Comments Received during the Public Review Period on the "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2010."

Commenter: T. J. Blasing, ORNL

Comment: *While looking at your international bunker fuels estimates on page ES-5 I noticed the footnote indicator after International Bunker Fuels should be c; not b.*

Commenter: Erik Colville

Comment: *Please stop wasting taxpayer money inventorying gasses that are not pollutants, do no harm to our environment or humanity, and even if they were reduced would do nothing measurable to affect climate change. What an embarrassing waste of public resources!*

Commenter: The Fertilizer Institute

Comment: *TFI thanks the Agency for the opportunity to present comments on those sections in the Draft Inventory that specifically describe the fertilizer industry. TFI feels that the review process has played a vital role in maintaining the high quality of the inventory. TFI has evaluated the chapters and annexes specifically related to our industry, including changes since last year's report for individual sources, as well as the executive summary, introduction, and reference sections of this document. TFI offers the following comments on the Draft Inventory. Specific comments are delineated in the sections below. TFI requests that EPA provide a meaningful response to these technical and public comments on the Draft Inventory, so that TFI members can review and understand the Agency's rationale in accepting or rejecting comments. TFI again offers to meet with EPA personnel to discuss concerns and specific comments.*

Commenter: The Fertilizer Institute

Comment: *TFI supports the creation of the Urea Consumption for Non-Agricultural Purposes in the Draft Inventory. The new category reflects a harmonized methodology throughout the Draft Inventory and attributes emissions to categories only when that category generates the emissions in question. TFI again offers to work with EPA on its planned future improvements to the urea consumption for non-agricultural purposes source category, by assisting in obtaining data on*

how much urea is consumed for specific applications in the United States and whether C is released to the environment fully during each application.

- *In Section 4.6 of the Draft Inventory, EPA includes a new, distinct category for Urea Consumption for Non-Agricultural Purposes. See Draft Inventory, pp. 4-20 – 4-22. In this subsection, EPA quantifies the CO2 generated during ammonia production and captured in the production of urea.*
- *TFI supports the inclusion of this category. As delineated in past years' comments, TFI feels that a separate category eliminates a major inconsistency in the Draft Inventory—specifically, that the ammonia/urea production category was one of the few categories in which CO2 emissions resulting from subsequent use of a material were attributed back to the manufacturing industry. TFI had previously stated that release of CO2 during urea consumption is dependent upon the specific use of urea and that there is no basis for assuming that consumed urea releases all CO2 to the environment. Further, because some portion of the non-fertilizer use of urea is attributable to source categories that have greenhouse gas emissions estimated in the Draft Inventory, greenhouse gas emissions may be overstated because of double-counting.*
- *Attributing CO2 emissions associated with urea production to ammonia/urea manufacturers is significant. According to the Draft Inventory, a separate category for non-agricultural uses of urea results in a 27 percent decrease in CO2 emissions identified by EPA for the ammonia/urea production category. Draft Inventory, p. 4-20. The CO2 used to manufacture urea is driven by stoichiometric rates and cannot be manipulated to decrease CO2 emissions attributable to ammonia production. Thus, the separate category for non-agricultural uses treats CO2 content of urea in a manner similar to other non-energy uses of carbon sources–that is, these emissions are attributed to the manufacturing sector emitting the CO2 during urea processing or use.*

Commenter: The Fertilizer Institute

Comment: *TFI requests that EPA provide affected and interested parties with a plan for harmonization of the Draft Inventory and the GHGRP, which results in a single database of GHG emissions in the U.S. based on empirical data. This database should be consistent with IPCC procedures, including the allocation of ammonia CO2 in the production of urea.*

Estimates for the remaining 10-15% of total GHG emissions for sources not included in the GHGRP can be used in the database unless or until the emissions data from these sources are also empirically quantified.

Throughout the Draft Inventory, EPA indicates in the Planned Improvements section that the Agency will use greenhouse gas emissions data from the EPA Greenhouse Gas Reporting Program (GHGRP) as a basis for improving emissions calculations. The EPA states that the Agency will assess how this data could be used to improve the overall method for calculating emissions and specifically assessing data to update emission factors and other calculations (see for example Ammonia Production section at 4-20).

TFI questions the efficacy of this methodology as opposed to harmonizing data to create a single report characterizing domestic greenhouse gas emissions. Now that empirical greenhouse gas emissions data are available in the GHGRP that cover 85-90% of the total greenhouse gas emissions in the U.S., by EPA's own estimate, TFI questions the value of EPA maintaining two separate databases–the Draft Inventory and the GHGRP– to describe these emissions from various sources. TFI believes it makes more sense to harmonize these data and methodologies so that EPA's annual inventory of greenhouse gas emissions in the U.S. is based on actual data, to the extent possible, that are consistent with the Intergovernmental Panel on Climate Change (IPCC) guidance, including the correct allocation of ammonia CO2 used in the production of urea that is subsequently consumed off-site from the ammonia and urea production facility. The use of qualifying disclaimers, such as Some CO2 is captured and is therefore not emitted as found on the GHGRP website, is inconsistent and insufficient in explaining that not all of the CO2 generated during the production of ammonia is emitted from the facility.

Commenter: Mary Power Giacoletti of San Luis Obispo County

Comment: *San Luis Obispo County recently approved a Climate Action Plan to reduce greenhouse gas emissions. The biggest flaw in that plan was the omission of the critical role that black carbon (soot) plays in the climate/pollution dynamic. NASA has listed soot as a top-priority pollutant in that regard. Tackling the enormous global problem of soot first, rather than last, should be an integral part of the EPA's Report. Unfortunately, the issue is as glossed over as it was in our county plan.*

- *There is a passing mention on page 24 (Energy) to difficulties calculating emissions from wood combustion (i.e. fireplaces and wood stoves.) San Luis Obispo County is not atypical. Our greatest, and most dangerous pollution is in the form of soot from mostly antiquated residential fireplaces and wood stoves. We have an additional and fast-growing wood-burning barbecue source, both residential and commercial, along with a similar trend in conversational fire pits. The end result is a very high level of soot and a high rate of disease (heart, cancer, asthma). Why there is difficultyon both the county and the federal level to not only calculate emissions but to reduce them is a bit of a mystery. Soot is a low-hanging fruit in the overall plan to modify global warming. I*

would suggest that the EPA Inventory Report give greater emphasis to the black carbon problem.

- *On page 19 (Energy): In general the carbon content per unit of energy of fossil fuels is the highest for coal products, followed by petroleum, and then natural gas. I believe that a report on the hierarchy of pollutants lists green waste as the highest, followed by dung, followed by wood - then followed by coal, etc.*
- *For the sake of the planet and the basic human right to breathe, I urge the EPA to address the pervasive problem of wood-burning soot in an overall climate/pollution plan.*

Commenter: America's Natural Gas Alliance

Comment: *The change in the methodology for estimating emissions from natural gas well liquid unloading (also referred to as cleanups) account for the majority of the increase in emissions from natural gas production from the 2010 Draft Inventory to the 2011 and 2012 Draft Inventories. The revised methodology contains a critical flaw in its failure to include emission reductions from the use of artificial lift systems, such as plunger lifts, that are not reported under the Natural Gas STAR Program because they are part of economic recovery as opposed to an emissions reduction technology.*

Artificial lift systems provide substantial reductions in emissions from liquid unloading, but as Staff acknowledged in its July 2011 webcast with stakeholders, EPA significantly underestimates their use in the inventory. Generally, venting of gas during lift cycles is an old practice that has been largely replaced with methods that capture the gas. In addition to plunger lift systems – which can eliminate emissions entirely – there are a number of technologies used to reduce or eliminate venting from unloading, including but not limited to:

- *Velocity string (install smaller diameter tubing to increase the velocity);*
- *Compression (reduce tubing pressure);*
- *Pumps;*
- *Gaslift (added gas to boost flow above critical);*
- *Foaming (soap sticks, back side soap injection, cap string);*
- *Injection systems (inject water below packer); and*
- *Venting/Stop Clocking/Equalizing (temporary methods that are used in some cases).*

The omission of emission reductions from the application of these practices results in a worst-case scenario approach that is not appropriate for an emissions inventory and dramatically overestimates the emissions from natural gas production.

EPA's new methodology raises concerns. EPA appears to have developed the methodology based on two sources.5 The first source, an EPA/Natural Gas STAR report Lessons Learned:

Installing Plunger Lift Systems in Natural Gas Wells6, provides an equation for estimating the volume of gas vented during a blowdown:

As noted by El Paso Corporation in their comments on the 2011 Draft Inventory, EPA has not indicated whether the equation or the results were adjusted for the purposes of the Draft Inventory or provided the data, or average characteristics, that EPA used in the equation. EPA states that it used production and permit data obtained from HPDI in October 2009 for at least part of the data to run the equation. HPDI supplied information on well depth, shut-in pressure, well counts and well production data. However, more detail on the data actually used, particularly the data used to calculate shut-in pressure (which is needed to ensure that EPA focused on low pressure wells where liquid unloading is more prevalent), is necessary to adequately evaluate the methodology and results.

The equation only provides the volume vented for each blowdown. To complete the inventory, EPA needs to know how many wells required cleanups (Wc) and how many blowdowns are required annually at those wells (BDa) so that:

*U.S. Methane Emissions from Cleanups = Wc*BDa*Vv*0.7887*

Annex 3, page A-150.

http://epa.gov/gasstar/documents/ll_plungerlift.pdf

The total volume of natural gas must be adjusted to differentiate methane from other gases. EPA assumes that 78.8 percent of vented gas is methane. Annex 3, A-151.

The documentation for the inventory does not indicate what data were used to estimate Wc or BDa. While the HPDI data would have provided the total number of wells, it is unlikely that HPDI's production data would have provided information on which wells perform cleanups and the number of blowdowns performed each year at those wells.

EPA has recently estimated these two variables. Appendix B of the Technical Support Document (TSD) developed in support of Subpart W of the Mandatory Greenhouse Gas Reporting Rule uses data from a 1992 survey conducted by the Gas Research Institute (GRI) to estimate that 41.3 percent of conventional wells require cleanups. The 1992 survey was of 25 well sites.

To determine the average number of blowdowns at each well, the TSD uses a simple average of blowdowns per well based on publicly available data from two Natural Gas STAR partners:

- *BP recovered 4 Bcf of emissions using plunger lifts with automation to optimize plunger cycles on 2,200 wells in the San Juan basin.8 Using the equation for blowdown emissions, EPA determined that 51 blowdowns per well would be required to match the reported 4 Bcf of emissions.*

- *ExxonMobil reported it recovered 12 MMcf using plunger lifts on 19 wells in Big Piney.9 EPA used the blowdown emissions equation to estimate about 11 blowdowns per well to match the 12 MMcf of emissions.*

ANGA notes that the blowdown estimate is based on two isolated data points and does not appear to account for well-specific variables, such as differences in well depth (shallow wells such as those in the San Juan Basin require more blowdowns than deep wells), that drive the number of necessary blowdowns. If EPA has developed additional assumptions for determining the number of blowdowns, including well-specific data, it should disclose them and provide an opportunity for comment.

To address these issues, ANGA supports the alternative approach detailed in El Paso Corporation's comments that begins with estimating emissions per event using approaches similar to those proposed in the Mandatory Reporting Rule and then applying the emissions estimate to wells that (a) use cleanups and (b) do not use artificial lift of any kind. As discussed in the next section, the emissions should also be adjusted for reasonable estimates on the amount of gas that is flared instead of vented.

Emissions from Unconventional Well Completions and Workovers

In the 2011 GHG Inventory, EPA added two new categories: unconventional gas well completions and unconventional gas well workovers.10 The addition of these two categories accounted for 28 percent of the increase in estimated 2008 emissions from natural gas field production from the 2010 to the 2011 GHG Inventory.

The Technical Support Document (TSD) prepared in support of Subpart W outlines the approach EPA used to develop the emissions factor. The Subpart W TSD uses four data points to develop an estimate of emissions from completions. The first presentation, dated September 21, 2004 and given by EPA at a Producer's Technology Transfer Workshop sponsored by the American Petroleum Institute, ExxonMobil Production Company, and EPA includes three of the data points11:

- *The presentation cites an EIA estimate of 45 Bcf of methane emissions from completions and workovers in 2002. In the TSD, EPA uses API's Basic Petroleum Handbook to estimate that there were 5,188 conventional wells drilled in 2002 and 7,783 unconventional wells. Using the default emissions factor from EPA's Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006 for the conventional wells (which EPA reports in the TSD is 49,570 scf/well-year), EPA concludes that conventional wells were responsible for 0.3 Bcf of the 45 Bcf of emissions from completions and workovers in 2002. EPA then divided the remaining 44.7 Bcf by the unconventional wells to arrive at a rounded estimate of 6,000 Mcf/completion.*
- *The second data point in the same presentation was a Natural Gas STAR case study from Devon Energy showing that they implemented reduced emission completion. These terms*

are not commonly used in industry. For clarity and consistency, EPA should use the same terminology it used in Subpart W and in the proposed Oil & Gas NSPS/NESHAP – with and without hydraulic fracturing.

- *The third data point in the same presentation was a case study of a project at three wells in a coal bed methane project. The project captured 2,000 Mcf or about 700 Mcf/completion in EPA's rounded estimate.*
- *The presentation, by the Williams Companies, estimated the natural gas captured from a project to reduce methane emissions from completions at an unconventional natural gas project. EPA's rounded estimate of recovered gas was 20,000 Mcf/completion.*

The Subpart W TSD took these four estimates and calculated a simple average ((6,000 + 10,000 + 700 + 20,000)/4) to arrive at an emissions estimate of 9,175 Mcf/completion for unconventional wells. EPA applied the same number to workovers. Since EPA does not have alternative data, it uses the same factor for recompletions as it does for initial completions.

EPA used the same analysis to estimate emissions from hydraulically fractured well completions and recompletions in the proposed O&G NSPS/NESHAP.13 As noted in ANGA's comments to EPA regarding the O&G NSPS/NESHAP,14 not only is the emission factor based on only four data points with the high end nearly 30 times higher than the low end, a fatal flaw in itself, but none of the data points were purported to be representative estimates of emissions from completions or recompletions. Rather, they are case studies from a voluntary EPA program aimed at reducing emissions (Natural Gas STAR) and, as such, they are reporting the results of a handful of projects in the field. They are not based on standardized and audited protocols. Moreover, case studies, by their nature, are typically based on projects that will provide statistically significant results and are not based on the average project. Since in this context, the best projects are the ones that capture the greatest amount of emissions, using those captured emissions to estimate average uncontrolled emissions can lead to grossly inaccurate results.

The bottom line is that EPA has the methodology backwards. The Agency should evaluate the volumes that are emitted from non-green completion activities rather than rely on green completion volumes from a voluntary program that was never intended to provide inventory-grade information to the Agency. ANGA urges EPA to work with operators to better understand how actual emissions from hydraulically fractured well completions and recompletions compare with their current estimates. We believe that the Agency would find that emissions are significantly less than EPA estimates. For example, eight ANGA member companies recently provided data to URS Corporation on 2011 well completions. As detailed in a memorandum prepared by URS Corporation for ANGA and submitted to EPA as part of the O&G NSPS/NESHAP and updated with a submission to EPA on January 19, 2011, 93% of 1475 wells in the consolidated dataset were green completed, compared to 15% assumed by EPA. Of those wells not completed using REC equipment, only 46% were vented, and the rest were pit flared. Using EPA's recommended method for calculating emissions from gas well completions (Equation W-11B as listed in the proposed September 9, 2011 revisions to Subpart W of the

MRR), URS found that natural gas emissions from vented wells were only about 8% of EPA's estimated emissions on a per well basis (765 Mcf of gas compared to 9175 Mcf used by EPA). The updated memorandum is attached.

