes in a manner that protects human health and the environment.¹¹¹ Subtitle D of the RCRA addresses non-hazardous solid wastes, including certain hazardous wastes which are exempted from the Subtitle C

108. Resource Conservation and Recovery Act, 42 U.S.C.A. §§ 6901–7000 (2011).

109. *Modern Shale Gas Primer*, *supra* note 1, at 37.

110. *Id.*

111. *Id.*

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regulations.¹¹²

In 1978, EPA proposed hazardous waste management standards that included reduced requirements for some industries, including oil and gas, with large volumes of wastes.¹¹³ EPA determined that these large volume “special wastes” were lower in toxicity than other wastes being regulated as hazardous waste under the RCRA.¹¹⁴ In 1980, the Solid Waste Disposal Act (SWDA) amended RCRA to exempt drilling fluids, produced waters, and other wastes associated with exploration, development, and production of crude oil, natural gas and geothermal energy.¹¹⁵ The SWDA Amendments also required EPA to provide a report to Congress on these wastes and to make a regulatory determination as to whether regulation of these wastes under RCRA Subtitle C was warranted.¹¹⁶

In 1987, EPA issued a Report to Congress that outlined the results of a study on the management, volume, and toxicity of wastes generated by the oil, natural gas and geothermal industries.¹¹⁷ In 1988, EPA issued a final regulatory determination stating that control of oil and gas exploration and production wastes under RCRA Subtitle C was not warranted.¹¹⁸ EPA made this determination because it found that other state and federal programs could protect human health and the environment more effectively.¹¹⁹ These wastes have remained exempt from Subtitle C regulations, but this does

112. *Id.*

113. Env'tl. Prot. Agency, *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations*, <http://epa.gov/epawaste/nonhaz/industrial/special/oil/oil-gas.pdf> (2002).

114. *Id.*

115. Resource Conservation and Recovery Act, Pub. L. No. 96-482, 94 Stat 2334 (1980).

116. Clarification of the Regulatory Determination for Wastes From the Exploration, Development and Production of Crude Oil, Natural Gas and Geothermal Energy, 58 Fed. Reg. 15, 284, 15,287 (March 22, 1993).

117. Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25447 (July 6, 1988).

118. *Modern Shale Gas Primer*, *supra* note 1, at 37.

119. *Id.*

not preclude these wastes from control under state regulations or other federal regulations.¹²⁰

In 1989, EPA worked with the Interstate Oil and Gas Compact Commission (IOGCC), state regulatory officials, industry representatives, and nationally recognized environmental groups to establish a Council on Regulatory Needs.¹²¹ The council was charged with reviewing state exploration and production waste management programs and with establishing guidelines that would represent minimum acceptable regulatory criteria.¹²² These groups then worked together with state regulatory agencies to review the state programs, on a voluntary basis, against these guidelines and to make recommendations for improvement.¹²³ This state review program continues today under the guidance of a non-profit organization called STRONGER.¹²⁴

Although EPA has made the determination that wastes from oil and gas exploration and production should be exempted from Subtitle C of RCRA, the same does not apply to backflow waste generated during the fracing process of natural gas well shale play sites.¹²⁵ Centrifugal technology can be used to facilitate the recovery of the drilling fluids while in preproduction and later as a remediation source post production.¹²⁶ Centrifuge equipment can be used to “desand” the material for reuse downhole, and by recycling these fluids, reduce the exposure of the operator as a function of mathematical volume reductions.¹²⁷ As a result of centrifugal recovery performance, the operators realize the benefits of reduced risk exposure and material demands.¹²⁸ In some instances, these fluids may also be land sprayed at

120. Env'tl. Prot. Agency, *supra* note 113.

121. *Modern Shale Gas Primer*, *supra* note 1, at 38.

122. State Review of Oil and Natural Gas Env'tl. Regulations, *Stronger*, COUNCIL ON REGULATORY NEEDS, <http://www.strongerinc.org/about/council.asp>.

123. *Modern Shale Gas Primer*, *supra* note 1, at 38.

124. *Id.*

125. Interview with Greg Warren, *supra* note 69.

126. *Id.*

127. *Id.*

128. *Id.*

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approved facilities, typically licensed municipal landfills which use them for dust and odor control.¹²⁹

Although the drilling cuttings are specifically exempted under RCRA, they tend to be extremely heavy, especially when an operator leaves fluids in them.¹³⁰ Centrifugal technology allows operators to remove the fluids from the cuttings, thus allowing them to avoid hauling a heavier and ultimately costlier material, to be disposed of.¹³¹ Although centrifugal technology allows operators to recycle drilling fluids and reduce related liability, it does nothing to eliminate salinity issues or isotopes in the backflow fluids that fracing generates.¹³² Additives can be employed to flocculate and control the PH acidity of the fluids, but saline content is onerous and expensive to abate.¹³³ As a result the saltwater disposal wells mentioned previously still have an advantage over centrifugal technology in this respect.¹³⁴

3. *Comprehensive Environmental Response, Compensation, and Liability Act*

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),¹³⁵ commonly known as Superfund, was enacted by Congress on December 11, 1980.¹³⁶ This law created a tax on the chemical and petroleum industries and provided broad federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment.¹³⁷ CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of

129. *Id.*

130. *Id.*

131. *Id.*

132. *Id.*

133. *Id.*

134. *Id.*

135. Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601–9675 (2002).

136. *Modern Shale Gas Primer*, *supra* note 1, at 40.

