INDICATOR PARAMETERS

- Pre-drill Baseline Groundwater Surveys
- Post-drill Groundwater Monitoring
- Gas Analysis

Ileana A. L. Rhodes, PhD

Environmental Chemistry

Projects & Technology - HSE Technology

Shell Global Solutions (US) Inc.

Technical Workshop on Analytical Chemical Methods

February 25, 2013

USEPA Research Triangle Park Campus

DEFINITIONS AND CAUTIONARY NOTE

The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this presentation "Shell", "Shell group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. "Subsidiaries", "Shell subsidiaries" and "Shell companies" as used in this presentation refer to companies in which Royal Dutch Shell either directly or indirectly has control, by having either a majority of the voting rights or the right to exercise a controlling influence. The companies in which Shell has significant influence but not control are referred to as "associated companies" or "associates" and companies in which Shell has joint control are referred to as "jointly controlled entities". In this presentation, associates and jointly controlled entities are also referred to as "equity-accounted investments". The term "Shell interest" is used for convenience to indicate the direct and/or indirect (for example, through our 23% shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as "anticipate", "believe", "could", "estimate", "expect", "intend", "may", "plan", "objectives", "outlook", "probably", "project", "will", "seek", "target", "risks", "goals", "should" and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including potential litigation and regulatory measures as a result of climate changes; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended 31 December, 2011 (available at www.shell.com/investor and www.sec.gov). These factors also should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, February 25, 2013. Neither Royal Dutch Shell nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation. There can be no assurance that dividend payments will match or exceed those set out in this presentation in the future, or that they will be made at all.

We use certain terms in this presentation, such as discovery potential, that the United States Securities and Exchange Commission (SEC) guidelines strictly prohibit us from including in filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.

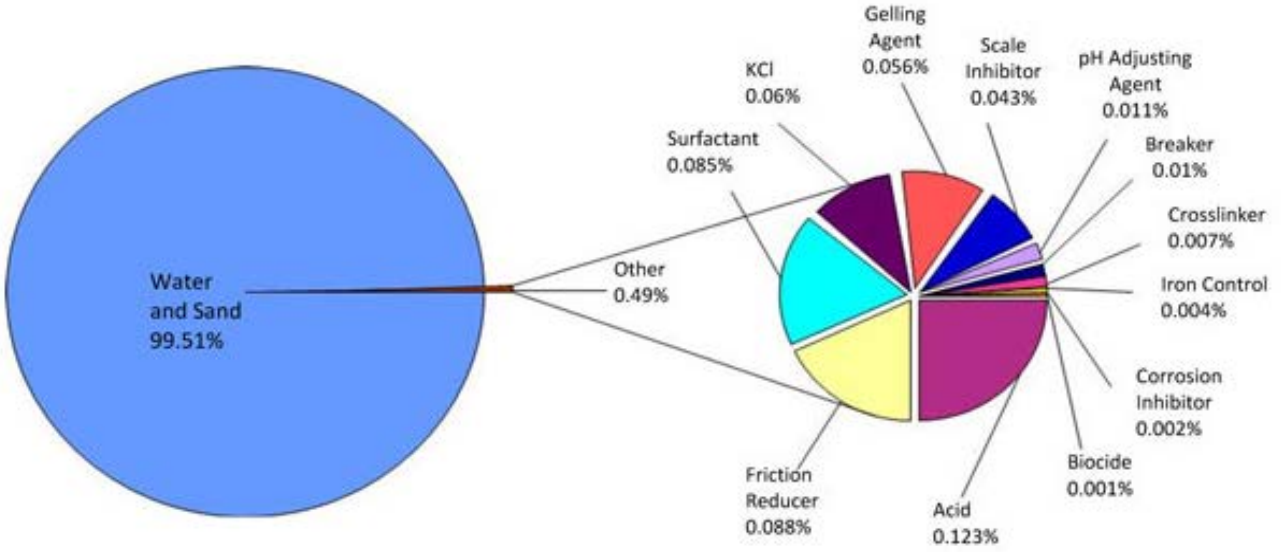
COMMON GROUNDWATER BASELINE PARAMETERS

The parameters listed below are commonly used. ***Many of these parameters are not always useful:***