In addition, we note that even the data point that was not based on green completions (the EIA data used for the 6,000 Mcf/completion estimate) raises serious concerns. First, when backing out emissions attributable to conventional well completions and workovers, the TSD uses the old emission factors for conventional wells and assumes the rest is attributable to unconventional wells. The TSD provides no support in the EIA data for this assumption, nor does EPA explain why it uses an old emissions factor that has been revised in the TSD.15 Based on the lack of data, a more reasonable approach would be to adjust based on the fraction of conventional wells – 40 percent. Making this adjustment,conventional wells would be responsible for 18 Bcf, leaving 27 Bcf attributable to unconventional wells. The TSD then applies all remaining emissions to completions, instead of first adjusting for workovers (the 45 Bcf applies to completions and workovers, but the TSD emissions estimate is for completions only). For example, according to data in the TSD, there were 13,403 unconventional well completions and workovers in 2007, and of these, 31 percent were workovers. After this adjustment, 18.6 Bcf are attributable to unconventional well completions. Dividing that by the number of completed wells yields an average emission rate of approximately 2,350/Mcf per completion – substantially less than half the estimate in the TSD. This provides further support to the conclusion that EPA's methodology significantly overestimates emissions from unconventional well completions and workovers.

Given the number of uncertainties with respect to the accuracy of the calculations of estimated emissions from well completions and recompletions, including the underlying data and assumptions, and the fact that EPA has not followed its own procedures in development of emissions factors for these activities,16 ANGA believes that it is inappropriate for EPA to continue to use these emissions factors. EPA must develop accurate, peer-reviewed emissions estimations that are based on valid data, assumptions and calculations. ANGA stands ready to continue to work with EPA to develop valid emission factors and estimates for well completions and recompletions that can serve as the basis for more accurate emissions estimates.

Conclusion

ANGA understands EPA's desire to accurately estimate emissions from unconventional wells, but the operative word must be accurately. Given the magnitude of the changes and their impact on the national inventory, the underlying data and assumptions must be rigorous and well supported. That is not the case for either natural gas well cleanups or unconventional well completions and workovers.

Last year, we noted that if the significant flaws in the methodologies were not corrected, the resulting emissions estimates will provide inaccurate information to those who rely on the

national inventory for analysis and decisions, including regulatory action, and undermine the purpose and credibility of the national inventory program. This warning has borne out as a number of researchers have used the 2011 GHG Inventory as the basis for lifecycle analyses of natural gas without acknowledging the clear shortcomings in EPA's methodology. In addition, there are several ongoing federal and state regulatory initiatives that will ultimately rely, in some part, on emission estimates as set forth in the inventory. In light of the serious concerns with respect to the methodology and the quality of the data generated for the Draft Inventory, we ask that either EPA update the emissions estimates for natural gas cleanups and unconventional well completions and workovers or exclude them from the inventory until more robust data and methodologies have been developed and subjected to public comment. At a minimum, EPA should include a statement at the beginning of Chapter 3 of the inventory, and in a footnote to every table and figure that includes emissions from Natural Gas Systems, indicating that it has received information and data related to National Gas System emissions estimates that indicates that the methodology needs to be revised, that the Agency is in the process of revising its methodology, and that until such time as the methodology has been revised and implemented and new emissions estimates based on the revised methodology are available, the emissions estimates in the inventory should not be relied upon or otherwise used as the basis for any analysis or regulatory action.

ATTACHMENTS

Table 1: Summary of Compiled Data

% of Wells GC		**93%**
% of Non-GC Flared		**54%**
Average Non-GC Flowback - AAPG Basin #160A	19 Samples	1,126 mcf
Non-GC Flowback - AAPG Basin #345	28 Samples	1,031 mcf
Non-GC Flowback - AAPG Basin #360	29 Samples	386 mcf
Non-GC Flowback - AAPG Basin #430	5 Samples	943 mcf
Non-GC Flowback - AAPG Basin #535	17 Samples	340 mcf
Average Flowback of Basins		765.1 mcf
Average total flowback of all non-GC events		765.4 mcf
Estimated emissions from well completions with hydraulic fracturing (Table 4-2, EPA TSD)		**9,175 mcf**
Using Equation W-11B		

Figure 2: Distribution of Single-Event Flowback Volumes (Non-Green Completions only)

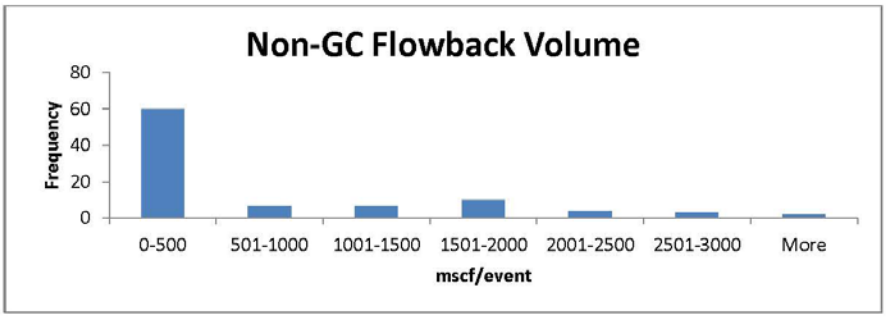


Figure 3: Distribution of Casing Pressures (Non-Green Completions only)

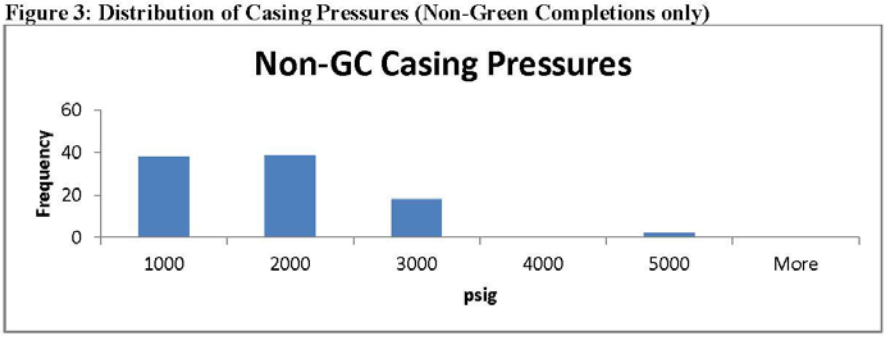


Figure 4: Distribution of Green Completion Durations

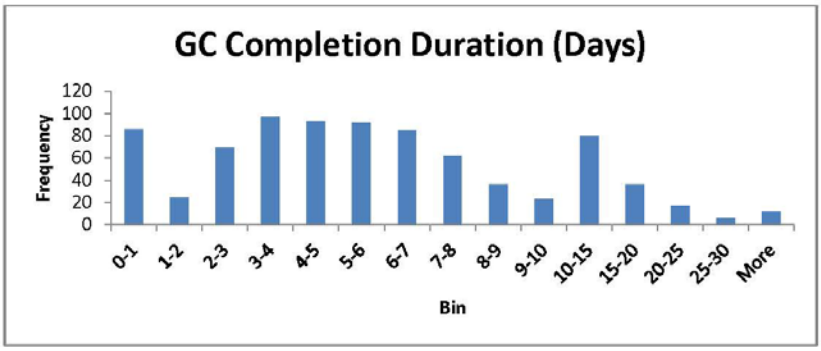


Figure 5: AAPG Basins Represented in Survey Sample (Non-GC Only)

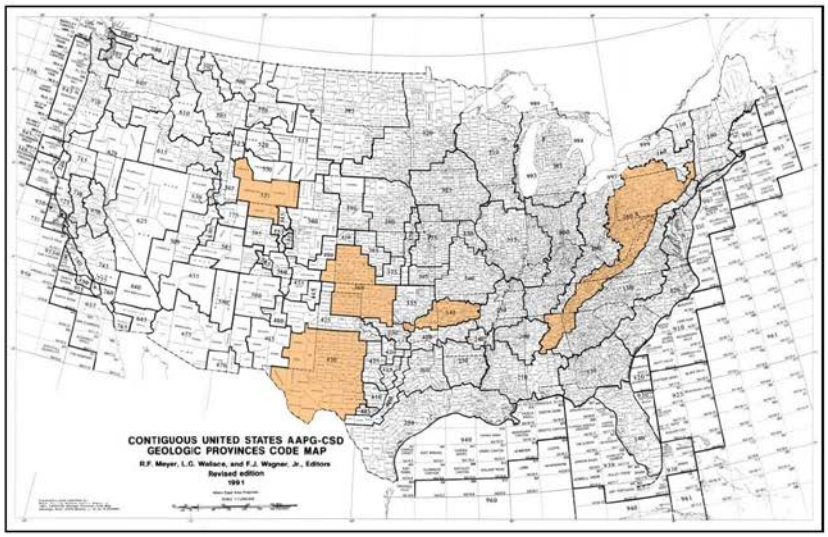
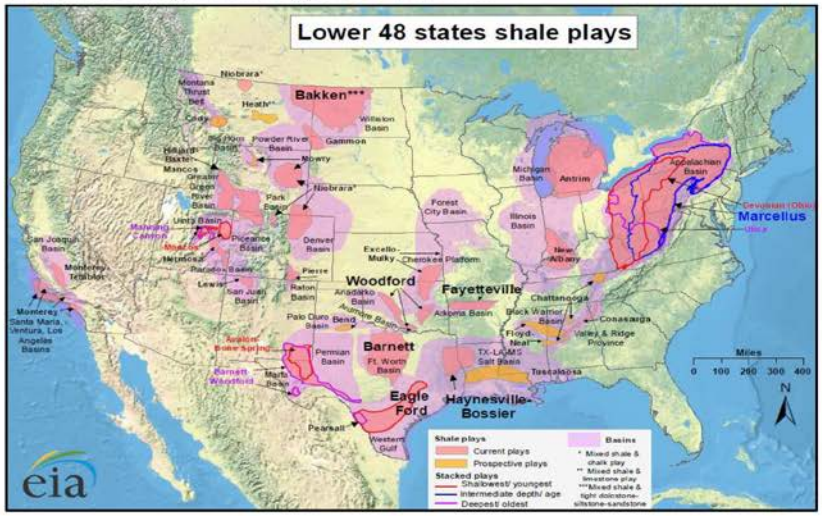


Figure 6: Location of Major Shale Plays in Continental US



Source:
http://www.slb.com/services/industry_challenges/~/media/Files/industry_challenges/unconventional_gas/other/shale_plays_lower_48.ashx

Table 6: Survey Data (Non-Green Completions, non-GC)

Well Number	Date Well Completed	Basin	Vertical or Horizontal?	Exploration, Appraisal, or Development?	Type of Well: Tight Sand, CBM, or Shale?	New Completion or Re-Completion?	Type of Frac: H_2O, N_2, CO_2, or Other	If N_2, Flared or Vented?	When Making Gas: Flowback Duration (Hours)	When Making Gas: MAX Choke Size (64ths)	When Making Gas: MAX Casing Pressure (psig)	Flowback (Mscf)	Duration (Days)
R1 - Well 1	6/1/2011	Delaware	Horizontal	Development	Shale	New Completion	H2O	Flared	336	14	4175	271	14.0
R1 - Well 2	2/23/2011	Delaware	Horizontal	Development	Shale	New Completion	H2O	Flared	120	14	4200	97	5.0
R1 - Well 3	6/28/2011	Delaware	Vertical	Exploration	Shale	New Completion	H2O	Flared	257	46	500	2,236	10.7
R1 - Well 4	7/26/2011	Delaware	Horizontal	Exploration	Shale	New Completion	H2O	Flared	758	24	1900	1,795	31.6
R1 - Well 5	5/4/2011	Delaware	Vertical	Exploration	Shale	New Completion	H2O	Flared	192	20	1900	316	8.0
R1 - Well 6	2/4/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	144	24	1100	341	6.0
R1 - Well 7	2/15/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	216	24	1500	511	9.0
R1 - Well 8	2/16/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	48	18	2300	64	2.0
R1 - Well 9	2/24/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	18	1900	128	4.0
R1 - Well 10	6/7/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	192	22	1100	382	8.0
R1 - Well 11	6/8/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	48	24	1650	114	2.0
R1 - Well 12	6/9/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	120	20	1300	197	5.0
R1 - Well 13	7/28/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	22	2200	191	4.0
R1 - Well 14	7/29/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	72	20	1450	118	3.0
R1 - Well 15	8/2/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	144	64	1250	2,425	6.0
R1 - Well 16	8/27/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	72	22	1350	143	3.0
R1 - Well 17	8/28/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	120	22	1625	239	5.0
R1 - Well 18	8/28/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	22	1550	191	4.0
R1 - Well 19	8/30/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	24	1600	227	4.0
R1 - Well 20	8/31/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	20	700	158	4.0
R1 - Well 21	8/31/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	96	20	1080	158	4.0
R1 - Well 22	8/31/2011	Eastern Green Riv	Vertical	Development	Tight Sand	New Completion	H2O	Flared	120	20	900	197	5.0
R1 - Well 23	5/27/2011	MidCon - Cana	Horizontal	Development	Shale	New Completion	H2O	Flared	59	32	2900	248	2.5
R1 - Well 24	5/18/2011	MidCon - Cana	Horizontal	Development	Shale	New Completion	H2O	Flared	184	20	2400	308	7.7
R1 - Well 25	5/27/2011	MidCon - Cana	Horizontal	Development	Shale	New Completion	H2O	Flared	36	20	4500	59	1.5
R1 - Well 26	6/14/2011	MidCon - Cana	Horizontal	Development	Shale	New Completion	H2O	Flared	48	22	2000	96	2.0
R1 - Well 27	1/14/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	15	24	0	36	0.6
R1 - Well 28	2/4/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	118	24	0	279	4.9
R1 - Well 29	2/23/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	15	48	1350	142	0.6
R1 - Well 30	3/3/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	73	48	2025	691	3.0
R1 - Well 31	3/4/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	24	48	1020	227	1.0
R1 - Well 32	3/22/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	99	48	1750	938	4.1
R1 - Well 33	4/8/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	14	48	1380	133	0.6
R1 - Well 34	4/14/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	11	48	1350	104	0.5
R1 - Well 35	4/29/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	32	48	2400	303	1.3
R1 - Well 36	5/13/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Flared	45	48	2750	425	1.9
R1 - Well 37	5/14/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	58	24	0	137	2.4
R1 - Well 38	5/24/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Flared	79	48	2450	748	3.3
R1 - Well 39	6/2/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	23	24	0	54	1.0
R1 - Well 40	6/29/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	109	48	950	1,032	4.5
R1 - Well 41	7/1/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	31	48	650	294	1.3
R1 - Well 42	7/4/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	52	48	700	493	2.2
R1 - Well 43	7/6/2011	Granite Wash	Vertical	Development	Tight Sand	Recompletion	H2O	Vented	52	24	1550	123	2.2
R1 - Well 44	7/11/2011	Granite Wash	Vertical	Development	Tight Sand	Recompletion	H2O	Vented	35	24	0	83	1.5
R1 - Well 45	7/28/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	169	64	480	2,846	7.0
R1 - Well 46	8/2/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	53	40	950	349	2.2
R1 - Well 47	8/5/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	24	48	2100	227	1.0
R1 - Well 48	8/13/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	3	48	1850	28	0.1
R1 - Well 49	8/19/2011	Granite Wash	Horizontal	Development	Tight Sand	New Completion	H2O	Vented	85	48	850	805	3.5
R2 - Well 1	6/2/2011	160A	HORIZONTAL	Appraisal	Shale	New Completion	H2O	Flared	49	48	1675	464	2.0
R2- Well 2	6/2/2011	160A	HORIZONTAL	Appraisal	Shale	New Completion	H2O	Flared	75	48	1460	710	3.1
R2 - Well 3	6/2/2011	160A	HORIZONTAL	Appraisal	Shale	New Completion	H2O	Flared	97	48	1360	919	4.0
R2 - Well 4	1/5/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	114	48	1500	1,080	4.8
R2- Well 5	1/15/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	70	128	840	4,715	2.9
R2 - Well 6	2/12/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	81	64	740	1,364	3.4
R2 - Well 7	2/18/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	64	64	520	1,078	2.7
R2- Well 8	3/4/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	0	0	0		0.0
R2 - Well 9	3/11/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	139	48	480	1,307	5.8
R2 - Well 10	3/17/2011	345	HORIZONTAL	Development	Shale	New Completion	H2O	Flared	0	0	0		
R2- Well 11	1/31/2011	360	VERTICAL	Development		New Completion	N2	Vented	0	0	0		
R2 - Well 12	6/17/2011	360	HORIZONTAL	Development	Tight Sand	New Completion	H2O	Vented	0	0	0		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 98	5/3/11	Fort Worth Basin	144	6.0
GCR1 - Well 99	5/3/11	Fort Worth Basin	696	29.0
GCR1 - Well 100	5/15/11	Fort Worth Basin	120	5.0
GCR1 - Well 101	5/21/11	Fort Worth Basin	48	2.0
GCR1 - Well 102	5/26/11	Fort Worth Basin	144	6.0
GCR1 - Well 103	5/26/11	Fort Worth Basin	120	5.0
GCR1 - Well 104	5/27/11	Fort Worth Basin	120	5.0
GCR1 - Well 105	5/28/11	Fort Worth Basin	72	3.0
GCR1 - Well 106	5/28/11	Fort Worth Basin	96	4.0
GCR1 - Well 107	5/31/11	Fort Worth Basin	48	2.0
GCR1 - Well 108	5/31/11	Fort Worth Basin	48	2.0
GCR1 - Well 109	6/2/11	Fort Worth Basin	288	12.0
GCR1 - Well 110	6/2/11	Fort Worth Basin	48	2.0
GCR1 - Well 111	6/9/11	Fort Worth Basin	24	1.0
GCR1 - Well 112	6/18/11	Fort Worth Basin	216	9.0
GCR1 - Well 113	6/18/11	Fort Worth Basin	120	5.0
GCR1 - Well 114	6/23/11	Fort Worth Basin	96	4.0
GCR1 - Well 115	6/23/11	Fort Worth Basin	48	2.0
GCR1 - Well 116	6/24/11	Fort Worth Basin	24	1.0
GCR1 - Well 117	6/25/11	Fort Worth Basin	24	1.0
GCR1 - Well 118	6/28/11	Fort Worth Basin	48	2.0
GCR1 - Well 119	7/11/11	Fort Worth Basin	96	4.0
GCR1 - Well 120	7/19/11	Fort Worth Basin	264	11.0
GCR1 - Well 121	8/1/11	Fort Worth Basin	240	10.0
GCR1 - Well 122	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 123	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 124	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 125	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 126	8/2/11	Fort Worth Basin	216	9.0
GCR1 - Well 127	8/9/11	Fort Worth Basin	24	1.0
GCR1 - Well 128	8/15/11	Fort Worth Basin	168	7.0
GCR1 - Well 129	8/17/11	Fort Worth Basin	120	5.0
GCR1 - Well 130	8/19/11	Fort Worth Basin	264	11.0
GCR1 - Well 131	8/19/11	Fort Worth Basin	168	7.0