137. *Id.*

hazardous waste at these sites, and established a trust fund to provide for cleanup when no responsible party could be identified.¹³⁸ CERCLA also requires the person in charge of a vessel or facility to immediately notify the National Response Center when there is a release of a hazardous substance in an amount equal to or greater than the reportable quantity (RQ) for that substance.¹³⁹

CERCLA Section 101(14) excludes certain substances from the definition of hazardous substance, thus exempting them from CERCLA regulation.¹⁴⁰ These substances include petroleum, meaning crude oil or any fraction thereof that is not specifically listed as a hazardous substance, natural gas, natural gas liquids, liquefied natural gas, and synthetic gas usable for fuel.¹⁴¹ If a release of one of these substances occurs, CERCLA notification is not required.¹⁴² Thus, CERCLA reporting will only apply to shale gas production and processing sites if hazardous substances other than crude oil or natural gas are spilled in reportable quantities.¹⁴³

Given the scope of CERCLA, current shale gas production and release of associated wastes are free from regulation, but problems for operators may arise in the future concerning older reserve pits utilized over the last forty years in the United States. A common practice of many operators is to simply bury reserve tanks causing the fluid to become a “sludge-like” material.¹⁴⁴ In some cases reserve pits, having been covered with a polyethylene sheet and buried, are literally in the same condition as the day the pond was covered.¹⁴⁵ While these sites are currently exempt from CERCLA jurisdiction, there is no guarantee that the Superfund law will not be amended to

138. Env'tl. Prot. Agency, *Superfund*, CERCLA OVERVIEW, <http://www.epa.gov/superfund/policy/cercla.htm> (last visited March 25, 2011).

139. CERCLA § 9603.

140. CERCLA § 9601.

141. *Id.*

142. *Id.*

143. *Modern Shale Gas Primer*, *supra* note 1, at 40.

144. Interview with Greg Warren, *supra* note 69.

145. *Id.*

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capture these sites under CERCLA jurisdiction in the future. This is especially true if these substances are found to be toxic and hazardous. Given this possibility, centrifugal technology may play a key role in the future, if operators are forced to remediate these sites under CERCLA.

B. France

Hydraulic fracturing is currently banned in France pending more information on the effect of the practice.¹⁴⁶ Water policy in France is largely governed under European Union directives. Similar to the Clean Water Act in the United States, the E.U. directives generally provide the framework for policy that member states carry out. Importantly, member states such as France also have autonomy to ban practices they find unappealing.¹⁴⁷ Hydraulic fracturing is one such practice currently put on hold by French lawmakers.¹⁴⁸ Hydraulic fracturing has been all but banned for environmental and water safety reasons, pending more information on the practices effects.¹⁴⁹ Few argue that hydraulic fracturing is a potentially environmentally harmful practice without proper regulation. However, under the appropriate regulatory regime hydraulic fracturing can be safely implemented and greatly benefit an ailing European economy.

The environmental concern with hydraulic fracturing starts with safe drinking water. Waste disposal and clean-up are also critically important to environmental quality. This section of the paper outlines the French regulatory systems approach to hydraulic fracturing's environmental impact. E.U. directive 2008/105/EC, dealing directly with chemical pollution in surface water, and a proposed directive on industrial emissions are the most critical directives with respect to drinking water and

146. Ricciardi, *supra* note 7; *see also* Patel, *supra* note 7.

147. *See* Magdalena Lickova, European Exceptionalism in International Law, 19 EUR. J. INT'L L. 463, 464–66 (2008) (noting that despite participating in supranational institutions, EU member states are “sovereign entities,” retaining the right to act apart from the EU collective).

148. Patel, *supra* note 7.

149. *Id.*

hydraulic fracturing.¹⁵⁰ Drilling mud and fracturing fluid compositions impact solid waste management processes. Accordingly, Council directive 1999/31/EC of April 26, 1999 deals with solid wastes management.¹⁵¹ Finally, waste clean-up is regulated under E.U. Directive 2004/35/CE.¹⁵²

1. *Directive 2008/105/EC (safe drinking water and the proposed directive on industrial emissions)*

The European Union water regulation parallels the Clean Water Act in the United States in many respects.¹⁵³ While an exhaustive analysis of EU water law is outside the scope of this paper, this paper will analyze the water directives most closely associated with oil and gas development.

EU Directive 2008/105/EC is specifically concerned with chemical pollution of surface water.¹⁵⁴ Like under the Clean Water Act, the Directive sets out environmental quality standards applicable to member states.¹⁵⁵ The environmental quality standards apply to bodies of surface water, requiring that certain chemical concentrations not exceed defined thresholds.¹⁵⁶

150. Council Directive 2008/105/EC, 2008 O.J. (L 348) 84 (EC).

151. Council Directive 1999/31/EC, 1999 O.J. (L 182) 1 (EC).

152. Council Directive 2004/35/EC, O.J. (L 143) 56 (EC).

153. See generally Holly Doremus, *Adapting to Climate Change With Laws that Bend Without Breaking*, 2 SAN DIEGO J. CLIMATE & ENERGY L. 45 (2010) (comparing antidegradation policy); Richard Thomas, *The European Directive on Protection of Groundwater: A Model for the United States*, 26 PACE ENVTL. L. REV. 259 (comparing eco-system based approaches).

154. Council Directive 2008/105/EC, 2008 O.J. (L 348) 84 (EC), available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0084:0097:EN:PDF>.

155. *Id.*

156. *Id.* at 88 (The standards address both long-term and short-term quality of the surface water); see also *Environmental Quality Standards Applicable to Surface Water*, EUROPA, available at http://europa.eu/legislation_summaries/environment/water_protection_management/128180_en.htm (last updated July 24, 2009) (The long-term quality standards focus on the average concentration of the substance in question over a year long period, and the short-term quality standards set forth the maximum allowable concentration of the substance. The standards vary for lakes and rivers (inland surface waters) and other surface waters, such as coastal waters).