- Field Screening: pH, Temperature, Specific Conductivity, DO, Redox
- General Water Quality: Alkalinity, TDS, TSS, Hardness, Turbidity, MBAS, TOC
- Anions: Chloride, Sulfate, Bromide, Nitrates (as Nitrogen)
- Total and/or Dissolved Metals: As, Ba, Ca, Cr, Fe, K, Pb, Mg, Mn, Na, Se, Sr
- Organics: BTEX, Dissolved Light Gases (C_1-C_3), glycols
  - $^{13}\delta C$ and $^{2}\delta H$ isotopes of Methane: Headspace or if dissolved methane exceeds a threshold value (1 to 20 mg/L, State-dependent)
  - $^{13}\delta C$ isotopes of Ethane, Propane+
- Radioactivity (less frequently)
  - Gross alpha, gross beta
  - Ra-226, Ra-228 may be more accurate measurements

OVERVIEW: COMPOSITION OF HYDRAULIC FRACTURING FLUIDS

- fracfocus.com has volume information and detailed composition of hydraulic fracturing fluids for most wells
- In general, additives are <1% total volume



Source: Shale_Gas_Primer_2009.pdf - "Modern Shale Gas Development in the United States: A Primer", Ground Water Protection Council (GWP) and ALL Consulting (Fayetteville 2008) for the U.S. Department of Energy, National Energy Technology Laboratory, 2009

- *What paramete[illegible] auic fracturing activities, flowback/produced water?*

INDICATOR PARAMETER SELECTION FOR POTENTIAL IMPACT TO GROUNDWATER FROM HYDRAULIC FRACTURING FLOWBACK/PRODUCED WATER

- Criteria for selection of indicator parameters
  - Relative abundance in flowback/produced water
  - Potential mobility in groundwater systems
  - Ability to identify and accurately quantify the parameter in produced water and groundwater using existing EPA and/or Standard Methods
- Identification of appropriate indicator parameters for assessment of potential impact to groundwater
  - Based on available data on produced water, TDS is significantly higher than any other parameter, chloride is the most abundant anion, sodium is the most abundant cation

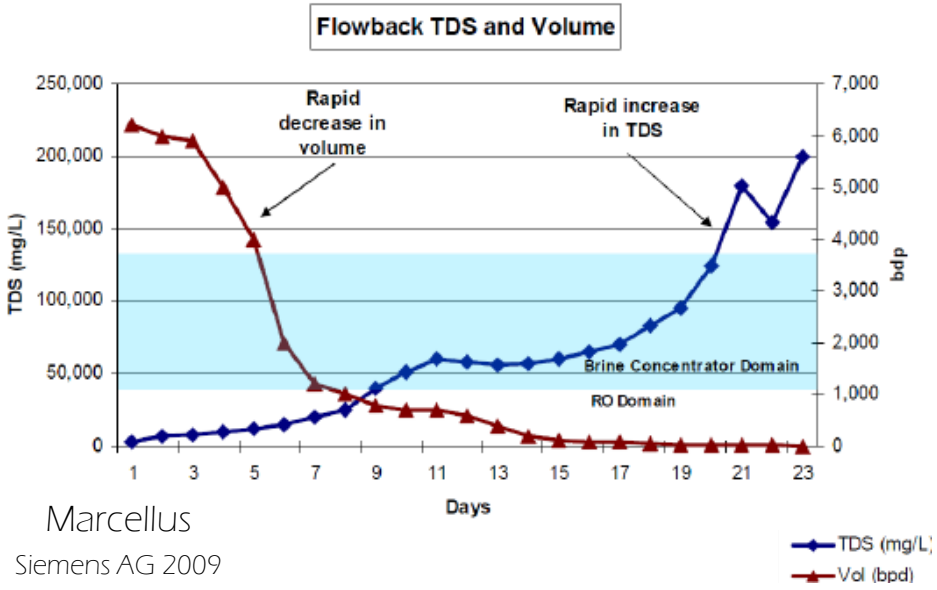
GROUNDWATER, INFLUENT, FLOWBACK, PRODUCED WATER

		Approximate Typical Pennsylvania Groundwater[1]	Influent[2]		5 Day Flowback[2]		Conventional Produced Water[3]
Parameter	**Units**	**Median**	**Range**	**Median**	**Range**	**Median**	**Range**
pH		7.5	6.7 - 7.4	7.2	5.8 - 7.2	6.2	5 - 8
TDS	mg/L	163	35 - 5,500	334	38,000 - 260,000	238,000	3,000 - 350,000
TOC	mg/L	<1	2 - 200	3.8	4 - 388	63	NA
O&G	mg/L	<5	19	31	<0.5 - 100	NA	3 - 100
Chloride	mg/L	5	4 - 3,000	42	26,000 - 148,000	42,000	
Sodium	mg/L	7	26 - 6,200	68	11,000 - 65,000	18,000	