									When Making Gas				
Well Number	Date Well Completed	Basin	Vertical or Horizontal?	Exploration, Appraisal, or Development?	Type of Well: Tight Sand, CBM, or Shale?	New Completion or Re-Completion?	Type of Frac: H_2O, N_2, CO_2, or Other	If No, Flared or Vented?	Flowback Duration (Hours)	MAX Choke Size (64ths)	MAX Casing Pressure (psig)	Flowback (Mscf)	Duration (Days)
R3 - Well 1	1/21/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	20	32	1642	84	0.8
R3 - Well 2	1/24/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	10	34	2450	48	0.4
R3 - Well 3	3/26/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	13	30	2275	48	0.5
R3 - Well 4	3/26/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	25	32	2500	105	1.0
R3 - Well 5	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	301	48	2853	2,851	12.5
R3 - Well 6	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	198	48	2239	1,875	8.3
R3 - Well 7	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	262	48	2097	2,482	10.9
R3 - Well 8	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	291	64	2100	4,900	12.1
R3 - Well 9	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	271	48	1591	2,567	11.3
R3 - Well 10	6/1/2011	Marcellus	Horizontal	Appraisal	Shale	New Completion	H2O	Flared	172	48	2106	1,629	7.2
R3 - Well 11	7/23/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	152	48	925	1,440	6.3
R3 - Well 12	8/9/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	70	24	2332	166	2.9
R3 - Well 13	8/26/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	39	48	1900	369	1.6
R3 - Well 14	5/18/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	15	48	1581	142	0.6
R3 - Well 15	8/3/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	38	48	268	360	1.6
R3 - Well 16	8/27/2011	Marcellus	Horizontal	Development	Shale	New Completion	H2O	Flared	24	48	1266	227	1.0
R4 - Well 1	1/4/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	980	406	1.0
R4 - Well 2	1/7/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	920	1,617	1.0
R4 - Well 3	1/13/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	570	1,617	1.0
R4 - Well 4	1/17/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	491	1,617	1.0
R4 - Well 5	1/26/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	925	406	1.0
R4 - Well 6	1/29/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	23.94	64	950	403	1.0
R4 - Well 7	2/1/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	1000	1,617	1.0
R4 - Well 8	2/8/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	1000	406	1.0
R4 - Well 9	3/8/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	1124	1,617	1.0
R4 - Well 10	3/11/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	959	1,617	1.0
R4 - Well 11	3/14/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	980	406	1.0
R4 - Well 12	4/1/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	128	580	1,617	1.0
R4 - Well 13	4/4/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	32	128	500	2,155	1.3
R4 - Well 14	4/12/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	72	64	1200	1,212	3.0
R4 - Well 15	4/18/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	1475	406	1.0
R4 - Well 16	4/23/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	1200	404	1.0
R4 - Well 17	4/26/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	35	1060	121	1.0
R4 - Well 18	5/19/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	26	64	1075	438	1.1
R4 - Well 19	5/22/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	23.8	64	590	401	1.0
R4 - Well 20	5/26/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	24	64	1008	404	1.0
R4 - Well 21	5/29/2011	Woodford	Horizontal	Development	Shale	New Completion	H2O	Vented	26	64	985	438	1.1
R5 - Well 1	1/26/2011	East Texas	Vertical	Exploration	Shale	New Completion	H2O	Flared					
R5 - Well 2	1/27/2011	East Texas	Vertical	Exploration	Shale	New Completion	H2O	Flared					
R5 - Well 3	1/13/2011	Arkoma	Vertical	Development	Tight Sant	Re-Completion	N2	Vented					
R5 - Well 4	3/2/2011	Arkoma	Vertical	Development	Tight Sant	Re-Completion	N2	Vented					
R5 - Well 5	1/13/2011	Arkoma	Vertical	Development	Tight Sant	Re-Completion	N2	Vented					

Table 7: Survey Data (Green Completions GC)