Groundwater is similarly regulated under the E.U. Water Framework Directive.¹⁵⁷ Complementing the Water Framework Directive, the new Groundwater Directive 2006/118/EC addresses water quality standards that account for local characteristics.¹⁵⁸ Effluent standards tailored to shale gas development may also effectuate the quality standards in Europe. In France specifically, waste water permits for industrial use are granted by the River Basin Agencies.¹⁵⁹ However, E.U. Member states are allowed to set up transitional mixing zones where concentrations may exceed the threshold amount for specific circumstances.¹⁶⁰ A member state exceeding an environmental quality standard is not per se breaching the directive either, as the directive sets out limited exceptions.¹⁶¹ For example, exceeding the standards due to a source of pollution outside of a member states national jurisdiction, or transboundary pollution is specifically excepted from the directive.¹⁶²

In the United States, some oil and gas development processes have been excepted from environmental regulation, specifically the Clean Water Act. Hydraulic Fracturing is one such exception, now commonly known as the “Halliburton

157. Council Directive 2000/60/EC, 2000 O.J. (L 327) 1 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:327:0001:0072:EN:PDF>.

158. Council Directive 2006/118/EC, 2006 O.J. (L 372) 19 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF>.

159. ROBERT GALE & STEPHAN BARG, GREEN BUDGET REFORM: AN INTERNATIONAL CASEBOOK OF LEADING PRACTICES, 200–10 (1995); *The System of Water Charges in France*, INSTITUTE FOR INTERNATIONAL SUSTAINABLE DEVELOPMENT, *available at* <http://www.iisd.org/greenbud/france.htm> (last visited Feb. 2, 2012).

160. Council Directive 2008/105/EC, 2008 O.J. (L 348) 84, 86 ¶ 19 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0084:0097:EN:PDF>.

161. *See* Council Directive 2008/105, of the European Parliament and of the Council of 16 December 2008 on Environmental Quality Standards in the Field of Water Policy, 2008 O.J. (L 348) 84 ¶ 26, 87, 89 ¶ 1, 94 n. 1 (EC), *available at* <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:348:0084:0097:EN:PDF>.

162. *Id.* at 84, 87 ¶ 26 (EC).

exception.”¹⁶³ The argument has largely centered on the use of diesel fuel in fracturing fluid, and the serious effect on drinking water should diesel fuel somehow get into the water table.¹⁶⁴ Diesel fuel is not a requisite of hydraulic fracturing fluid, and the public sentiment toward fracturing is suspicious at best.¹⁶⁵ Although drinking water contamination by fracture fluid migration is hardly likely, transportation spills do occur, and faulty casinghead is a possibility at any well.¹⁶⁶ The benefit of excepting fracturing fluid from E.U. water directives, or from French domestic regulation may not outweigh the potential hurdles. Furthermore, reaching stringent effluent limitations set by the French regulators is unlikely to force out the much needed economic benefit of shale gas production.

Currently utilized centrifugal technology to manage drillsite waste can significantly enhance operator compliance. When the fracturing fluid is pumped back up out of the wellbore, along with drilling mud, centrifugal technology separates the fluids from the solids.¹⁶⁷

Perhaps the greatest benefit of using centrifugal technology is the ability to re-use the drilling fluids. Re-using the fluid not only reduces the amount of effluent produced by an operator, but also reduces the amount of water required to fracture a

163. *Halliburton Loophole*, EARTHWORKS, <http://www.earthworksaction.org/halliburton.cfm>.

164. Tom Zeller Jr., *Gas Drilling Technique Is Labeled Violation*, N.Y. TIMES (Jan. 31, 2011), <http://www.nytimes.com/2011/02/01/business/energy-environment/01gas.html>.

165. A Memorandum of Agreement, EPA and Halliburton Energy Services, Elimination of Diesel Fuel in Hydraulic Fracturing Fluids Injected into Underground Sources of Drinking Water During Hydraulic Fracturing of Coalbed Methane Wells (Dec. 12, 2003), available at http://www.epa.gov/safewater/uic/pdfs/moa_uic_hydract.pdf.

166. See Katy Gresh, *DEP Fines Atlas Resources for Drilling Wastewater Spill in Washington County*, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION, <http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=13595&typeid=1>.

167. American Petroleum Institute, *Hydraulic Fracturing Operations—Well Construction and Integrity Guidelines*, at 18–19 (2009), available at <http://www.shalegas.energy.gov/resources/HF1.pdf>.

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formation.¹⁶⁸ Given the current technological advancements, and utilizing proper regulatory frameworks, France could stand at the world's forefront of safe, efficient, and clean shale gas development.

2. *Council Directive 1999/31/EC of April 26, 1999 (solid waste management)*

The E.U. solid waste regulations seem to parallel RCRA in the U. S. Solids waste management in France is primarily regulated by European Union Directives, and Council Directive 1999/31/EC of 26 April 1999 specifically regulates solid waste management in landfills.¹⁶⁹ The Directive sets out the overall objective of creating “stringent operations and technical requirements” in landfill waste management.¹⁷⁰ Solid wastes are categorized as (1) non-hazardous, (2) hazardous, or (3) inert wastes.¹⁷¹ The directive further outlines the importance of using treatment processes in landfills that are appropriate to specific wastes.¹⁷² Furthermore, the Directive encourages defining classes of waste by technical standards.¹⁷³ In sum, the Directive encourages member states to conform landfill waste management processes. On a general level, solid waste management may be regulated efficiently into the above three categories using technical standards, however shale gas development wastes may not be as easily conformable.

Drilling mud and hydraulic fracturing fluid can contain hazardous substances depending not only on the chemical makeup of the solution, but also on the geology of the formation itself.¹⁷⁴ The solid wastes directive pushes for conformity, and with good reason, but successful exploitation of a shale play

168. Congressional Research Services, *Unconventional Gas Shales: Development, Technology, and Policy Issues*, 34–36 (2009), available at <http://www.fas.org/sgp/crs/misc/R40894.pdf>.