[1] Pennsylvania State University, 2011 , http://www.iogawv.com/Resources/Docs/Marcellus-drinking-water-2011.pdf

[2] Hayes, http://www.epa.gov/hfstudy/12_Hayes_-_Marcellus_Flowback_Reuse_508.pdf

[3] IPEC, 2004 GRI, 1994



Marcellus

Siemens AG 2009

Typical Produced Water TDS Levels (USGS):

–Fayetteville Shale –25,000 mg/L

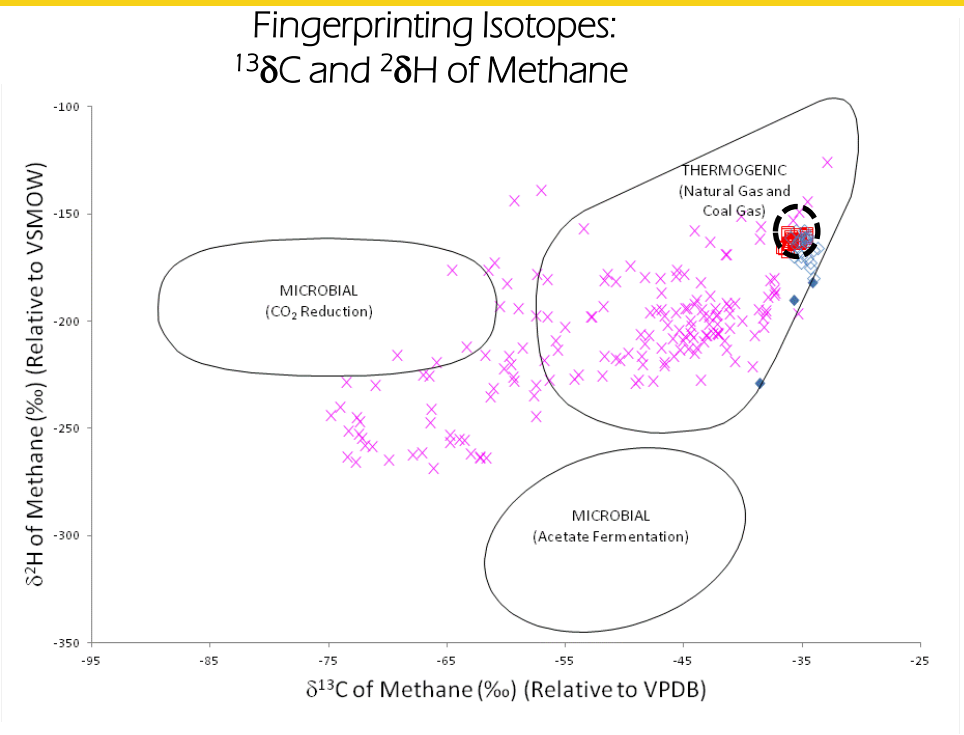
–Barnett Shale –60,000 mg/L

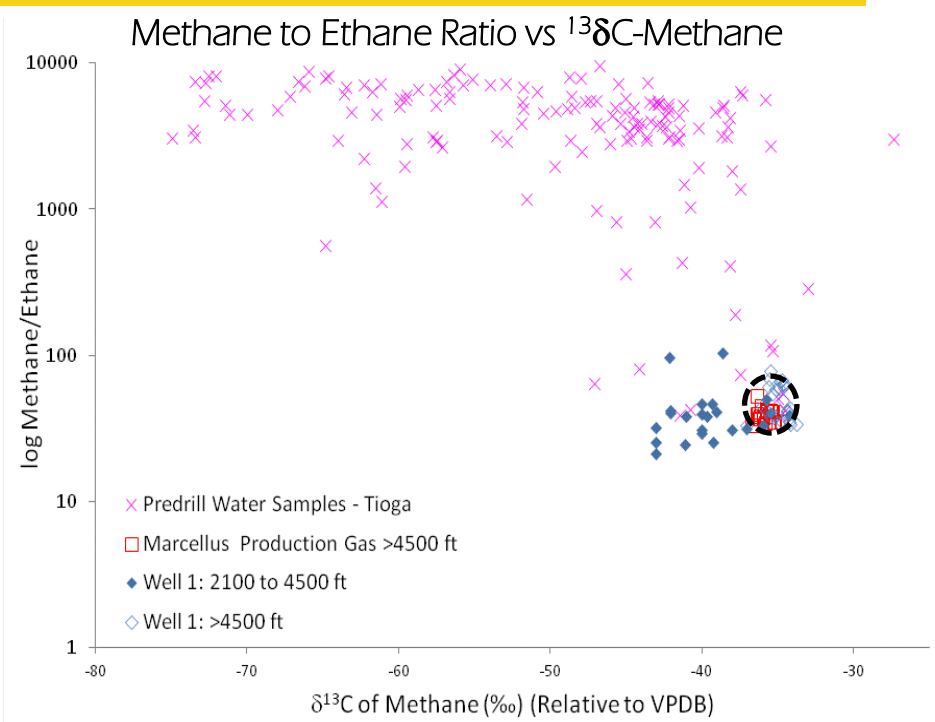
–Haynesville Shale –120,000 mg/L

–Permian Basin –140,000 mg/L

–Marcellus Shale –180,000 mg/L

GAS CHARACTERIZATION

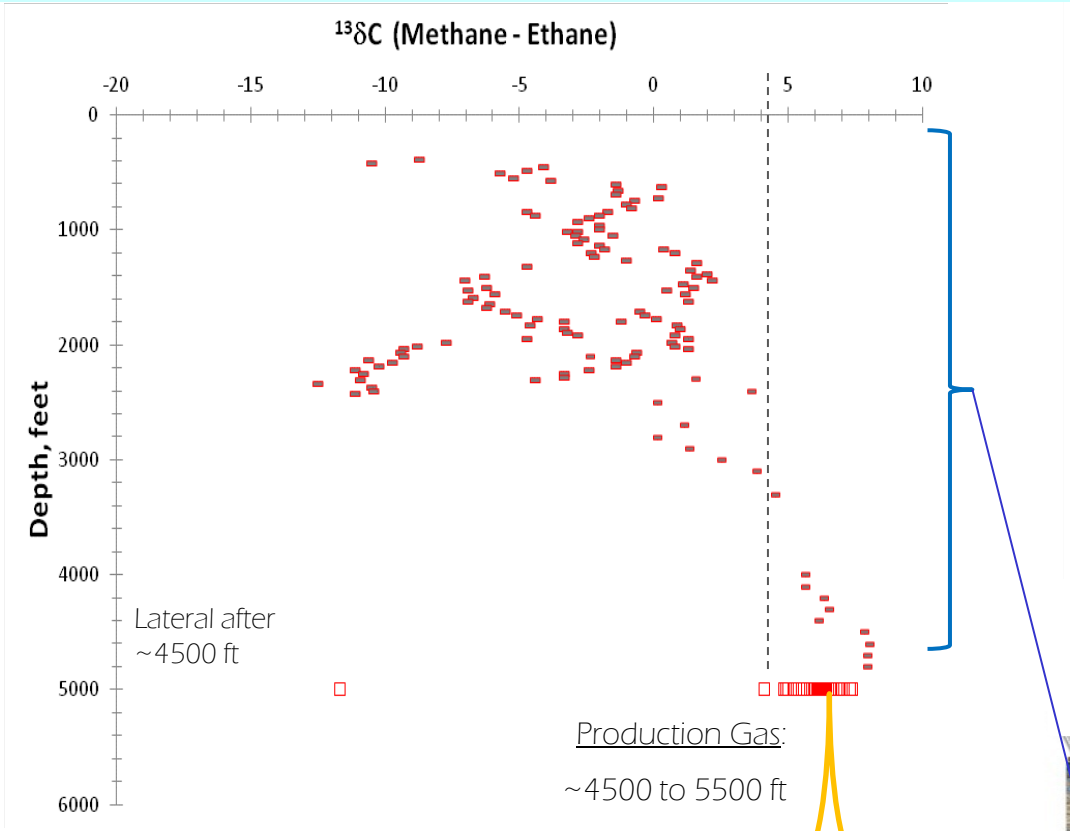


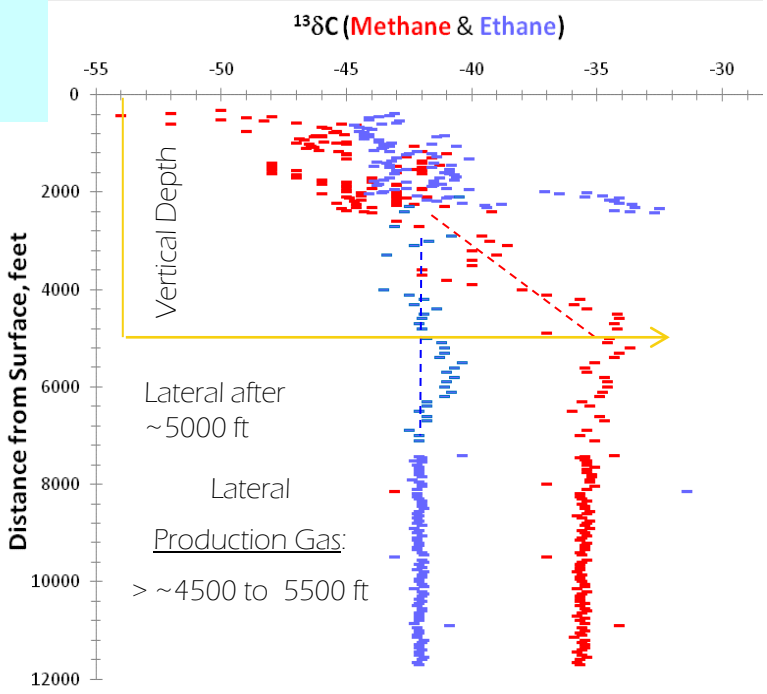


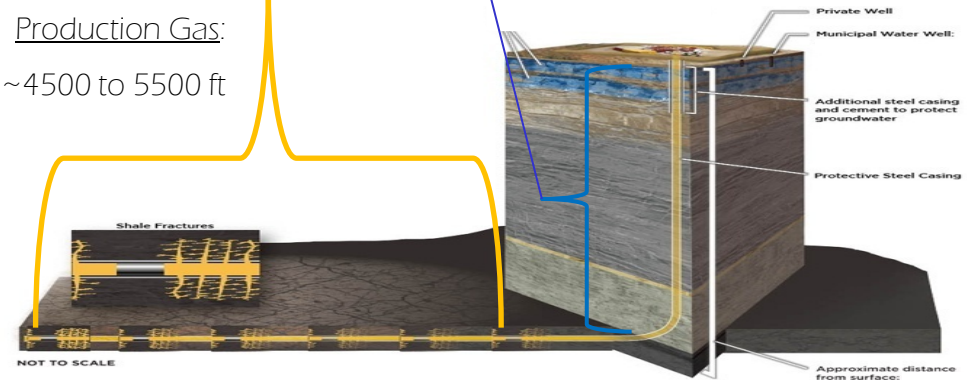
- Lack of consensus on sampling method for casing headspace and dissolved gas