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 1	2/7/11	East Texas	433	18.0
GCR1 - Well 2	5/25/11	East Texas	400	16.7
GCR1 - Well 3	1/11/11	East Texas	422	17.6
GCR1 - Well 4	5/26/11	East Texas	474	19.8
GCR1 - Well 5	3/18/11	East Texas	746	31.1
GCR1 - Well 6	1/3/11	East Texas	634	26.4
GCR1 - Well 7	1/9/11	East Texas	108	4.5
GCR1 - Well 8	4/16/11	East Texas	336	14.0
GCR1 - Well 9	1/9/11	East Texas	120	5.0
GCR1 - Well 10	4/5/11	East Texas	276	11.5
GCR1 - Well 11	3/20/11	East Texas	360	15.0
GCR1 - Well 12	3/19/11	East Texas	324	13.5
GCR1 - Well 13	6/8/11	East Texas	264	11.0
GCR1 - Well 14	2/6/11	East Texas	288	12.0
GCR1 - Well 15	8/5/11	East Texas	420	17.5
GCR1 - Well 16	8/31/11	East Texas	156	6.5
GCR1 - Well 17	8/6/11	East Texas	492	20.5
GCR1 - Well 18	6/1/11	East Texas	288	12.0
GCR1 - Well 19	4/10/11	East Texas	540	22.5
GCR1 - Well 20	3/22/11	East Texas	370	15.4
GCR1 - Well 21	7/1/11	East Texas	216	9.0
GCR1 - Well 22	2/25/11	East Texas	490	20.4
GCR1 - Well 23	2/4/11	Eastern Green River	96	4.0
GCR1 - Well 24	2/15/11	Eastern Green River	72	3.0
GCR1 - Well 25	2/15/11	Eastern Green River	72	3.0
GCR1 - Well 26	2/16/11	Eastern Green River	72	3.0
GCR1 - Well 27	2/17/11	Eastern Green River	96	4.0
GCR1 - Well 28	2/25/11	Eastern Green River	96	4.0
GCR1 - Well 29	2/25/11	Eastern Green River	72	3.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 30	6/7/11	Eastern Green River	72	3.0
GCR1 - Well 31	6/8/11	Eastern Green River	72	3.0
GCR1 - Well 32	6/8/11	Eastern Green River	48	2.0
GCR1 - Well 33	6/9/11	Eastern Green River	72	3.0
GCR1 - Well 34	6/22/11	Eastern Green River	48	2.0
GCR1 - Well 35	6/22/11	Eastern Green River	72	3.0
GCR1 - Well 36	6/22/11	Eastern Green River	72	3.0
GCR1 - Well 37	6/23/11	Eastern Green River	72	3.0
GCR1 - Well 38	6/23/11	Eastern Green River	72	3.0
GCR1 - Well 39	7/28/11	Eastern Green River	120	5.0
GCR1 - Well 40	7/29/11	Eastern Green River	96	4.0
GCR1 - Well 41	1/4/11	Fort Worth Basin	48	2.0
GCR1 - Well 42	1/10/11	Fort Worth Basin	24	1.0
GCR1 - Well 43	1/10/11	Fort Worth Basin	72	3.0
GCR1 - Well 44	1/10/11	Fort Worth Basin	72	3.0
GCR1 - Well 45	1/12/11	Fort Worth Basin	24	1.0
GCR1 - Well 46	1/13/11	Fort Worth Basin	48	2.0
GCR1 - Well 47	1/17/11	Fort Worth Basin	48	2.0
GCR1 - Well 48	1/18/11	Fort Worth Basin	144	6.0
GCR1 - Well 49	1/21/11	Fort Worth Basin	144	6.0
GCR1 - Well 50	1/21/11	Fort Worth Basin	264	11.0
GCR1 - Well 51	1/24/11	Fort Worth Basin	120	5.0
GCR1 - Well 52	1/24/11	Fort Worth Basin	48	2.0
GCR1 - Well 53	1/25/11	Fort Worth Basin	168	7.0
GCR1 - Well 54	1/26/11	Fort Worth Basin	24	1.0
GCR1 - Well 55	1/26/11	Fort Worth Basin	168	7.0
GCR1 - Well 56	1/26/11	Fort Worth Basin	24	1.0
GCR1 - Well 57	1/26/11	Fort Worth Basin	144	6.0
GCR1 - Well 58	1/26/11	Fort Worth Basin	96	4.0
GCR1 - Well 59	1/27/11	Fort Worth Basin	48	2.0
GCR1 - Well 60	1/28/11	Fort Worth Basin	72	3.0
GCR1 - Well 61	1/28/11	Fort Worth Basin	96	4.0
GCR1 - Well 62	2/7/11	Fort Worth Basin	72	3.0
GCR1 - Well 63	2/7/11	Fort Worth Basin	24	1.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 64	2/9/11	Fort Worth Basin	72	3.0
GCR1 - Well 65	2/12/11	Fort Worth Basin	72	3.0
GCR1 - Well 66	2/12/11	Fort Worth Basin	48	2.0
GCR1 - Well 67	2/12/11	Fort Worth Basin	168	7.0
GCR1 - Well 68	2/13/11	Fort Worth Basin	72	3.0
GCR1 - Well 69	2/15/11	Fort Worth Basin	144	6.0
GCR1 - Well 70	2/16/11	Fort Worth Basin	96	4.0
GCR1 - Well 71	2/16/11	Fort Worth Basin	48	2.0
GCR1 - Well 72	2/17/11	Fort Worth Basin	24	1.0
GCR1 - Well 73	2/18/11	Fort Worth Basin	672	28.0
GCR1 - Well 74	2/18/11	Fort Worth Basin	672	28.0
GCR1 - Well 75	2/25/11	Fort Worth Basin	24	1.0
GCR1 - Well 76	3/18/11	Fort Worth Basin	96	4.0
GCR1 - Well 77	3/18/11	Fort Worth Basin	96	4.0
GCR1 - Well 78	3/26/11	Fort Worth Basin	72	3.0
GCR1 - Well 79	3/26/11	Fort Worth Basin	192	8.0
GCR1 - Well 80	3/26/11	Fort Worth Basin	120	5.0
GCR1 - Well 81	3/28/11	Fort Worth Basin	120	5.0
GCR1 - Well 82	4/1/11	Fort Worth Basin	24	1.0
GCR1 - Well 83	4/2/11	Fort Worth Basin	96	4.0
GCR1 - Well 84	4/3/11	Fort Worth Basin	240	10.0
GCR1 - Well 85	4/3/11	Fort Worth Basin	72	3.0
GCR1 - Well 86	4/4/11	Fort Worth Basin	240	10.0
GCR1 - Well 87	4/6/11	Fort Worth Basin	72	3.0
GCR1 - Well 88	4/9/11	Fort Worth Basin	168	7.0
GCR1 - Well 89	4/10/11	Fort Worth Basin	120	5.0
GCR1 - Well 90	4/11/11	Fort Worth Basin	336	14.0
GCR1 - Well 91	4/11/11	Fort Worth Basin	216	9.0
GCR1 - Well 92	4/13/11	Fort Worth Basin	144	6.0
GCR1 - Well 93	4/26/11	Fort Worth Basin	216	9.0
GCR1 - Well 94	4/26/11	Fort Worth Basin	216	9.0
GCR1 - Well 95	4/29/11	Fort Worth Basin	96	4.0
GCR1 - Well 96	5/1/11	Fort Worth Basin	744	31.0
GCR1 - Well 97	5/2/11	Fort Worth Basin	552	23.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 98	5/3/11	Fort Worth Basin	144	6.0
GCR1 - Well 99	5/3/11	Fort Worth Basin	696	29.0
GCR1 - Well 100	5/15/11	Fort Worth Basin	120	5.0
GCR1 - Well 101	5/21/11	Fort Worth Basin	48	2.0
GCR1 - Well 102	5/26/11	Fort Worth Basin	144	6.0
GCR1 - Well 103	5/26/11	Fort Worth Basin	120	5.0
GCR1 - Well 104	5/27/11	Fort Worth Basin	120	5.0
GCR1 - Well 105	5/28/11	Fort Worth Basin	72	3.0
GCR1 - Well 106	5/28/11	Fort Worth Basin	96	4.0
GCR1 - Well 107	5/31/11	Fort Worth Basin	48	2.0
GCR1 - Well 108	5/31/11	Fort Worth Basin	48	2.0
GCR1 - Well 109	6/2/11	Fort Worth Basin	288	12.0
GCR1 - Well 110	6/2/11	Fort Worth Basin	48	2.0
GCR1 - Well 111	6/9/11	Fort Worth Basin	24	1.0
GCR1 - Well 112	6/18/11	Fort Worth Basin	216	9.0
GCR1 - Well 113	6/18/11	Fort Worth Basin	120	5.0
GCR1 - Well 114	6/23/11	Fort Worth Basin	96	4.0
GCR1 - Well 115	6/23/11	Fort Worth Basin	48	2.0
GCR1 - Well 116	6/24/11	Fort Worth Basin	24	1.0
GCR1 - Well 117	6/25/11	Fort Worth Basin	24	1.0
GCR1 - Well 118	6/28/11	Fort Worth Basin	48	2.0
GCR1 - Well 119	7/11/11	Fort Worth Basin	96	4.0
GCR1 - Well 120	7/19/11	Fort Worth Basin	264	11.0
GCR1 - Well 121	8/1/11	Fort Worth Basin	240	10.0
GCR1 - Well 122	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 123	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 124	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 125	8/1/11	Fort Worth Basin	96	4.0
GCR1 - Well 126	8/2/11	Fort Worth Basin	216	9.0
GCR1 - Well 127	8/9/11	Fort Worth Basin	24	1.0
GCR1 - Well 128	8/15/11	Fort Worth Basin	168	7.0
GCR1 - Well 129	8/17/11	Fort Worth Basin	120	5.0
GCR1 - Well 130	8/19/11	Fort Worth Basin	264	11.0
GCR1 - Well 131	8/19/11	Fort Worth Basin	168	7.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 132	8/23/11	Fort Worth Basin	384	16.0
GCR1 - Well 133	8/23/11	Fort Worth Basin	360	15.0
GCR1 - Well 134	8/23/11	Fort Worth Basin	384	16.0
GCR1 - Well 135	1/12/11	Fort Worth Basin	144	6.0
GCR1 - Well 136	1/12/11	Fort Worth Basin	144	6.0
GCR1 - Well 137	1/13/11	Fort Worth Basin	168	7.0
GCR1 - Well 138	1/14/11	Fort Worth Basin	192	8.0
GCR1 - Well 139	1/17/11	Fort Worth Basin	120	5.0
GCR1 - Well 140	1/18/11	Fort Worth Basin	336	14.0
GCR1 - Well 141	1/18/11	Fort Worth Basin	336	14.0
GCR1 - Well 142	1/18/11	Fort Worth Basin	576	24.0
GCR1 - Well 143	1/20/11	Fort Worth Basin	72	3.0
GCR1 - Well 144	1/21/11	Fort Worth Basin	168	7.0
GCR1 - Well 145	1/25/11	Fort Worth Basin	408	17.0
GCR1 - Well 146	1/26/11	Fort Worth Basin	168	7.0
GCR1 - Well 147	1/26/11	Fort Worth Basin	168	7.0
GCR1 - Well 148	1/27/11	Fort Worth Basin	120	5.0
GCR1 - Well 149	1/27/11	Fort Worth Basin	168	7.0
GCR1 - Well 150	2/6/11	Fort Worth Basin	288	12.0
GCR1 - Well 151	2/8/11	Fort Worth Basin	600	25.0
GCR1 - Well 152	2/8/11	Fort Worth Basin	48	2.0
GCR1 - Well 153	2/9/11	Fort Worth Basin	144	6.0
GCR1 - Well 154	2/9/11	Fort Worth Basin	192	8.0
GCR1 - Well 155	2/12/11	Fort Worth Basin	240	10.0
GCR1 - Well 156	2/12/11	Fort Worth Basin	432	18.0
GCR1 - Well 157	2/14/11	Fort Worth Basin	360	15.0
GCR1 - Well 158	2/15/11	Fort Worth Basin	192	8.0
GCR1 - Well 159	2/16/11	Fort Worth Basin	312	13.0
GCR1 - Well 160	2/17/11	Fort Worth Basin	288	12.0
GCR1 - Well 161	2/19/11	Fort Worth Basin	96	4.0
GCR1 - Well 162	2/23/11	Fort Worth Basin	24	1.0
GCR1 - Well 163	3/12/11	Fort Worth Basin	216	9.0
GCR1 - Well 164	3/21/11	Fort Worth Basin	168	7.0
GCR1 - Well 165	3/22/11	Fort Worth Basin	144	6.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 166	3/23/11	Fort Worth Basin	168	7.0
GCR1 - Well 167	3/23/11	Fort Worth Basin	168	7.0
GCR1 - Well 168	3/23/11	Fort Worth Basin	168	7.0
GCR1 - Well 169	3/24/11	Fort Worth Basin	144	6.0
GCR1 - Well 170	3/25/11	Fort Worth Basin	192	8.0
GCR1 - Well 171	3/26/11	Fort Worth Basin	96	4.0
GCR1 - Well 172	3/27/11	Fort Worth Basin	72	3.0
GCR1 - Well 173	3/28/11	Fort Worth Basin	120	5.0
GCR1 - Well 174	4/5/11	Fort Worth Basin	240	10.0
GCR1 - Well 175	4/12/11	Fort Worth Basin	72	3.0
GCR1 - Well 176	4/14/11	Fort Worth Basin	360	15.0
GCR1 - Well 177	4/15/11	Fort Worth Basin	312	13.0
GCR1 - Well 178	4/16/11	Fort Worth Basin	312	13.0
GCR1 - Well 179	4/17/11	Fort Worth Basin	72	3.0
GCR1 - Well 180	4/17/11	Fort Worth Basin	360	15.0
GCR1 - Well 181	4/18/11	Fort Worth Basin	24	1.0
GCR1 - Well 182	4/18/11	Fort Worth Basin	144	6.0
GCR1 - Well 183	4/18/11	Fort Worth Basin	264	11.0
GCR1 - Well 184	4/19/11	Fort Worth Basin	96	4.0
GCR1 - Well 185	4/19/11	Fort Worth Basin	120	5.0
GCR1 - Well 186	4/19/11	Fort Worth Basin	168	7.0
GCR1 - Well 187	4/20/11	Fort Worth Basin	96	4.0
GCR1 - Well 188	4/22/11	Fort Worth Basin	120	5.0
GCR1 - Well 189	4/23/11	Fort Worth Basin	192	8.0
GCR1 - Well 190	4/26/11	Fort Worth Basin	120	5.0
GCR1 - Well 191	4/29/11	Fort Worth Basin	48	2.0
GCR1 - Well 192	4/30/11	Fort Worth Basin	24	1.0
GCR1 - Well 193	4/30/11	Fort Worth Basin	384	16.0
GCR1 - Well 194	5/2/11	Fort Worth Basin	48	2.0
GCR1 - Well 195	5/8/11	Fort Worth Basin	144	6.0
GCR1 - Well 196	5/10/11	Fort Worth Basin	312	13.0
GCR1 - Well 197	5/10/11	Fort Worth Basin	312	13.0
GCR1 - Well 198	5/11/11	Fort Worth Basin	168	7.0
GCR1 - Well 199	5/11/11	Fort Worth Basin	288	12.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 200	5/12/11	Fort Worth Basin	144	6.0
GCR1 - Well 201	5/12/11	Fort Worth Basin	168	7.0
GCR1 - Well 202	5/12/11	Fort Worth Basin	264	11.0
GCR1 - Well 203	5/13/11	Fort Worth Basin	120	5.0
GCR1 - Well 204	5/13/11	Fort Worth Basin	144	6.0
GCR1 - Well 205	5/16/11	Fort Worth Basin	168	7.0
GCR1 - Well 206	5/17/11	Fort Worth Basin	144	6.0
GCR1 - Well 207	5/18/11	Fort Worth Basin	168	7.0
GCR1 - Well 208	5/23/11	Fort Worth Basin	96	4.0
GCR1 - Well 209	5/24/11	Fort Worth Basin	72	3.0
GCR1 - Well 210	6/3/11	Fort Worth Basin	192	8.0
GCR1 - Well 211	6/3/11	Fort Worth Basin	192	8.0
GCR1 - Well 212	6/6/11	Fort Worth Basin	192	8.0
GCR1 - Well 213	6/9/11	Fort Worth Basin	168	7.0
GCR1 - Well 214	6/14/11	Fort Worth Basin	144	6.0
GCR1 - Well 215	6/14/11	Fort Worth Basin	144	6.0
GCR1 - Well 216	6/14/11	Fort Worth Basin	144	6.0
GCR1 - Well 217	6/15/11	Fort Worth Basin	120	5.0
GCR1 - Well 218	6/20/11	Fort Worth Basin	192	8.0
GCR1 - Well 219	6/20/11	Fort Worth Basin	192	8.0
GCR1 - Well 220	6/21/11	Fort Worth Basin	168	7.0
GCR1 - Well 221	6/27/11	Fort Worth Basin	120	5.0
GCR1 - Well 222	6/28/11	Fort Worth Basin	144	6.0
GCR1 - Well 223	6/30/11	Fort Worth Basin	264	11.0
GCR1 - Well 224	7/1/11	Fort Worth Basin	264	11.0
GCR1 - Well 225	7/26/11	Fort Worth Basin	192	8.0
GCR1 - Well 226	7/27/11	Fort Worth Basin	384	16.0
GCR1 - Well 227	7/27/11	Fort Worth Basin	216	9.0
GCR1 - Well 228	7/27/11	Fort Worth Basin	288	12.0
GCR1 - Well 229	7/27/11	Fort Worth Basin	168	7.0
GCR1 - Well 230	7/29/11	Fort Worth Basin	144	6.0
GCR1 - Well 231	8/9/11	Fort Worth Basin	72	3.0
GCR1 - Well 232	8/9/11	Fort Worth Basin	168	7.0
GCR1 - Well 233	8/9/11	Fort Worth Basin	216	9.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR1 - Well 234	8/10/11	Fort Worth Basin	312	13.0
GCR1 - Well 235	8/15/11	Fort Worth Basin	48	2.0
GCR1 - Well 236	8/18/11	Fort Worth Basin	96	4.0
GCR1 - Well 237	8/21/11	Fort Worth Basin	216	9.0
GCR1 - Well 238	8/22/11	Fort Worth Basin	48	2.0
GCR1 - Well 239	8/22/11	Fort Worth Basin	144	6.0
GCR1 - Well 240	8/25/11	Fort Worth Basin	96	4.0
GCR1 - Well 241	1/16/11	Groesbeck	192	8.0
GCR1 - Well 242	2/23/11	Groesbeck	54	2.3
GCR1 - Well 243	4/19/11	Groesbeck	364	15.2
GCR1 - Well 244	1/21/11	Groesbeck	72	3.0
GCR1 - Well 245	7/13/11	Groesbeck	325	13.5
GCR1 - Well 246	7/14/11	Groesbeck	463	19.3
GCR1 - Well 247	3/18/11	Groesbeck	355	14.8
GCR1 - Well 248	4/12/11	North LA	294	12.3
GCR1 - Well 249	7/8/11	North LA	474	19.8
GCR1 - Well 250	2/21/11	South Texas	377	15.7
GCR1 - Well 251	7/21/11	South Texas	232	9.7
GCR1 - Well 252	3/11/11	South Texas	3	0.1
GCR1 - Well 253	4/5/11	South Texas	130	5.4
GCR1 - Well 254	8/17/11	South Texas	196	8.2
GCR1 - Well 255	8/9/11	STX - Eagleford	344	14.3
GCR1 - Well 256	8/9/11	STX - Eagleford	330	13.8
GCR2 - Well 1	8/29/2011	360		
GCR2 - Well 2	8/18/2011	415		
GCR2 - Well 3	3/23/2011	160A		
GCR2 - Well 4	3/8/2011	360		
GCR2 - Well 5	4/30/2011	360		
GCR2 - Well 6	2/21/2011	415		
GCR2 - Well 7	7/29/2011	415		
GCR2 - Well 8	2/22/2011	345	136	5.7
GCR2 - Well 9	6/1/2011	360		
GCR2 - Well 10	6/20/2011	360		
GCR2 - Well 11	4/6/2011	360		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 12	8/31/2011	415		
GCR2 - Well 13	6/1/2011	360		
GCR2 - Well 14	6/9/2011	360		
GCR2 - Well 15	8/11/2011	415		
GCR2 - Well 16	8/30/2011	415		
GCR2 - Well 17	6/9/2011	360		
GCR2 - Well 18	3/31/2011	360		
GCR2 - Well 19	6/8/2011	360		
GCR2 - Well 20	1/8/2011	415		
GCR2 - Well 21	6/22/2011	415		
GCR2 - Well 22	6/7/2011	220		
GCR2 - Well 23	3/19/2011	360		
GCR2 - Well 24	5/2/2011	360		
GCR2 - Well 25	1/30/2011	415		
GCR2 - Well 26	5/28/2011	220		
GCR2 - Well 27	6/27/2011	415		
GCR2 - Well 28	3/21/2011	415		
GCR2 - Well 29	7/13/2011	220		
GCR2 - Well 30	1/29/2011	345		
GCR2 - Well 31	3/22/2011	360		
GCR2 - Well 32	6/29/2011	160A		
GCR2 - Well 33	4/15/2011	360		
GCR2 - Well 34	1/3/2011	360		
GCR2 - Well 35	3/30/2011	345		
GCR2 - Well 36	3/13/2011	415		
GCR2 - Well 37	5/1/2011	360		
GCR2 - Well 38	7/5/2011	360		
GCR2 - Well 39	7/13/2011	220		
GCR2 - Well 40	7/13/2011	360		
GCR2 - Well 41	4/4/2011	360		
GCR2 - Well 42	2/12/2011	345		
GCR2 - Well 43	8/15/2011	360		
GCR2 - Well 44	1/5/2011	360		
GCR2 - Well 45	7/19/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 46	2/9/2011	260		
GCR2 - Well 47	2/11/2011	345		
GCR2 - Well 48	3/15/2011	345		
GCR2 - Well 49	6/6/2011	220		
GCR2 - Well 50	3/28/2011	360		
GCR2 - Well 51	7/1/2011	220		
GCR2 - Well 52	5/10/2011	415		
GCR2 - Well 53	6/2/2011	360		
GCR2 - Well 54	2/24/2011	360		
GCR2 - Well 55	3/17/2011	360		
GCR2 - Well 56	1/28/2011	360		
GCR2 - Well 57	5/17/2011	360		
GCR2 - Well 58	2/26/2011	360		
GCR2 - Well 59	5/22/2011	420		
GCR2 - Well 60	8/15/2011	360		
GCR2 - Well 61	1/28/2011	345		
GCR2 - Well 62	7/11/2011	220		
GCR2 - Well 63	3/13/2011	345		
GCR2 - Well 64	2/23/2011	360		
GCR2 - Well 65	7/20/2011	415		
GCR2 - Well 66	8/29/2011	415		
GCR2 - Well 67	6/14/2011	230		
GCR2 - Well 68	6/15/2011	220		
GCR2 - Well 69	2/21/2011	360		
GCR2 - Well 70	1/8/2011	415		
GCR2 - Well 71	8/12/2011	415		
GCR2 - Well 72	2/27/2011	360		
GCR2 - Well 73	8/24/2011	415	166	6.9
GCR2 - Well 74	4/7/2011	415		
GCR2 - Well 75	7/21/2011	415		
GCR2 - Well 76	7/1/2011	220		
GCR2 - Well 77	3/19/2011	220		
GCR2 - Well 78	5/16/2011	415		
GCR2 - Well 79	3/25/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 80	3/24/2011	415		
GCR2 - Well 81	2/23/2011	360		
GCR2 - Well 82	6/20/2011	360		
GCR2 - Well 83	4/15/2011	220		
GCR2 - Well 84	5/8/2011	415		
GCR2 - Well 85	8/28/2011	415		
GCR2 - Well 86	5/2/2011	360		
GCR2 - Well 87	1/8/2011	360		
GCR2 - Well 88	3/14/2011	415		
GCR2 - Well 89	7/6/2011	415		
GCR2 - Well 90	6/29/2011	415		
GCR2 - Well 91	3/4/2011	415		
GCR2 - Well 92	3/12/2011	415		
GCR2 - Well 93	4/6/2011	415		
GCR2 - Well 94	3/10/2011	360		
GCR2 - Well 95	8/1/2011	415		
GCR2 - Well 96	4/3/2011	415		
GCR2 - Well 97	7/22/2011	360		
GCR2 - Well 98	6/29/2011	360		
GCR2 - Well 99	1/30/2011	415		
GCR2 - Well 100	5/22/2011	400		
GCR2 - Well 101	7/6/2011	415		
GCR2 - Well 102	6/6/2011	220		
GCR2 - Well 103	4/17/2011	415		
GCR2 - Well 104	4/8/2011	360		
GCR2 - Well 105	4/23/2011	415		
GCR2 - Well 106	4/23/2011	415		
GCR2 - Well 107	3/20/2011	415		
GCR2 - Well 108	6/15/2011	415		
GCR2 - Well 109	1/7/2011	415		
GCR2 - Well 110	2/1/2011	415		
GCR2 - Well 111	4/29/2011	360		
GCR2 - Well 112	4/17/2011	415		
GCR2 - Well 113	4/28/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 114	6/26/2011	415		
GCR2 - Well 115	1/2/2011	415		
GCR2 - Well 116	4/16/2011	415		
GCR2 - Well 117	5/3/2011	415		
GCR2 - Well 118	3/6/2011	345		
GCR2 - Well 119	5/21/2011	350		
GCR2 - Well 120	2/3/2011	360		
GCR2 - Well 121	6/25/2011	415		
GCR2 - Well 122	7/11/2011	415		
GCR2 - Well 123	6/1/2011	415		
GCR2 - Well 124	8/9/2011	360		
GCR2 - Well 125	4/4/2011	360		
GCR2 - Well 126	3/27/2011	415		
GCR2 - Well 127	1/12/2011	415		
GCR2 - Well 128	7/17/2011	415		
GCR2 - Well 129	2/21/2011	345	383	16.0
GCR2 - Well 130	4/20/2011	415		
GCR2 - Well 131	8/28/2011	415		
GCR2 - Well 132	7/21/2011	360		
GCR2 - Well 133	7/27/2011	415		
GCR2 - Well 134	1/12/2011	415		
GCR2 - Well 135	5/3/2011	415		
GCR2 - Well 136	5/4/2011	160A		
GCR2 - Well 137	7/12/2011	360		
GCR2 - Well 138	8/26/2011	415		
GCR2 - Well 139	7/13/2011	415		
GCR2 - Well 140	2/25/2011	415		
GCR2 - Well 141	1/30/2011	415		
GCR2 - Well 142	6/26/2011	415		
GCR2 - Well 143	4/29/2011	415		
GCR2 - Well 144	3/4/2011	415		
GCR2 - Well 145	8/19/2011	415		
GCR2 - Well 146	2/25/2011	415		
GCR2 - Well 147	2/25/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 148	4/4/2011	360		
GCR2 - Well 149	3/15/2011	230		
GCR2 - Well 150	7/20/2011	415		
GCR2 - Well 151	6/16/2011	360		
GCR2 - Well 152	2/16/2011	415		
GCR2 - Well 153	1/20/2011	415		
GCR2 - Well 154	4/15/2011	220		
GCR2 - Well 155	8/2/2011	415		
GCR2 - Well 156	5/4/2011	360		
GCR2 - Well 157	6/21/2011	415		
GCR2 - Well 158	2/21/2011	360		
GCR2 - Well 159	8/19/2011	415		
GCR2 - Well 160	2/24/2011	415		
GCR2 - Well 161	2/15/2011	415		
GCR2 - Well 162	6/7/2011	415		
GCR2 - Well 163	7/30/2011	415		
GCR2 - Well 164	2/23/2011	415		
GCR2 - Well 165	8/30/2011	415		
GCR2 - Well 166	1/27/2011	415		
GCR2 - Well 167	3/21/2011	415		
GCR2 - Well 168	4/2/2011	415		
GCR2 - Well 169	4/23/2011	415		
GCR2 - Well 170	6/12/2011	360		
GCR2 - Well 171	3/25/2011	415		
GCR2 - Well 172	4/1/2011	415		
GCR2 - Well 173	1/27/2011	415		
GCR2 - Well 174	5/12/2011	260		
GCR2 - Well 175	7/1/2011	415		
GCR2 - Well 176	6/25/2011	415		
GCR2 - Well 177	3/20/2011	415		
GCR2 - Well 178	2/16/2011	415		
GCR2 - Well 179	6/26/2011	415		
GCR2 - Well 180	4/22/2011	415		
GCR2 - Well 181	3/21/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 182	4/30/2011	415		
GCR2 - Well 183	2/8/2011	415		
GCR2 - Well 184	5/22/2011	415		
GCR2 - Well 185	8/7/2011	160A		
GCR2 - Well 186	6/25/2011	415		
GCR2 - Well 187	2/15/2011	415		
GCR2 - Well 188	3/29/2011	360		
GCR2 - Well 189	6/14/2011	415		
GCR2 - Well 190	7/28/2011	415		
GCR2 - Well 191	1/22/2011	415		
GCR2 - Well 192	4/27/2011	415		
GCR2 - Well 193	5/8/2011	415		
GCR2 - Well 194	4/3/2011	360		
GCR2 - Well 195	1/30/2011	415		
GCR2 - Well 196	3/26/2011	415		
GCR2 - Well 197	6/28/2011	415		
GCR2 - Well 198	6/27/2011	415		
GCR2 - Well 199	3/1/2011	415		
GCR2 - Well 200	3/23/2011	415		
GCR2 - Well 201	6/30/2011	220		
GCR2 - Well 202	6/28/2011	415		
GCR2 - Well 203	4/11/2011	360		
GCR2 - Well 204	1/29/2011	360		
GCR2 - Well 205	1/27/2011	360		
GCR2 - Well 206	1/22/2011	415		
GCR2 - Well 207	5/2/2011	415		
GCR2 - Well 208	7/21/2011	415		
GCR2 - Well 209	5/10/2011	415		
GCR2 - Well 210	2/16/2011	360		
GCR2 - Well 211	2/17/2011	415		
GCR2 - Well 212	4/4/2011	415		
GCR2 - Well 213	1/9/2011	415		
GCR2 - Well 214	3/31/2011	345		
GCR2 - Well 215	4/26/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 216	4/8/2011	415		
GCR2 - Well 217	6/25/2011	415		
GCR2 - Well 218	4/13/2011	415		
GCR2 - Well 219	1/25/2011	260		
GCR2 - Well 220	2/21/2011	345		
GCR2 - Well 221	1/27/2011	415		
GCR2 - Well 222	8/21/2011	415		
GCR2 - Well 223	3/23/2011	415		
GCR2 - Well 224	6/14/2011	415		
GCR2 - Well 225	6/25/2011	415		
GCR2 - Well 226	6/27/2011	160A		
GCR2 - Well 227	4/8/2011	415		
GCR2 - Well 228	7/11/2011	415		
GCR2 - Well 229	7/27/2011	415		
GCR2 - Well 230	4/15/2011	230		
GCR2 - Well 231	6/3/2011	415		
GCR2 - Well 232	3/8/2011	415		
GCR2 - Well 233	8/21/2011	415		
GCR2 - Well 234	1/9/2011	415		
GCR2 - Well 235	4/22/2011	415		
GCR2 - Well 236	6/6/2011	415		
GCR2 - Well 237	3/21/2011	415		
GCR2 - Well 238	1/21/2011	260		
GCR2 - Well 239	4/18/2011	415		
GCR2 - Well 240	1/27/2011	400		
GCR2 - Well 241	1/26/2011	415		
GCR2 - Well 242	8/5/2011	415		
GCR2 - Well 243	4/22/2011	415		
GCR2 - Well 244	2/16/2011	415		
GCR2 - Well 245	8/19/2011	415		
GCR2 - Well 246	1/4/2011	360		
GCR2 - Well 247	6/16/2011	415		
GCR2 - Well 248	4/28/2011	415		
GCR2 - Well 249	4/8/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 250	1/27/2011	415		
GCR2 - Well 251	4/28/2011	400		
GCR2 - Well 252	3/5/2011	415		
GCR2 - Well 253	6/22/2011	415		
GCR2 - Well 254	2/18/2011	415		
GCR2 - Well 255	6/29/2011	415		
GCR2 - Well 256	3/26/2011	415		
GCR2 - Well 257	8/24/2011	415		
GCR2 - Well 258	6/13/2011	415		
GCR2 - Well 259	7/10/2011	415		
GCR2 - Well 260	5/7/2011	160A		
GCR2 - Well 261	4/16/2011	415		
GCR2 - Well 262	2/26/2011	160A		
GCR2 - Well 263	3/6/2011	415		
GCR2 - Well 264	5/6/2011	415		
GCR2 - Well 265	6/17/2011	415		
GCR2 - Well 266	1/6/2011	415		
GCR2 - Well 267	5/23/2011	360		
GCR2 - Well 268	2/21/2011	415		
GCR2 - Well 269	2/13/2011	415		
GCR2 - Well 270	7/13/2011	415		
GCR2 - Well 271	5/4/2011	400		
GCR2 - Well 272	8/16/2011	160A		
GCR2 - Well 273	6/7/2011	415		
GCR2 - Well 274	5/10/2011	415	244	10.2
GCR2 - Well 275	3/14/2011	360		
GCR2 - Well 276	2/11/2011	360		
GCR2 - Well 277	3/1/2011	415		
GCR2 - Well 278	3/15/2011	415		
GCR2 - Well 279	8/29/2011	415		
GCR2 - Well 280	6/19/2011	415		
GCR2 - Well 281	6/16/2011	230		
GCR2 - Well 282	7/11/2011	415		
GCR2 - Well 283	2/19/2011	415		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 284	6/24/2011	360		
GCR2 - Well 285	5/13/2011	415		
GCR2 - Well 286	6/17/2011	415		
GCR2 - Well 287	8/9/2011	160A		
GCR2 - Well 288	8/23/2011	415		
GCR2 - Well 289	7/23/2011	415		
GCR2 - Well 290	3/8/2011	230		
GCR2 - Well 291	7/10/2011	415		
GCR2 - Well 292	1/26/2011	360		
GCR2 - Well 293	2/22/2011	415		
GCR2 - Well 294	8/18/2011	360		
GCR2 - Well 295	8/26/2011	230		
GCR2 - Well 296	5/14/2011	160A		
GCR2 - Well 297	4/15/2011	415		
GCR2 - Well 298	4/29/2011	400		
GCR2 - Well 299	4/4/2011	415		
GCR2 - Well 300	8/10/2011	220		
GCR2 - Well 301	6/30/2011	220		
GCR2 - Well 302	4/18/2011	415		
GCR2 - Well 303	4/28/2011	415		
GCR2 - Well 304	8/17/2011	415		
GCR2 - Well 305	2/20/2011	415		
GCR2 - Well 306	3/11/2011	360		
GCR2 - Well 307	3/14/2011	230		
GCR2 - Well 308	8/29/2011	415		
GCR2 - Well 309	3/23/2011	415		
GCR2 - Well 310	5/17/2011	415		
GCR2 - Well 311	7/15/2011	415		
GCR2 - Well 312	8/29/2011	415		
GCR2 - Well 313	5/25/2011	415		
GCR2 - Well 314	6/13/2011	415		
GCR2 - Well 315	3/23/2011	415		
GCR2 - Well 316	5/23/2011	400		
GCR2 - Well 317	6/12/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 318	5/3/2011	220		
GCR2 - Well 319	8/11/2011	360		
GCR2 - Well 320	8/18/2011	415		
GCR2 - Well 321	4/13/2011	415		
GCR2 - Well 322	5/9/2011	230		
GCR2 - Well 323	2/26/2011	415		
GCR2 - Well 324	4/8/2011	230		
GCR2 - Well 325	8/15/2011	160A		
GCR2 - Well 326	3/31/2011	230		
GCR2 - Well 327	1/4/2011	360		
GCR2 - Well 328	7/9/2011	415		
GCR2 - Well 329	1/28/2011	360		
GCR2 - Well 330	5/1/2011	415		
GCR2 - Well 331	6/15/2011	220		
GCR2 - Well 332	4/22/2011	230		
GCR2 - Well 333	8/31/2011	415		
GCR2 - Well 334	6/20/2011	415		
GCR2 - Well 335	8/15/2011	415		
GCR2 - Well 336	2/17/2011	230		
GCR2 - Well 337	1/11/2011	415		
GCR2 - Well 338	1/28/2011	415		
GCR2 - Well 339	6/21/2011	230		
GCR2 - Well 340	6/20/2011	415		
GCR2 - Well 341	2/22/2011	415		
GCR2 - Well 342	3/2/2011	415		
GCR2 - Well 343	7/16/2011	415		
GCR2 - Well 344	6/30/2011	230		
GCR2 - Well 345	6/7/2011	360		
GCR2 - Well 346	2/24/2011	360		
GCR2 - Well 347	7/29/2011	360		
GCR2 - Well 348	3/21/2011	415		
GCR2 - Well 349	2/1/2011	260		
GCR2 - Well 350	5/14/2011	360		
GCR2 - Well 351	5/13/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 352	5/17/2011	360		
GCR2 - Well 353	3/8/2011	415		
GCR2 - Well 354	4/18/2011	230	114	
GCR2 - Well 355	6/14/2011	230		
GCR2 - Well 356	2/20/2011	415		
GCR2 - Well 357	5/20/2011	230		
GCR2 - Well 358	7/28/2011	360		
GCR2 - Well 359	2/17/2011	230		
GCR2 - Well 360	8/8/2011	160A		
GCR2 - Well 361	5/10/2011	160A		
GCR2 - Well 362	3/27/2011	415		
GCR2 - Well 363	6/22/2011	415		
GCR2 - Well 364	3/11/2011	415		
GCR2 - Well 365	3/4/2011	230		
GCR2 - Well 366	2/23/2011	230		
GCR2 - Well 367	4/8/2011	360		
GCR2 - Well 368	2/13/2011	220		
GCR2 - Well 369	5/4/2011	400		
GCR2 - Well 370	8/5/2011	415		
GCR2 - Well 371	5/24/2011	415		
GCR2 - Well 372	4/4/2011	230		
GCR2 - Well 373	8/25/2011	415		
GCR2 - Well 374	5/24/2011	415		
GCR2 - Well 375	7/17/2011	415		
GCR2 - Well 376	6/22/2011	415		
GCR2 - Well 377	7/15/2011	415		
GCR2 - Well 378	6/7/2011	415		
GCR2 - Well 379	3/23/2011	230		
GCR2 - Well 380	8/25/2011	415		
GCR2 - Well 381	3/2/2011	230		
GCR2 - Well 382	5/2/2011	415		
GCR2 - Well 383	5/13/2011	415		
GCR2 - Well 384	8/22/2011	360		
GCR2 - Well 385	7/22/2011	160A		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 386	2/9/2011	230		
GCR2 - Well 387	4/27/2011	360		
GCR2 - Well 388	5/27/2011	360		
GCR2 - Well 389	7/11/2011	220		
GCR2 - Well 390	1/30/2011	415		
GCR2 - Well 391	4/15/2011	160A		
GCR2 - Well 392	3/17/2011	230		
GCR2 - Well 393	2/24/2011	230		
GCR2 - Well 394	3/10/2011	230		
GCR2 - Well 395	7/18/2011	230		
GCR2 - Well 396	1/17/2011	360		
GCR2 - Well 397	1/24/2011	230		
GCR2 - Well 398	3/10/2011	415		
GCR2 - Well 399	3/1/2011	230		
GCR2 - Well 400	7/25/2011	230		
GCR2 - Well 401	1/10/2011	230		
GCR2 - Well 402	6/23/2011	230		
GCR2 - Well 403	8/12/2011	360		
GCR2 - Well 404	1/15/2011	400		
GCR2 - Well 405	6/3/2011	415		
GCR2 - Well 406	1/27/2011	415		
GCR2 - Well 407	7/5/2011	230		
GCR2 - Well 408	7/25/2011	230		
GCR2 - Well 409	5/31/2011	230		
GCR2 - Well 410	7/1/2011	360		
GCR2 - Well 411	6/7/2011	415		
GCR2 - Well 412	4/26/2011	160A	186	
GCR2 - Well 413	3/26/2011	415		
GCR2 - Well 414	7/15/2011	415		
GCR2 - Well 415	6/23/2011	230		
GCR2 - Well 416	5/26/2011	160A		
GCR2 - Well 417	8/1/2011	230		
GCR2 - Well 418	1/10/2011	230		
GCR2 - Well 419	8/20/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 420	3/11/2011	230		
GCR2 - Well 421	1/31/2011	360		
GCR2 - Well 422	7/13/2011	415		
GCR2 - Well 423	7/22/2011	230		
GCR2 - Well 424	1/25/2011	260		
GCR2 - Well 425	7/10/2011	415		
GCR2 - Well 426	3/1/2011	415		
GCR2 - Well 427	6/10/2011	230		
GCR2 - Well 428	3/8/2011	415		
GCR2 - Well 429	7/25/2011	230		
GCR2 - Well 430	2/13/2011	415		
GCR2 - Well 431	3/2/2011	230		
GCR2 - Well 432	4/26/2011	230		
GCR2 - Well 433	4/21/2011	230		
GCR2 - Well 434	6/27/2011	230		
GCR2 - Well 435	7/15/2011	415		
GCR2 - Well 436	3/1/2011	415		
GCR2 - Well 437	6/29/2011	415		
GCR2 - Well 438	5/31/2011	230		
GCR2 - Well 439	3/9/2011	230		
GCR2 - Well 440	5/9/2011	230		
GCR2 - Well 441	3/23/2011	230		
GCR2 - Well 442	3/9/2011	230		
GCR2 - Well 443	6/14/2011	415		
GCR2 - Well 444	2/18/2011	230		
GCR2 - Well 445	1/21/2011	230		
GCR2 - Well 446	3/27/2011	415		
GCR2 - Well 447	6/4/2011	415		
GCR2 - Well 448	3/13/2011	415		
GCR2 - Well 449	8/6/2011	230		
GCR2 - Well 450	4/1/2011	415		
GCR2 - Well 451	8/8/2011	160A		
GCR2 - Well 452	7/15/2011	230		
GCR2 - Well 453	7/22/2011	160A		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 454	1/7/2011	360		
GCR2 - Well 455	4/11/2011	230		
GCR2 - Well 456	3/31/2011	360		
GCR2 - Well 457	5/17/2011	230		
GCR2 - Well 458	2/23/2011	230		
GCR2 - Well 459	5/25/2011	230		
GCR2 - Well 460	7/5/2011	230		
GCR2 - Well 461	7/21/2011	230		
GCR2 - Well 462	8/25/2011	230		
GCR2 - Well 463	3/22/2011	230		
GCR2 - Well 464	6/10/2011	230		
GCR2 - Well 465	4/12/2011	230		
GCR2 - Well 466	6/10/2011	415		
GCR2 - Well 467	2/28/2011	230		
GCR2 - Well 468	5/18/2011	230		
GCR2 - Well 469	8/18/2011	230		
GCR2 - Well 470	7/21/2011	160A		
GCR2 - Well 471	4/20/2011	160A		
GCR2 - Well 472	1/7/2011	230		
GCR2 - Well 473	7/20/2011	160A		
GCR2 - Well 474	4/14/2011	230		
GCR2 - Well 475	6/23/2011	220		
GCR2 - Well 476	4/30/2011	230		
GCR2 - Well 477	6/29/2011	230		
GCR2 - Well 478	5/25/2011	360		
GCR2 - Well 479	1/19/2011	230		
GCR2 - Well 480	8/29/2011	230		
GCR2 - Well 481	1/7/2011	230		
GCR2 - Well 482	4/13/2011	230		
GCR2 - Well 483	3/10/2011	230		
GCR2 - Well 484	8/2/2011	230		
GCR2 - Well 485	1/22/2011	230		
GCR2 - Well 486	6/6/2011	230		
GCR2 - Well 487	2/8/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 488	6/25/2011	160A		
GCR2 - Well 489	7/15/2011	230		
GCR2 - Well 490	1/17/2011	230		
GCR2 - Well 491	2/25/2011	230		
GCR2 - Well 492	4/16/2011	230		
GCR2 - Well 493	8/10/2011	230		
GCR2 - Well 494	5/24/2011	160A	178	
GCR2 - Well 495	7/28/2011	415		
GCR2 - Well 496	2/27/2011	260		
GCR2 - Well 497	3/12/2011	230		
GCR2 - Well 498	8/12/2011	230		
GCR2 - Well 499	5/28/2011	230		
GCR2 - Well 500	6/21/2011	230		
GCR2 - Well 501	4/8/2011	230		
GCR2 - Well 502	1/7/2011	230		
GCR2 - Well 503	8/15/2011	230		
GCR2 - Well 504	6/6/2011	230		
GCR2 - Well 505	3/18/2011	230		
GCR2 - Well 506	2/23/2011	415		
GCR2 - Well 507	3/1/2011	415		
GCR2 - Well 508	1/3/2011	230		
GCR2 - Well 509	4/27/2011	230		
GCR2 - Well 510	7/2/2011	160A		
GCR2 - Well 511	7/28/2011	415		
GCR2 - Well 512	1/12/2011	230		
GCR2 - Well 513	7/15/2011	230		
GCR2 - Well 514	3/17/2011	230		
GCR2 - Well 515	7/27/2011	230		
GCR2 - Well 516	3/15/2011	230		
GCR2 - Well 517	3/2/2011	415		
GCR2 - Well 518	1/8/2011	230		
GCR2 - Well 519	7/6/2011	230		
GCR2 - Well 520	6/25/2011	230		
GCR2 - Well 521	7/22/2011	160A		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 522	7/21/2011	160A	139	
GCR2 - Well 523	6/24/2011	230		
GCR2 - Well 524	8/9/2011	230		
GCR2 - Well 525	5/5/2011	230		
GCR2 - Well 526	1/21/2011	230		
GCR2 - Well 527	8/16/2011	230		
GCR2 - Well 528	8/3/2011	230		
GCR2 - Well 529	4/13/2011	230		
GCR2 - Well 530	7/29/2011	230		
GCR2 - Well 531	7/28/2011	230		
GCR2 - Well 532	4/9/2011	230		
GCR2 - Well 533	3/18/2011	260		
GCR2 - Well 534	6/13/2011	260		
GCR2 - Well 535	1/8/2011	230		
GCR2 - Well 536	1/31/2011	230		
GCR2 - Well 537	3/23/2011	230		
GCR2 - Well 538	5/19/2011	230		
GCR2 - Well 539	4/4/2011	230		
GCR2 - Well 540	7/14/2011	415		
GCR2 - Well 541	8/1/2011	230		
GCR2 - Well 542	1/27/2011	230		
GCR2 - Well 543	6/17/2011	260		
GCR2 - Well 544	5/31/2011	230		
GCR2 - Well 545	6/29/2011	230		
GCR2 - Well 546	8/29/2011	260		
GCR2 - Well 547	5/14/2011	230		
GCR2 - Well 548	8/27/2011	230		
GCR2 - Well 549	6/9/2011	230		
GCR2 - Well 550	6/24/2011	230		
GCR2 - Well 551	3/4/2011	230		
GCR2 - Well 552	3/2/2011	415		
GCR2 - Well 553	8/31/2011	160A		
GCR2 - Well 554	3/26/2011	415		
GCR2 - Well 555	6/1/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 556	8/25/2011	415		
GCR2 - Well 557	8/12/2011	230		
GCR2 - Well 558	8/8/2011	160A		
GCR2 - Well 559	3/26/2011	415		
GCR2 - Well 560	8/10/2011	230		
GCR2 - Well 561	8/8/2011	160A		
GCR2 - Well 562	8/12/2011	230		
GCR2 - Well 563	2/26/2011	230		
GCR2 - Well 564	8/8/2011	160A		
GCR2 - Well 565	1/21/2011	230		
GCR2 - Well 566	7/5/2011	230		
GCR2 - Well 567	5/17/2011	230		
GCR2 - Well 568	4/30/2011	230		
GCR2 - Well 569	2/25/2011	230		
GCR2 - Well 570	2/9/2011	230		
GCR2 - Well 571	7/12/2011	230		
GCR2 - Well 572	7/1/2011	230	139	5.8
GCR2 - Well 573	8/15/2011	230		
GCR2 - Well 574	1/12/2011	230		
GCR2 - Well 575	8/4/2011	230		
GCR2 - Well 576	7/15/2011	230		
GCR2 - Well 577	8/13/2011	230		
GCR2 - Well 578	8/29/2011	230		
GCR2 - Well 579	7/6/2011	230		
GCR2 - Well 580	8/29/2011	230		
GCR2 - Well 581	8/18/2011	230		
GCR2 - Well 582	7/19/2011	230		
GCR2 - Well 583	8/24/2011	230		
GCR2 - Well 584	7/11/2011	230		
GCR2 - Well 585	7/22/2011	230		
GCR2 - Well 586	1/18/2011	230		
GCR2 - Well 587	8/10/2011	230		
GCR2 - Well 588	8/30/2011	230		
GCR2 - Well 589	2/24/2011	230		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 590	8/18/2011	230		
GCR2 - Well 591	6/20/2011	160A		
GCR2 - Well 592	6/10/2011	230		
GCR2 - Well 593	8/9/2011	160A		
GCR2 - Well 594	8/10/2011	230		
GCR2 - Well 595	1/7/2011	360		
GCR2 - Well 596	3/30/2011	220		
GCR2 - Well 597	3/19/2011	230		
GCR2 - Well 598	4/23/2011	230		
GCR2 - Well 599	2/22/2011	230		
GCR2 - Well 600	2/18/2011	230		
GCR2 - Well 601	5/3/2011	230		
GCR2 - Well 602	3/19/2011	230		
GCR2 - Well 603	5/31/2011	230		
GCR2 - Well 604	8/8/2011	160A		
GCR2 - Well 605	6/2/2011	230		
GCR2 - Well 606	5/13/2011	230		
GCR2 - Well 607	5/10/2011	230		
GCR2 - Well 608	4/6/2011	160A		
GCR2 - Well 609	6/20/2011	230		
GCR2 - Well 610	8/14/2011	230		
GCR2 - Well 611	8/12/2011	230		
GCR2 - Well 612	7/27/2011	230		
GCR2 - Well 613	4/4/2011	230		
GCR2 - Well 614	8/26/2011	230		
GCR2 - Well 615	7/14/2011	230		
GCR2 - Well 616	2/22/2011	230		
GCR2 - Well 617	3/4/2011	160A		
GCR2 - Well 618	4/23/2011	230		
GCR2 - Well 619	6/28/2011	230		
GCR2 - Well 620	7/30/2011	230		
GCR2 - Well 621	7/1/2011	160A		
GCR2 - Well 622	3/4/2011	160A		
GCR2 - Well 623	6/20/2011	160A		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR2 - Well 624	6/22/2011	160A		
GCR2 - Well 625	3/2/2011	415		
GCR2 - Well 626	6/11/2011	160A		
GCR2 - Well 627	6/20/2011	160A		
GCR2 - Well 628	2/7/2011	160A	795	33.1
GCR2 - Well 629	4/6/2011	160A		
GCR2 - Well 630	6/21/2011	160A		
GCR2 - Well 631	2/11/2011	160A		
GCR2 - Well 632	6/22/2011	160A		
GCR2 - Well 633	8/9/2011	160A		
GCR2 - Well 634	2/7/2011	160A		
GCR2 - Well 635	2/22/2011	160A		
GCR2 - Well 636	4/10/2011	160A		
GCR2 - Well 637	2/27/2011	160A		
GCR2 - Well 638	5/1/2011	160A		
GCR2 - Well 639	2/7/2011	160A		
GCR2 - Well 640	3/2/2011	360		
GCR2 - Well 641	2/11/2011	160A		
GCR2 - Well 642	2/27/2011	160A		
GCR2 - Well 643	8/17/2011	160A		
GCR2 - Well 644	4/10/2011	160A		
GCR2 - Well 645	2/20/2011	160A		
GCR2 - Well 646	6/11/2011	160A		
GCR2 - Well 647	2/20/2011	160A		
GCR2 - Well 648	1/14/2011	160A		
GCR2 - Well 649	6/30/2011	160A		
GCR2 - Well 650	3/20/2011	345		
GCR2 - Well 651	3/21/2011	345		
GCR3 - Well 1	3/17/2011	Green River Basin - Pinedale	63	2.6
GCR3 - Well 2	3/16/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 3	3/22/2011	Green River Basin - Pinedale	63	2.6
GCR3 - Well 4	3/21/2011	Green River Basin - Pinedale	63	2.6
GCR3 - Well 5	3/26/2011	Green River Basin - Pinedale	89	3.7
GCR3 - Well 6	3/27/2011	Green River Basin - Pinedale	89	3.7