169. Council Directive 1999/31, art. 1, 1999 O.J. (L 182) 1, 3 (EC).

170. *Id.*

171. Council Directive 1999/31, art. 4, 1999 O.J. (L 182) 1, 5 (EC).

172. Council Directive 1999/31, 1999 O.J. (L 182) 1 ¶ 8 (EC).

173. Council Directive 1999/31, 1999 O.J. (L 182) 1, 2 ¶ 13 (EC).

174. American Petroleum Institute, *supra* note 167, at 18.

requires individual treatment.¹⁷⁵ Drilling mud is not a universal compound; in fact it is tailored on an individual basis. Hydraulic fracturing fluid is no different. Dangerous carcinogens like benzene, toluene, xylene, and ethyl benzene have been used in fracturing fluid, though occurring primarily due to the use of diesel fuel.¹⁷⁶

Currently, neither France nor the EU has a directive addressing fracture fluid composition disclosures.¹⁷⁷ A number of states in the U. S. have enacted legislation requiring operators to divulge the chemical composition of fracturing fluid.¹⁷⁸ In order to fully comply with Directive 1999/31/EC, France is likely to enact similar legislation in the future. Without knowing the composition of fracturing fluid, it would be impossible to categorize the waste as it is currently required in France.

The primary obstacle for disclosure in the United States has been the operators themselves. The industry has fought against disclosure primarily because of the proprietary information they claim in their fracturing fluids.¹⁷⁹ Operators argue that large quantities of money go into developing the most appropriate composition for recovery in each individual shale play.¹⁸⁰ However, because mineral ownership in France is so different from that in the United States, it seems operators would be less

175. *Id.* at 34–35.

176. Ian Urbina, *Chemicals Were Injected Into Wells, Report Says*, N.Y. TIMES (Apr. 16, 2011), <http://www.nytimes.com/2011/04/17/science/earth/17gas.html>; see also Zeller, *supra* note 165.

177. See Ruth Wood, *Shale Gas: a provisional assessment of climate change and environment impacts*, TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH, at 57–58, available at http://www.karooplaces.com/wp-content/uploads/2011/06/coop_shale_gas_report_final_200111.pdf.

178. Texas House Bill 3328; Wyoming Oil and Gas Conservation Commission § 45, Ch. 3. Of the Oil and Gas Regulations, available at <http://soswy.state.wy.us/Rules/RULES/7928.pdf>.

179. Mark Jaffee, *Drillers Claim Trade Secrets When They Don't Reveal Chemicals in Fracking Fluid*, DENVER POST (Dec. 4, 2011), available at http://www.denverpost.com/business/ci_19461782.

180. Perry Baycroft, *Low-toxicity Frac Fluid Costs Offshore*, E&P MAG, Nov. 4, 2005, available at http://www.epmag.com/EP-Magazine/archive/Low-toxicity-frac-fluid-cuts-costs-offshore_4124#.

likely to quarrel over disclosure.¹⁸¹ Operators in France do not have the same competitive operators concern as those in the U. S. because of the lack of personal mineral ownership.¹⁸² As stated above, disclosure will be a necessity to properly categorize the waste.

Because the primary danger from fracture fluid exposure is not from seepage into the water table during the fracture process as discussed previously; the primary danger is from accidents or the disposal of the fracturing fluid after it resurfaces from the wellbore, solid waste management should be the site of confrontation.¹⁸³ As with effluent limitations, solids waste management is greatly enhanced through use of centrifugal technology at the drillsite. Drilling mud is heavy with fluids, including fracturing fluid, and difficult to transport and clean.¹⁸⁴ However, utilizing emerging centrifugal technology, an operator can separate the fluids from drilling mud solids.¹⁸⁵ Operators then have less waste weight to transport, and consequently solids waste management sites have less waste to clean.

If French law requires chemical composition disclosures in the future, and operators implement emerging centrifugal technology, the result is a solids waste management process that is more efficient than current models and that can comply with

181. See Harold R. Newman, *The Mineral Industry of France* (2004), available at <http://minerals.usgs.gov/minerals/pubs/country/2004/frmyb04.pdf> (The source explains that France has a tradition of highly-centralized administrative regulations within their economic system. While the current trend is decentralization, government oversight still exists. Therefore it is reasonable to infer that an investor seeking to obtain mineral ownership in France would expect more stringent regulations including disclosure laws).

182. Tara Patel, *Paris Shale-Oil Ban Makes Toreador Casualty of Public Outcry*, BLOOMBERG (June 16, 2011), <http://www.bloomberg.com/news/2011-06-15/paris-shale-oil-ban-makes-toreador-casualty-of-popular-outcry.html>.

183. *Fracturing Fluid Management*, FRACFOCUS CHEMICAL DISLCOSURE REGISTRY, http://www.eoearth.org/article/Energy_profile_of_France (last visited May 24, 2012).

184. Hugh M. French, *Terrain, Land Use and Waste Drilling Fluid Disposal Problems, Arctic Canada*, 33 ARTIC 4 (Dec. 1980), available at <http://pubs.aina.ucalgary.ca/arctic/Arctic33-4-794.pdf>.

185. *Drilling Mud Treating System Drilling fluids treatment*, GN SOLIDS CONTROL, <http://oilfield.gnsolidscontrol.com/drilling-mud-treating-system-fluids-treatment/> (last visited May 24, 2012).

the current, more stringent, water regulation.