- Gas analyses and isotopic analyses should be carefully considered using multiple lines of evidence to determine potential gas migration source: Mud gas data, geological data, depth profile, area groundwater quality data are essential
- Conduct pre-drill baseline assessment of groundwater and water supply wells including isotopic analyses of headspace and dissolved gas (methane, ethane, propane+)
- Gas can be present in shallow groundwater and shallow to deep zones above shale prior to hydraulic stimulation operations

ISOTOPE REVERSAL - TIOGA: $^{13}\delta$ C-METHANE & $^{13}\delta$ C–ETHANE

- This correlation may not be applicable in the entire county
- Successful source identification requires multiple lines of evidence and a thorough understanding of site conditions







SUMMARY

Groundwater

If indicator parameters (TDS, chloride, sodium) are elevated above pre-drill and/or background conditions in groundwater at a given site or well, further evaluation may be warranted

- Note*: Increases in TDS, chloride, and sodium do not always imply connection to deep production water from hydraulic stimulation*. Changes in water well operations and water table fluctuations may introduce water from restricted flow zones with relatively high salinity and not from production water

Gas

Characterization of pre-drill groundwater and water supply wells, production gas, and shallow mud gas are helpful in gas migration investigations. *Multiple lines of evidence* are necessary for determination of gas composition and isotopic ratios of carbon and hydrogen (preferably methane, ethane, propane) with respect to depth, geologic strata, structure, etc. In areas where "wet" gas is produced, analysis for BTEX may be considered.