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR3 - Well 7	4/7/2011	Green River Basin - Pinedale	46	1.9
GCR3 - Well 8	4/2/2011	Green River Basin - Pinedale	55	2.3
GCR3 - Well 9	4/6/2011	Green River Basin - Pinedale	72	3.0
GCR3 - Well 10	4/1/2011	Green River Basin - Pinedale	65	2.7
GCR3 - Well 11	4/11/2011	Green River Basin - Pinedale	109	4.5
GCR3 - Well 12	4/12/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 13	4/16/2011	Green River Basin - Pinedale	108	4.5
GCR3 - Well 14	4/17/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 15	4/22/2011	Green River Basin - Pinedale	113	4.7
GCR3 - Well 16	4/21/2011	Green River Basin - Pinedale	86	3.6
GCR3 - Well 17	4/26/2011	Green River Basin - Pinedale	132	5.5
GCR3 - Well 18	5/1/2011	Green River Basin - Pinedale	89	3.7
GCR3 - Well 19	4/27/2011	Green River Basin - Pinedale	87	3.6
GCR3 - Well 20	5/2/2011	Green River Basin - Pinedale	86	3.6
GCR3 - Well 21	5/6/2011	Green River Basin - Pinedale	87	3.6
GCR3 - Well 22	5/7/2011	Green River Basin - Pinedale	92	3.8
GCR3 - Well 23	5/11/2011	Green River Basin - Pinedale	89	3.7
GCR3 - Well 24	5/12/2011	Green River Basin - Pinedale	67	2.8
GCR3 - Well 25	5/16/2011	Green River Basin - Pinedale	81	3.4
GCR3 - Well 26	5/17/2011	Green River Basin - Pinedale	94	3.9
GCR3 - Well 27	5/21/2011	Green River Basin - Pinedale	74	3.1
GCR3 - Well 28	5/22/2011	Green River Basin - Pinedale	88	3.7
GCR3 - Well 29	5/27/2011	Green River Basin - Pinedale	81	3.4
GCR3 - Well 30	5/26/2011	Green River Basin - Pinedale	109	4.5
GCR3 - Well 31	5/31/2011	Green River Basin - Pinedale	101	4.2
GCR3 - Well 32	5/31/2011	Green River Basin - Pinedale	64	2.7
GCR3 - Well 33	6/6/2011	Green River Basin - Pinedale	101	4.2
GCR3 - Well 34	6/5/2011	Green River Basin - Pinedale	110	4.6
GCR3 - Well 35	6/10/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 36	6/16/2011	Green River Basin - Pinedale	88	3.7
GCR3 - Well 37	6/11/2011	Green River Basin - Pinedale	85	3.5
GCR3 - Well 38	6/17/2011	Green River Basin - Pinedale	68	2.8
GCR3 - Well 39	6/21/2011	Green River Basin - Pinedale	132	5.5
GCR3 - Well 40	6/26/2011	Green River Basin - Pinedale	153	6.4