3. *E.U. Directive 2004/35/CE (Environmental waste clean-up regulation)*

The E.U. pollution remediation regulation parallels CERCLA.¹⁸⁶ Although the E.U. lacks a Superfund like CERCLA in the United States, European Union Directive 2004/35/CE works to meet a similar objective.¹⁸⁷ Directive 2004/35/EC provides a baseline requirement that E.U. member states must follow for pollution remediation.¹⁸⁸ As a baseline rule however, member states are free to require more stringent rules.¹⁸⁹ Directive 2004/35/CE's main objective is to "prevent and remedy environmental damage" at the community, rather than state, level.¹⁹⁰ The Directive also applies to a wider array of environmental damages than CERCLA, including damage to protected species and habitats, water, and soil.¹⁹¹ Like CERCLA, the Directive establishes a "polluter pays" principle.¹⁹² Unlike CERCLA, no superfund is established for polluters unable to pay. Under the Directive the violating party is strictly liable for any damage caused by specifically prohibited activities.¹⁹³

French wine growing regions are important for more than just domestic and foreign consumption; in fact France accounts for a large amount of its income based on tourism.¹⁹⁴ Shale gas

186. Council Directive 2004/35, 2004 O.J. (L 143).

187. See Directive 2004/35, of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage, 2004 O.J. (L 143/56) 56 ¶ 1 (EC), available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:143:0056:0075:EN:PDF>

188. Council Directive 2004/35/CE, 2004 O.J. (L 143) 56 ¶ 3 (EU).

189. *Id.* at 58 ¶ 29.

190. *Id.* at 59 art. 1.

191. *Id.* at 57 ¶ 9.

192. *Id.* at 56 ¶ 2.

193. *Id.*

194. *France is the World's Number One Tourist Destination*, FRANCE DIPLOMATIE, <http://www.diplomatie.gouv.fr/en/france/welcome-to-france/general-points-6984/article/france-is-the-world-s-number-one> (last visited May 24, 2012) (stating that International tourism revenues reached €35 Billion in 2006 and identifying France as the world's

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development's effects on tourism are not yet fully understood. Furthermore, a liable party under Directive 2004/35/CE is required to make preventative action if an immediate threat of environmental damage occurs, as well as remedy any actual damage.¹⁹⁵

Reserve pits and accidents make up the most likely circumstances to invoke Directive 2004/35/EC in oil and gas production operations.¹⁹⁶ However, as previously discussed, implementing emerging centrifugal technology reduces the volume of waste and waste disposal requirements at the drillsite.¹⁹⁷ Furthermore, on drillsites where centrifugal technology was not used, such technology can be later implemented for remediation purposes later.

C. China

Hydraulic fracturing is not regulated directly in China. Water policy is defined through the 中华人民共和国水污染防治法/Zhonghua Renmin Gongheguo Shuiwuran Fangzhi Fa or The Water Pollution Prevention and Control Law (WPPCL).¹⁹⁸ The 中华人民共和国固体废物污染环境防治法/Zhonghuan Renmin Gongheguo Gutifeiwu Wuran Huanjing Fangzhifa or The Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (PCEPSW) is comparable to RCRA in the U.S. though enforcement is limited. The 中华人民共和国环境保护法/Zhonghua Renmin Gongheguo Huanjin Baohufa or The Environmental Protection Law of the People's Republic of China (EPL) provides the closest

number one tourist destination).

195. Council Directive 1999/31, art. 6, 1999 O.J. (L 182) 1, 3 (EC).

196. See *New Offshore Drilling Rules*, EU ISSUE TRACKER: REGULATORY MONITORING, Oct. 28, 2011, <http://www.euissuetracker.com/en/focus/Pages/New-Offshore-Drilling-Rules.aspx>.

197. See *supra* Part III.

198. See Zhonghua Renmin Gongheguo Shuiwuran Fangzhi Fa (中华人民共和国水污染防治法) [LAW OF THE PEOPLE'S REPUBLIC OF CHINA ON THE PREVENTION AND CONTROL OF WATER POLLUTION](promulgated by the Standing Comm. Nat'l People's Cong. Feb. 28, 2008, effective June 1, 2008) (China), available at faolex.fao.org/docs/texts/chn23549.doc.

comparison to CERCLA, but interpretation and enforcement materially limit the EPL. Although it seems contrary, Chinese environmental laws and regulations are fairly comprehensive, but the real problems are the numerous factors pushing against effective enforcement.

1. *中华人民共和国水污染防治法/Zhonghua Renmin Gongheguo Shuiwuran Fangzhi Fa or The Water Pollution Prevention and Control Law (safe drinking water)*

Safe drinking water is of particular concern in China. As a nation holding 22% of the world's population, China only has 7% of the world's accessible fresh water.¹⁹⁹ Estimates have shown that China's freshwater supplies are only capable of supporting 650 million people on a sustainable basis – only half the nation's population.²⁰⁰ The primary Chinese law concerning water policy is the *中华人民共和国水污染防治法/Zhonghua Renmin Gongheguo Shuiwuran Fangzhi Fa or The Water Pollution Prevention and Control Law (WPPCL)*.

The WPPCL was originally enacted in 1984.²⁰¹ The 1984 version of the WPPCL had altogether 7 chapters and 46 articles. It is China's first legislation on pollution prevention and control with a focus on industrial pollution. Since 1984, the WPPCL has undergone two amendments, with the most recent being in 2008.²⁰² The current version of the WPPCL consists of 4 major strategies that attempt to deal with the increasing water pollution in China:

1. Strengthening environmental protection responsibility of local governments.²⁰³

199. Don Hinrichsen, *Freshwater: Lifeblood of the Planet*, PEOPLE AND THE PLANET (2012), <http://peopleandplanet.net/?lid=26385§ion=38&topic=44>.

200. *Id.*

201. See LAW OF THE PEOPLE'S REPUBLIC OF CHINA ON THE PREVENTION AND CONTROL OF WATER POLLUTION, *supra* note 198.

202. See *id.* at Preamble.

203. See *id.* art. 4–5.

2. Increased opportunities for public participation and citizen suits.²⁰⁴
3. Increased fines and more innovative punishment schemes to ensure compliance.²⁰⁵
4. Improvements to several existing control schemes.²⁰⁶

As previously discussed in section 1, one of the most serious barriers to effective enforcement of Chinese environmental laws is local protectionism. Traditionally, Gross Domestic Product (GDP) growth was a key indicator for evaluating the achievement of government officials in Chinese official posts, while an indicator related to environmental quality was present but not considered at all.²⁰⁷ As a result, the success of a local official is dependent only on increased GDP, and the local officials are highly motivated to pursue GDP growth at whatever costs to the environment, as short term GDP increase often means benefits and advancement opportunities.

The 2008 WPPCL amendments tackled this problem by specifically requiring officials above the county level to take into consideration water protection along with economic growth and social development.²⁰⁸ The WPPCL also requires local officials to

204. See *id.* art. 25; see also Jingyun Li & Lingjing Liu, *A China Environmental Health Project Research Brief, Quest for Clean Water: China's Newly Amended Water Pollution Control Law*, CIRCLE OF BLUE, available at http://www.circleofblue.org/waternews/wp-content/uploads/2011/03/water_pollution_law_jan09.pdf (Jan. 2009) (discussing how 2008 WPPCL includes provisions increasing opportunities for public participation and allowing lawsuits on behalf of public interest).

205. See *id.* art. 83, (stating that, if the water pollution accident is ordinary or relatively serious, the fine shall be calculated on the basis of 20 percent of the direct losses caused by the accident; if the accident is serious or extraordinarily serious, the fine shall be calculated on the basis of 30 percent of the direct losses caused by the accident).

206. See *id.* art. 1, 3, 6, 40 (discussing the overall goal of the law to improve the environment through the implementation of strategies and techniques designed to prevent and control water pollution, apply advanced technologies, and increase public education).

207. See Wang Canfa, *Chinese Environmental Law Enforcement: Current Deficiencies and Suggested Reforms*, 8 VT. J. ENVTL. L. 159, 171 (2007).

208. See LAW OF THE PEOPLE'S REPUBLIC OF CHINA ON THE PREVENTION AND CONTROL OF WATER POLLUTION, *supra* note 198, art. 4.

take countermeasures and actions to prevent and treat water pollution, and to be responsible for the quality of the water in their respective regions of administration.²⁰⁹ Perhaps most importantly, the law required as part of a performance evaluation, whether the official is able to accomplish the mandated water protections objectives.²¹⁰ Specifically, provincial governments are required to sign a responsibility pledge with the State Council committing to fulfill the environmental protection target set up in the 11th Five-Year Plan, and the State Council will directly oversee the progress local officials make in fulfilling their pledges.²¹¹

With the guillotine of the local officials' pledge hanging over their heads, there would be a large drive to speedily bring polluted areas into compliance with the environmental protection targets set up in the 11th Five-Year Plan. Centrifugal technology is a strong resource available to achieve those targets. As previously discussed, the effluent limitations standard in the U.S. CWA and the effluent limitations standard in the EU Groundwater Directive are served by centrifugal technology, which recovers over 90% of all water used in hydraulic fracturing.

The new WPPCL sets up a unification system for the release of information to the public. Previously, both the Ministry of Water Resources and the Ministry of Environmental Protection (中华人民共和国水利部/Zhonghua Renmin Gongheguo Shuili Bu and 中华人民共和国环境保护部/Zhonghua Renmin Gongheguo Huanjing Baohubu, respectively) have been publishing this information. However, differences in methods, metrics, and analysis between the two publishing agencies have caused much confusion and conflicts in the reports published. The 2008

209. *Id.* See also Jingyun Li & Lingjing Liu, *A China Environmental Health Project Research Brief, Quest for Clean Water: China's Newly Amended Water Pollution Control Law*, CIRCLE OF BLUE (Jan. 2009), available at http://www.circleofblue.org/waternews/wp-content/uploads/2011/03/water_pollution_law_jan09.pdf (discussing the requirement of provincial governments to sign responsibility pledges with the State Council).

210. LAW OF THE PEOPLE'S REPUBLIC OF CHINA ON THE PREVENTION AND CONTROL OF WATER POLLUTION, *supra* note 198, art. 5.

211. *Id.*

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WPPCL appoints only the Ministry of Environmental Protection to release information on water bodies in China.²¹²

In the United States, private suits are available to ameliorate whatever oversights the EPA may have had in enforcing environmental regulations. However, Chinese requirements are much more stringent.²¹³ The new law aids somewhat in overcoming this hurdle. Article 88 states that environmental protection bureaus and social groups may legally support the parties whose legitimate rights and interests are damaged in a water pollution incident to file a lawsuit.²¹⁴ However, the use of the word “support,” instead of “represent” makes it clear that these groups only have a supporting role, and would not be able to directly represent the injured citizens.²¹⁵ Interestingly enough, Article 88 specifically allows for class actions when injured citizens number above 10, and that these parties can select a representative to file suit for the class.²¹⁶

Inadequate punishment measures have long stood as a barrier against effective enforcement. For example, the implementing regulation of the 1996 WPPCL limited serious water related accidents to 1 million Yuan.²¹⁷ Compared with the economic benefits of illegal pollutant discharge for most enterprises, it was more efficient for the pollutant to eat the penalty and pollute anyway.

Addressing this problem, the new law completely removes ceilings on fines.²¹⁸ Secondly, the new law imposes much tougher fines for other activities violating the law. Under the

212. *Id.* art. 25.

213. Patti Goldman, *Public Interest Environmental Litigation in China: Lessons Learned From the U.S. Experience*, 8 VT. J. ENVTL. L. 251, 255–57 (2007).

214. Prevention and Control of Water Pollution (promulgated by the Standing Comm. Nat'l People's Cong., Feb. 28, 2008, effective Jun. 1, 2008) Art. 88 (China) [hereinafter WPPCL].

215. *Id.*

216. *Id.*

217. *Id.* art. 43.

218. *Id.* art. 83 (setting the fine as a percentage of the losses caused by the accident).