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR3 - Well 41	6/22/2011	Green River Basin - Pinedale	102	4.3
GCR3 - Well 42	6/27/2011	Green River Basin - Pinedale	135	5.6
GCR3 - Well 43	7/1/2011	Green River Basin - Pinedale	112	4.7
GCR3 - Well 44	7/5/2011	Green River Basin - Pinedale	60	2.5
GCR3 - Well 45	7/10/2011	Green River Basin - Pinedale	96	4.0
GCR3 - Well 46	7/6/2011	Green River Basin - Pinedale	66	2.8
GCR3 - Well 47	7/11/2011	Green River Basin - Pinedale	72	3.0
GCR3 - Well 48	7/16/2011	Green River Basin - Pinedale	65	2.7
GCR3 - Well 49	7/15/2011	Green River Basin - Pinedale	87	3.6
GCR3 - Well 50	7/21/2011	Green River Basin - Pinedale	92	3.8
GCR3 - Well 51	7/20/2011	Green River Basin - Pinedale	88	3.7
GCR3 - Well 52	7/25/2011	Green River Basin - Pinedale	96	4.0
GCR3 - Well 53	7/26/2011	Green River Basin - Pinedale	90	3.8
GCR3 - Well 54	7/30/2011	Green River Basin - Pinedale	89	3.7
GCR3 - Well 55	7/31/2011	Green River Basin - Pinedale	86	3.6
GCR3 - Well 56	8/7/2011	Green River Basin - Pinedale	90	3.8
GCR3 - Well 57	8/6/2011	Green River Basin - Pinedale	108	4.5
GCR3 - Well 58	8/11/2011	Green River Basin - Pinedale	129	5.4
GCR3 - Well 59	8/12/2011	Green River Basin - Pinedale	118	4.9
GCR3 - Well 60	8/16/2011	Green River Basin - Pinedale	113	4.7
GCR3 - Well 61	8/15/2011	Green River Basin - Pinedale	122	5.1
GCR3 - Well 62	8/20/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 63	8/21/2011	Green River Basin - Pinedale	90	3.8
GCR3 - Well 64	8/24/2011	Green River Basin - Pinedale	111	4.6
GCR3 - Well 65	8/29/2011	Green River Basin - Pinedale	90	3.8
GCR3 - Well 66	8/25/2011	Green River Basin - Pinedale	89	3.7
GCR3 - Well 67	8/30/2011	Green River Basin - Pinedale	88	3.7
GCR3 - Well 68	1/6/2011	TX-LA Salt Basin - Haynesville	113	4.7
GCR3 - Well 69	1/14/2011	TX-LA Salt Basin - Haynesville	118	4.9
GCR3 - Well 70	1/28/2011	TX-LA Salt Basin - Haynesville	100	4.2
GCR3 - Well 71	1/27/2011	TX-LA Salt Basin - Haynesville	115	4.8
GCR3 - Well 72	2/5/2011	TX-LA Salt Basin - Haynesville	78	3.3
GCR3 - Well 73	2/7/2011	TX-LA Salt Basin - Haynesville	77	3.2
GCR3 - Well 74	2/15/2011	TX-LA Salt Basin - Haynesville	150	6.3