1996 WPPCL, penalties were quite low. For example, fines with an amount of 100,000 Yuan were considered a strict penalty. In the 2008 version of the WPPCL, fines up to 200,000 or 500,000 Yuan are quite common, a two to five times increase.²¹⁹

Article 83 also provides for personal liability against the management. For entities violating the law and causing a water pollution incident, a fine will be imposed upon the polluting entity as mentioned before. If the incident is serious, the person in charge of the polluting entity will be directly liable and fined not more than 50 percent of the income earned from the entity in the previous year.²²⁰ This particular provision is meant to increase accountability in upper management, and decrease incentive to bribe local officials. As such, enterprises are much more motivated to bring into compliance otherwise violating procedures. Management would be highly motivated to seek the best technology in order to effectuate compliance, *i.e.* centrifugal technology.

The 1996 WPPCL did not provide for a pollution permitting process. The new law creates such a system by requiring polluters to obtain a permit. All entities are prohibited from discharging wastewater and sewage without the pollutant discharge permit or they are in violation of the terms of the permit.²²¹ Presumably, this would set the framework for a trading system for allowable pollution, much as the Tokyo Accord creates for world-wide carbon emission.

The use of centrifuge technology would likely not only satisfy the requirements of the permitting system, but allow for a tradable surplus, thus effectively lowering the cost of implementing centrifuge technology for violating enterprises.

One of the most notable provisions in the 2008 WPPCL updates protection specifically for drinking water. Much like the differing effluent standards in the EU Ground Water Directive,²²² this provision provides for specific drinking water

219. *Id.*

220. *Id.*

221. *Id.* art. 20.

222. *Id.* art. 25.

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protection zones. Drinking water source protection zones are classified into Grade I and Grade II, allowing more lax regulations on the peripheries of primary drinking water sources, creating a pollution buffer zone in order to protect the source.²²³ The new law mandates that no new pollution sources can be set up in any protection zones.²²⁴ Moreover, it is prohibited to build, renovate, or enlarge any projects that are not a water treatment facility in a Grade I drinking water protection zone. Similarly, the law prohibits the building, renovating, or enlarging of construction projects that discharge pollutants in a Grade II drinking water source protection zone.²²⁵

2. *中华人民共和国固体废物污染环境防治法/Zhonghuan Renmin Gongheguo Gutifeiwu Wuran Huanjing Fangzhifa or Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (solid waste management)*

RCRA in the U.S. finds its counterpart in the Law of the People's Republic of China on the 中华人民共和国固体废物污染环境防治法/Zhonghuan Renmin Gongheguo Gutifeiwu Wuran Huanjing Fangzhifa or The Prevention and Control of Environmental Pollution by Solid Waste (PCEPSW). However, one major problem with the PCEPSW is inadequate research which has led to disjunction between provisions of the act and the practice of environmental protection.²²⁶ Lawmakers did not have the necessary basic information detailing both the research on the pollution mechanism of solid wastes and the availability of disposal technology methods for solid waste.²²⁷ As such, the provisions are almost impossible to satisfy. Provisions providing for government supervision of the disposal process for solid waste

223. *Id.* art. 56.

224. *Id.* art. 57.

225. *Id.* art. 59.

226. Canfa Wang, *Chinese Environmental Law Enforcement: Current Deficiencies and Suggested Reforms*, 8 VT. J. ENVTL. L. 159, 170 (2007).

227. *Id.*

were drafted in the 1990s. This inadequate research has led to the lax enforcement and compliance of the law. The National People's Congress Standing Committee report indicates that the disposal rate of municipal domestic garbage in 2003 was 58.2%. It remains common for most counties and towns in China to dispose of wastes without any treatment.²²⁸

3. *中华人民共和国环境保护法/Zhonghua Renmin Gongheguo Huanjin Baohufa or The Environmental Protection Law of the People's Republic of China (waste clean-up)*

There is no equivalent to the CERCLA superfund in China. The closest body of law, *中华人民共和国环境保护法/Zhonghua Renmin Gongheguo Huanjin Baohufa* or the Environmental Protection Law of the People's Republic of China (EPL) has none of the specific language in the CERCLA that created liability for persons responsible for release of hazardous wastes, that set specific standards for waste sites, and that sets up the Superfund.²²⁹ The EPL provides a series of amorphous guidelines that are especially weak to interpretation by interested local officials.²³⁰

228. *Id.*

229. WPPCL, *supra* note 214, art. 25.

230. Article 3 of the EPL, provides that "the targets and tasks for protecting and improving the environment shall be defined in urban planning." The chapter requires that all levels of government establish measures to protect "regions representing various types of natural ecological systems, regions with a natural distribution of rare and endangered wild animals and plants, regions where major sources of water are conserved, geological structures of major scientific and cultural value Damage to the above shall be strictly forbidden." Yet, there is nothing that provides for what will happen should damage occur, or what exactly is damage. Article 4 provides that "[t]he plans for environmental protection formulated by the state must be incorporated into the national economic and social development plans; the state shall adopt economic and technological policies and measures favorable for environmental protection so as to coordinate the work of environmental protection with economic construction and social development." The lack of specifics in this provision means that local officials have carte blanche to define and develop policies and measures, whether they are "favorable for environmental protection" can be defined widely precisely due to the lack of specifics. Article 12 provides that "[t]he competent departments of environmental protection administration of the people's governments at or above the county level shall, in

4. *Enforcement Problems*

As previously discussed, the theoretical framework for environmental protection is fairly adequate. However, it is the enforcement of those provisions that are problematic. While some of the lax enforcement could be attributed to problematic drafting in the statutes themselves, the majority of the problem is attributable to corruption, whether it be from local officials²³¹ or from judges²³². For example, 中华人民共和国环境影响评价法/*Zhonghua Renmin Gongheguo Huanjin Yingxiang Pingjiafa*) or China's Environmental Impact Assessment Law (EIA Law) requires the assessment of construction projects affecting the environment.²³³ Article 17 of EIA specifically lists the required elements for this assessment.²³⁴ According to the State Environmental Protection Administration (SEPA), environmental assessments for construction sites exceeded 90% since 1998, and increased to 98.3% in 2002.²³⁵ If these statistics are accurate, and all environmental assessments have been conducted and approved by the appropriate departments, then pollution should be almost non-existent in China. The fact remains that China's

conjunction with relevant departments, make an investigation and an assessment of the environmental situation within areas under their jurisdiction, draw up plans for environmental protection which shall, subject to overall balancing by the department of planning, be submitted to the people's government at the same level for approval before implementation." While this is good law in theory, the previous discussion on the manpower available for the SEPA (now MEP) means that enforcement will necessarily be lax.

231. See Stanley Lubman, *Looking for Law in China*, 20 COLUM. J. ASIAN L. 1, 74 (2006) (explaining that "China's poorly paid government officials are highly vulnerable to corruption").

232. See Jerome Alan Cohen, *China's Legal Reforms at the Crossroads*, FAR E. ECON. REV., March 2006, at 25 (referring to "massive corruption" in the courts); Jim Yardley, *A Judge Tests China's Courts, Making History*, N.Y. TIMES, Nov. 28, 2005, at A1 (explaining that "political pressure on judges is routine").

233. Wang Canfa, *On Limitations of Legislation on Environmental Administration Mechanism of China and the Ways of Perfecting It*, 21 J. OF CHINA UNI. POL. SCI. & L. (Aug. 2003).

234. *Id.*

235. National Development and Reform Commission (NDRC), *Cleaner Production in China*; State Env'tl. Prot. Admin., National Env'tl. Statistics 2002.

environmental condition is continually deteriorating. As an example, 1,921 pollution accidents occurred in 2002 alone.²³⁶ While SEPA has addressed 82 serious violations,²³⁷ 80% of the 70 approved steel construction projects have yet to comply with the EIA Law.²³⁸ These statistics paint a clear picture; the legal framework for environmental protection is a paper tiger, its claws removed by corrupt local officials.

While the executive government in China suffers from corruption, the Chinese legal system also suffers from fundamental flaws. Judges apply legal requirements inconsistently or rule in favor of entrenched political or economic interests because they are beholden to the local officials who pay their salaries and who pressure them to protect the enterprises that provide revenue for the local government.²³⁹

5. *Solutions*

While the problems with the Chinese environmental protection legal framework are still substantial, the Chinese government has taken significant steps in attempting to fix such problems as evidenced by the new WPPCL, and other various enforcement changes.²⁴⁰

236. STATE ENTL. PROT. ADMIN., THE STATISTICS OF THE STATE ENTL. PROT. ADMIN. 2002 (June 5, 2003).

237. STATE ENVTL. PROT. ADMIN., 82 PROJECTS SERIOUSLY VIOLATING EIA RULES BLACKLISTED AND EIA APPROVAL OF CONSTRUCTION PROJECTS IN SOME REGIONS OR ENTERPRISES SUSPENDED (Jan. 12, 2007).

238. *Id.*

239. See Cohen, *supra* note 232.

240. To implement and enforce the various environmental laws, the Environment Supervision Bureau (ESB) was created within SEPA (now MEP) in July 2002. The ESB is charged with spot law enforcement, including: drafting and implementing policies, regulations, and rules to monitor the environment and pollution discharges; guiding and coordinating solutions to pollution problems within local communities, departments, and across jurisdictions; and investigating large-scale pollution accidents and ecosystem destruction. See State Envtl. Prot. Admin., State Envtl. Prot. Admin. Document No. UNCED 2003 190, <http://www.zhb.gov.cn/epi-sepa/zcfg/w3/fa2003-190.htm> (last visited July 27th, 2011). In 2003, the ESB actively pursued its obligations. It carried out 2,290,000 inspections of 410,000 machines (with some machines inspected multiple times). Of these inspections, 1,015,000 dealt with pollution prevention. The ESB also inspected 197,000 newly built and rebuilt projects, 52,000 of which were given a specific

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The problem now for China is coming to be similar to the U.S. and France, *i.e.* having the right technology to ensure that legal limits are readily compliable. As previously discussed, centrifuge technology allows compliance by a wide margin for existing Clean Water Act requirements through the NPDES permits. The combination of technological innovation and legislative revision can mitigate the onslaught of environmental deterioration.

Centrifugal technology will not cure all waste problems associated with oil and gas development, but it alleviates much of the environmental concern at the drillsite. Again, utilizing emerging technology, paired with strong regulatory frameworks are the key to safe, efficient and environmentally responsible energy production.

VI. CONCLUSION

This article has compared selected water, solid waste, and remediation statutes currently existing in the United States, France, and China. In the United States, the Clean Water Act, Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act are the major environmental laws affecting hydraulic fracturing wastes. In France, Directive 2008/105/EC and the accompanied proposed Directive on Industrial Emissions, Council Directive 1999/31/EC of April 26, 1999, and E.U. Directive 2004/35/CE are the major environmental laws affecting hydraulic fracturing wastes. For China, the Water Pollution Prevention and Control Law, the Environmental Protection Law of the People's Republic of China, and the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste are the major environmental laws affecting hydraulic fracturing wastes.

The authors have elucidated common drillsite waste management techniques as space herein has provided. These

deadline to make improvements, and 118,000 of which were issued discharge licenses. *Environment Problems from Various Law Enforcement Initiatives*, SINA NEWS, Apr. 22, 2004, <http://news.sina.com.cn/c/2004-04-22/09582374471s.shtml>.

waste management techniques include: (1) separation of mud from cuttings, (2) solidification and stabilization, (3) onsite burial, (4) bioremediation, (5) commercial disposal facilities. Emerging centrifugal technology appears to solve many of the questions of water quality, conservation and safety to a measurable degree. Additionally, this technology provides appreciable reduction in solid waste. Centrifugal technology can impact current and potential waste sites, providing for less arduous remediation where necessary.