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR3 - Well 75	2/14/2011	TX-LA Salt Basin - Haynesville	149	6.2
GCR3 - Well 76	3/2/2011	TX-LA Salt Basin - Haynesville	123	5.1
GCR3 - Well 77	3/9/2011	TX-LA Salt Basin - Haynesville	103	4.3
GCR3 - Well 78	3/10/2011	TX-LA Salt Basin - Haynesville	103	4.3
GCR3 - Well 79	4/9/2011	TX-LA Salt Basin - Haynesville	114	4.8
GCR3 - Well 80	4/18/2011	TX-LA Salt Basin - Haynesville	141	5.9
GCR3 - Well 81	4/19/2011	TX-LA Salt Basin - Haynesville	138	5.8
GCR3 - Well 82	4/20/2011	TX-LA Salt Basin - Haynesville	142	5.9
GCR3 - Well 83	4/23/2011	TX-LA Salt Basin - Haynesville	172	7.2
GCR3 - Well 84	5/1/2011	TX-LA Salt Basin - Haynesville	116	4.8
GCR3 - Well 85	5/2/2011	TX-LA Salt Basin - Haynesville	115	4.8
GCR3 - Well 86	5/14/2011	TX-LA Salt Basin - Haynesville	159	6.6
GCR3 - Well 87	5/15/2011	TX-LA Salt Basin - Haynesville	153	6.4
GCR3 - Well 88	6/1/2011	TX-LA Salt Basin - Haynesville	111	4.6
GCR3 - Well 89	6/9/2011	TX-LA Salt Basin - Haynesville	117	4.9
GCR3 - Well 90	6/7/2011	TX-LA Salt Basin - Haynesville	118	4.9
GCR3 - Well 91	6/30/2011	TX-LA Salt Basin - Haynesville	106	4.4
GCR3 - Well 92	7/1/2011	TX-LA Salt Basin - Haynesville	108	4.5
GCR3 - Well 93	7/29/2011	TX-LA Salt Basin - Haynesville	120	5.0
GCR3 - Well 94	7/28/2011	TX-LA Salt Basin - Haynesville	120	5.0
GCR3 - Well 95	8/21/2011	TX-LA Salt Basin - Haynesville	120	5.0
GCR3 - Well 96	8/22/2011	TX-LA Salt Basin - Haynesville	115	4.8
GCR3 - Well 97	8/30/2011	TX-LA Salt Basin - Haynesville	136	5.7
GCR3 - Well 98	8/29/2011	TX-LA Salt Basin - Haynesville	138	5.8
GCR4 - Well 1	1/11/2011	Anadarko	10	0.4
GCR4 - Well 2	02/20/11	Anadarko	10	0.4
GCR4 - Well 3	1/18/2011	Anadarko	10	0.4
GCR4 - Well 4	03/26/11	Anadarko	10	0.4
GCR4 - Well 5	2/9/2011	Anadarko	10	0.4
GCR4 - Well 6	04/11/11	Anadarko	10	0.4
GCR4 - Well 7	2/16/2011	Anadarko	10	0.4
GCR4 - Well 8	3/16/2011	Anadarko	10	0.4
GCR4 - Well 9	03/08/11	Anadarko	10	0.4
GCR4 - Well 10	4/1/2011	Anadarko	10	0.4

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR4 - Well 11	07/05/11	Anadarko	10	0.4
GCR4 - Well 12	7/12/2011	Anadarko	10	0.4
GCR4 - Well 13	04/27/11	Anadarko	10	0.4
GCR4 - Well 14	8/2/2011	Anadarko	10	0.4
GCR4 - Well 15	07/19/11	Anadarko	10	0.4
GCR4 - Well 16	6/20/2011	Anadarko	10	0.4
GCR4 - Well 17	08/09/11	Anadarko	10	0.4
GCR4 - Well 18	8/16/2011	Anadarko	10	0.4
GCR5 - Well 1	1/1/2011	Haynesville	6	0.3
GCR5 - Well 2	1/4/2011	Haynesville	10	0.4
GCR5 - Well 3	1/12/2011	Haynesville	15	0.6
GCR5 - Well 4	1/13/2011	Haynesville	15	0.6
GCR5 - Well 5	1/14/2011	Haynesville	11	0.5
GCR5 - Well 6	1/15/2011	Haynesville	11	0.5
GCR5 - Well 7	1/28/2011	Haynesville	4	0.2
GCR5 - Well 8	1/29/2011	Haynesville	4	0.2
GCR5 - Well 9	2/8/2011	Haynesville	14	0.6
GCR5 - Well 10	2/19/2011	Haynesville	5	0.2
GCR5 - Well 11	2/20/2011	Haynesville	14	0.6
GCR5 - Well 12	2/21/2011	Haynesville	9	0.4
GCR5 - Well 13	3/2/2011	Haynesville	16	0.7
GCR5 - Well 14	3/2/2011	Haynesville	12	0.5
GCR5 - Well 15	3/3/2011	Haynesville	12	0.5
GCR5 - Well 16	3/5/2011	Haynesville	12	0.5
GCR5 - Well 17	3/5/2011	Haynesville	12	0.5
GCR5 - Well 18	3/22/2011	Haynesville	13	0.5
GCR5 - Well 19	3/24/2011	Haynesville	19	0.8
GCR5 - Well 20	3/24/2011	Haynesville	16	0.7
GCR5 - Well 21	3/29/2011	Haynesville	13	0.5
GCR5 - Well 22	4/4/2011	Haynesville	11	0.5
GCR5 - Well 23	4/12/2011	Haynesville	13	0.5
GCR5 - Well 24	4/14/2011	Haynesville	15	0.6
GCR5 - Well 25	4/14/2011	Haynesville	14	0.6
GCR5 - Well 26	4/18/2011	Haynesville	15	0.6

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR5 - Well 27	4/26/2011	Haynesville	22	0.9
GCR5 - Well 28	4/25/2011	Haynesville	14	0.6
GCR5 - Well 29	5/4/2011	Haynesville	10	0.4
GCR5 - Well 30	5/6/2011	Haynesville	8	0.3
GCR5 - Well 31	5/12/2011	Haynesville	11	0.5
GCR5 - Well 32	5/20/2011	Haynesville	10	0.4
GCR5 - Well 33	6/1/2011	Haynesville	7	0.3
GCR5 - Well 34	6/5/2011	Haynesville	13	0.5
GCR5 - Well 35	6/13/2011	Haynesville	13	0.5
GCR5 - Well 36	6/17/2011	Haynesville	3	0.1
GCR5 - Well 37	6/24/2011	Haynesville	5	0.2
GCR5 - Well 38	7/4/2011	Haynesville	15	0.6
GCR5 - Well 39	7/10/2011	Haynesville	13	0.5
GCR5 - Well 40	7/14/2011	Haynesville	14	0.6
GCR5 - Well 41	7/23/2011	Haynesville	13	0.5
GCR5 - Well 42	7/23/2011	Haynesville	17	0.7
GCR5 - Well 43	8/4/2011	Haynesville	11	0.5
GCR5 - Well 44	8/13/2011	Haynesville	12	0.5
GCR5 - Well 45	8/13/2011	Haynesville	12	0.5
GCR5 - Well 46	9/28/2011	Haynesville	11	0.5
GCR5 - Well 47	8/31/2011	Haynesville	11	0.5
GCR5 - Well 48	8/31/2011	Haynesville	11	0.5
GCR5 - Well 49	9/15/2011	Haynesville		0.0
GCR5 - Well 50	10/6/2011	Haynesville	8	0.3
GCR5 - Well 51	10/14/2011	Haynesville	8	0.3
GCR5 - Well 52	10/21/2011	Haynesville	7	0.3
GCR5 - Well 53	11/3/2011	Haynesville	3	0.1
GCR6 - Well 1	6/22/2011	Appalachia		
GCR6 - Well 2	6/3/2011	Appalachia		
GCR6 - Well 3	4/16/2011	Appalachia		
GCR6 - Well 4	4/14/2011	Appalachia		
GCR6 - Well 5	4/12/2011	Appalachia		
GCR6 - Well 6	6/6/2011	Appalachia		
GCR6 - Well 7	6/4/2011	Appalachia		

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 8	2/15/2011	Appalachia		
GCR6 - Well 9	2/13/2011	Appalachia		
GCR6 - Well 10	2/11/2011	Appalachia		
GCR6 - Well 11	12/29/2010	Arkoma	72	3.0
GCR6 - Well 12	12/22/2010	Arkoma	288	12.0
GCR6 - Well 13	12/23/2010	Arkoma	288	12.0
GCR6 - Well 14	12/22/2010	Arkoma	312	13.0
GCR6 - Well 15	12/23/2010	Arkoma	312	13.0
GCR6 - Well 16	12/27/2010	Arkoma	216	9.0
GCR6 - Well 17	12/28/2010	Arkoma	192	8.0
GCR6 - Well 18	12/29/2010	Arkoma	168	7.0
GCR6 - Well 19	12/31/2010	Arkoma	192	8.0
GCR6 - Well 20	12/31/2010	Arkoma	192	8.0
GCR6 - Well 21	1/6/2011	Arkoma	144	6.0
GCR6 - Well 22	1/1/2011	Arkoma	264	11.0
GCR6 - Well 23	12/30/2010	Arkoma	312	13.0
GCR6 - Well 24	1/1/2011	Arkoma	288	12.0
GCR6 - Well 25	1/1/2011	Arkoma	312	13.0
GCR6 - Well 26	1/2/2011	Arkoma	288	12.0
GCR6 - Well 27	12/30/2010	Arkoma	360	15.0
GCR6 - Well 28	12/29/2010	Arkoma	384	16.0
GCR6 - Well 29	12/29/2010	Arkoma	384	16.0
GCR6 - Well 30	1/7/2011	Arkoma	240	10.0
GCR6 - Well 31	1/7/2011	Arkoma	312	13.0
GCR6 - Well 32	1/6/2011	Arkoma	336	14.0
GCR6 - Well 33	1/8/2011	Arkoma	288	12.0
GCR6 - Well 34	12/29/2010	Arkoma	552	23.0
GCR6 - Well 35	1/17/2011	Arkoma	120	5.0
GCR6 - Well 36	1/18/2011	Arkoma	96	4.0
GCR6 - Well 37	1/18/2011	Arkoma	96	4.0
GCR6 - Well 38	1/12/2011	Arkoma	288	12.0
GCR6 - Well 39	1/13/2011	Arkoma	264	11.0
GCR6 - Well 40	1/12/2011	Arkoma	288	12.0
GCR6 - Well 41	1/15/2011	Arkoma	264	11.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 42	1/14/2011	Arkoma	288	12.0
GCR6 - Well 43	1/21/2011	Arkoma	144	6.0
GCR6 - Well 44	1/19/2011	Arkoma	192	8.0
GCR6 - Well 45	1/21/2011	Arkoma	168	7.0
GCR6 - Well 46	1/22/2011	Arkoma	144	6.0
GCR6 - Well 47	1/17/2011	Arkoma	264	11.0
GCR6 - Well 48	1/24/2011	Arkoma	96	4.0
GCR6 - Well 49	1/15/2011	Arkoma	312	13.0
GCR6 - Well 50	1/12/2011	Arkoma	528	22.0
GCR6 - Well 51	1/26/2011	Arkoma	216	9.0
GCR6 - Well 52	1/27/2011	Arkoma	192	8.0
GCR6 - Well 53	1/31/2011	Arkoma	120	5.0
GCR6 - Well 54	2/1/2011	Arkoma	144	6.0
GCR6 - Well 55	2/2/2011	Arkoma	120	5.0
GCR6 - Well 56	2/2/2011	Arkoma	144	6.0
GCR6 - Well 57	2/1/2011	Arkoma	192	8.0
GCR6 - Well 58	1/31/2011	Arkoma	264	11.0
GCR6 - Well 59	2/2/2011	Arkoma	240	10.0
GCR6 - Well 60	2/1/2011	Arkoma	264	11.0
GCR6 - Well 61	1/31/2011	Arkoma	288	12.0
GCR6 - Well 62	2/3/2011	Arkoma	240	10.0
GCR6 - Well 63	2/4/2011	Arkoma	216	9.0
GCR6 - Well 64	2/3/2011	Arkoma	240	10.0
GCR6 - Well 65	2/4/2011	Arkoma	216	9.0
GCR6 - Well 66	12/4/2010	Arkoma	1728	72.0
GCR6 - Well 67	1/28/2011	Arkoma	408	17.0
GCR6 - Well 68	2/7/2011	Arkoma	192	8.0
GCR6 - Well 69	2/2/2011	Arkoma	336	14.0
GCR6 - Well 70	2/13/2011	Arkoma	96	4.0
GCR6 - Well 71	2/14/2011	Arkoma	72	3.0
GCR6 - Well 72	2/12/2011	Arkoma	120	5.0
GCR6 - Well 73	1/24/2011	Arkoma	576	24.0
GCR6 - Well 74	2/12/2011	Arkoma	144	6.0
GCR6 - Well 75	2/13/2011	Arkoma	120	5.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 76	2/14/2011	Arkoma	96	4.0
GCR6 - Well 77	1/25/2011	Arkoma	576	24.0
GCR6 - Well 78	1/26/2011	Arkoma	552	23.0
GCR6 - Well 79	1/25/2011	Arkoma	576	24.0
GCR6 - Well 80	2/20/2011	Arkoma	72	3.0
GCR6 - Well 81	2/18/2011	Arkoma	120	5.0
GCR6 - Well 82	2/17/2011	Arkoma	144	6.0
GCR6 - Well 83	2/20/2011	Arkoma	72	3.0
GCR6 - Well 84	2/18/2011	Arkoma	120	5.0
GCR6 - Well 85	8/20/2010	Arkoma	4608	192.0
GCR6 - Well 86	2/23/2011	Arkoma	144	6.0
GCR6 - Well 87	2/22/2011	Arkoma	168	7.0
GCR6 - Well 88	2/21/2011	Arkoma	192	8.0
GCR6 - Well 89	2/23/2011	Arkoma	144	6.0
GCR6 - Well 90	2/22/2011	Arkoma	168	7.0
GCR6 - Well 91	2/21/2011	Arkoma	192	8.0
GCR6 - Well 92	2/24/2011	Arkoma	144	6.0
GCR6 - Well 93	2/24/2011	Arkoma	144	6.0
GCR6 - Well 94	2/24/2011	Arkoma	144	6.0
GCR6 - Well 95	2/23/2011	Arkoma	168	7.0
GCR6 - Well 96	2/22/2011	Arkoma	192	8.0
GCR6 - Well 97	2/21/2011	Arkoma	240	10.0
GCR6 - Well 98	2/22/2011	Arkoma	216	9.0
GCR6 - Well 99	2/25/2011	Arkoma	168	7.0
GCR6 - Well 100	2/26/2011	Arkoma	144	6.0
GCR6 - Well 101	2/23/2011	Arkoma	240	10.0
GCR6 - Well 102	2/24/2011	Arkoma	216	9.0
GCR6 - Well 103	3/2/2011	Arkoma	120	5.0
GCR6 - Well 104	3/7/2011	Arkoma	48	2.0
GCR6 - Well 105	3/5/2011	Arkoma	96	4.0
GCR6 - Well 106	3/5/2011	Arkoma	96	4.0
GCR6 - Well 107	3/6/2011	Arkoma	96	4.0
GCR6 - Well 108	3/11/2011	Arkoma	120	5.0
GCR6 - Well 109	3/9/2011	Arkoma	192	8.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 110	3/9/2011	Arkoma	192	8.0
GCR6 - Well 111	3/10/2011	Arkoma	168	7.0
GCR6 - Well 112	3/10/2011	Arkoma	168	7.0
GCR6 - Well 113	3/11/2011	Arkoma	144	6.0
GCR6 - Well 114	3/4/2011	Arkoma	312	13.0
GCR6 - Well 115	3/12/2011	Arkoma	144	6.0
GCR6 - Well 116	3/11/2011	Arkoma	168	7.0
GCR6 - Well 117	3/10/2011	Arkoma	192	8.0
GCR6 - Well 118	3/14/2011	Arkoma	120	5.0
GCR6 - Well 119	3/15/2011	Arkoma	96	4.0
GCR6 - Well 120	3/11/2011	Arkoma	216	9.0
GCR6 - Well 121	3/12/2011	Arkoma	216	9.0
GCR6 - Well 122	3/4/2011	Arkoma	408	17.0
GCR6 - Well 123	1/28/2011	Arkoma	1272	53.0
GCR6 - Well 124	1/29/2011	Arkoma	1248	52.0
GCR6 - Well 125	1/29/2011	Arkoma	1248	52.0
GCR6 - Well 126	3/5/2011	Arkoma	408	17.0
GCR6 - Well 127	3/16/2011	Arkoma	168	7.0
GCR6 - Well 128	3/15/2011	Arkoma	192	8.0
GCR6 - Well 129	3/20/2011	Arkoma	72	3.0
GCR6 - Well 130	3/11/2011	Arkoma	288	12.0
GCR6 - Well 131	3/17/2011	Arkoma	168	7.0
GCR6 - Well 132	3/18/2011	Arkoma	144	6.0
GCR6 - Well 133	3/17/2011	Arkoma	192	8.0
GCR6 - Well 134	3/18/2011	Arkoma	168	7.0
GCR6 - Well 135	3/19/2011	Arkoma	144	6.0
GCR6 - Well 136	3/7/2011	Arkoma	480	20.0
GCR6 - Well 137	3/8/2011	Arkoma	456	19.0
GCR6 - Well 138	3/7/2011	Arkoma	480	20.0
GCR6 - Well 139	3/7/2011	Arkoma	480	20.0
GCR6 - Well 140	3/6/2011	Arkoma	504	21.0
GCR6 - Well 141	3/25/2011	Arkoma	144	6.0
GCR6 - Well 142	3/26/2011	Arkoma	120	5.0
GCR6 - Well 143	3/26/2011	Arkoma	120	5.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 144	3/26/2011	Arkoma	120	5.0
GCR6 - Well 145	3/27/2011	Arkoma	96	4.0
GCR6 - Well 146	3/24/2011	Arkoma	168	7.0
GCR6 - Well 147	3/25/2011	Arkoma	144	6.0
GCR6 - Well 148	3/22/2011	Arkoma	216	9.0
GCR6 - Well 149	3/27/2011	Arkoma	120	5.0
GCR6 - Well 150	3/28/2011	Arkoma	96	4.0
GCR6 - Well 151	3/23/2011	Arkoma	264	11.0
GCR6 - Well 152	3/24/2011	Arkoma	240	10.0
GCR6 - Well 153	4/2/2011	Arkoma	96	4.0
GCR6 - Well 154	4/2/2011	Arkoma	96	4.0
GCR6 - Well 155	4/1/2011	Arkoma	144	6.0
GCR6 - Well 156	4/4/2011	Arkoma	72	3.0
GCR6 - Well 157	4/1/2011	Arkoma	144	6.0
GCR6 - Well 158	3/31/2011	Arkoma	168	7.0
GCR6 - Well 159	4/1/2011	Arkoma	144	6.0
GCR6 - Well 160	3/27/2011	Arkoma	288	12.0
GCR6 - Well 161	3/29/2011	Arkoma	240	10.0
GCR6 - Well 162	3/28/2011	Arkoma	264	11.0
GCR6 - Well 163	3/31/2011	Arkoma	192	8.0
GCR6 - Well 164	4/5/2011	Arkoma	72	3.0
GCR6 - Well 165	4/4/2011	Arkoma	96	4.0
GCR6 - Well 166	3/31/2011	Arkoma	192	8.0
GCR6 - Well 167	4/5/2011	Arkoma	168	7.0
GCR6 - Well 168	4/5/2011	Arkoma	168	7.0
GCR6 - Well 169	4/4/2011	Arkoma	192	8.0
GCR6 - Well 170	4/9/2011	Arkoma	120	5.0
GCR6 - Well 171	4/10/2011	Arkoma	120	5.0
GCR6 - Well 172	4/9/2011	Arkoma	144	6.0
GCR6 - Well 173	4/11/2011	Arkoma	96	4.0
GCR6 - Well 174	4/9/2011	Arkoma	144	6.0
GCR6 - Well 175	4/10/2011	Arkoma	120	5.0
GCR6 - Well 176	4/11/2011	Arkoma	96	4.0
GCR6 - Well 177	4/10/2011	Arkoma	144	6.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 178	4/11/2011	Arkoma	120	5.0
GCR6 - Well 179	4/11/2011	Arkoma	120	5.0
GCR6 - Well 180	4/12/2011	Arkoma	120	5.0
GCR6 - Well 181	3/20/2011	Arkoma	696	29.0
GCR6 - Well 182	4/13/2011	Arkoma	144	6.0
GCR6 - Well 183	4/12/2011	Arkoma	168	7.0
GCR6 - Well 184	4/12/2011	Arkoma	192	8.0
GCR6 - Well 185	4/16/2011	Arkoma	96	4.0
GCR6 - Well 186	4/13/2011	Arkoma	192	8.0
GCR6 - Well 187	4/13/2011	Arkoma	192	8.0
GCR6 - Well 188	4/16/2011	Arkoma	168	7.0
GCR6 - Well 189	4/13/2011	Arkoma	312	13.0
GCR6 - Well 190	4/14/2011	Arkoma	288	12.0
GCR6 - Well 191	4/13/2011	Arkoma	312	13.0
GCR6 - Well 192	4/17/2011	Arkoma	240	10.0
GCR6 - Well 193	4/18/2011	Arkoma	216	9.0
GCR6 - Well 194	4/17/2011	Arkoma	240	10.0
GCR6 - Well 195	4/22/2011	Arkoma	144	6.0
GCR6 - Well 196	4/23/2011	Arkoma	144	6.0
GCR6 - Well 197	4/25/2011	Arkoma	96	4.0
GCR6 - Well 198	4/23/2011	Arkoma	144	6.0
GCR6 - Well 199	4/26/2011	Arkoma	96	4.0
GCR6 - Well 200	4/25/2011	Arkoma	120	5.0
GCR6 - Well 201	4/25/2011	Arkoma	144	6.0
GCR6 - Well 202	4/25/2011	Arkoma	144	6.0
GCR6 - Well 203	4/22/2011	Arkoma	264	11.0
GCR6 - Well 204	4/22/2011	Arkoma	264	11.0
GCR6 - Well 205	4/27/2011	Arkoma	192	8.0
GCR6 - Well 206	4/29/2011	Arkoma	168	7.0
GCR6 - Well 207	4/29/2011	Arkoma	168	7.0
GCR6 - Well 208	4/27/2011	Arkoma	216	9.0
GCR6 - Well 209	4/27/2011	Arkoma	216	9.0
GCR6 - Well 210	5/2/2011	Arkoma	192	8.0
GCR6 - Well 211	5/3/2011	Arkoma	168	7.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 212	5/2/2011	Arkoma	192	8.0
GCR6 - Well 213	5/5/2011	Arkoma	168	7.0
GCR6 - Well 214	5/6/2011	Arkoma	144	6.0
GCR6 - Well 215	5/6/2011	Arkoma	144	6.0
GCR6 - Well 216	5/6/2011	Arkoma	144	6.0
GCR6 - Well 217	5/7/2011	Arkoma	144	6.0
GCR6 - Well 218	5/8/2011	Arkoma	120	5.0
GCR6 - Well 219	5/6/2011	Arkoma	168	7.0
GCR6 - Well 220	5/4/2011	Arkoma	216	9.0
GCR6 - Well 221	5/5/2011	Arkoma	192	8.0
GCR6 - Well 222	5/5/2011	Arkoma	192	8.0
GCR6 - Well 223	5/9/2011	Arkoma	144	6.0
GCR6 - Well 224	5/10/2011	Arkoma	120	5.0
GCR6 - Well 225	5/13/2011	Arkoma	144	6.0
GCR6 - Well 226	5/17/2011	Arkoma	72	3.0
GCR6 - Well 227	5/13/2011	Arkoma	168	7.0
GCR6 - Well 228	5/14/2011	Arkoma	144	6.0
GCR6 - Well 229	4/15/2011	Arkoma	840	35.0
GCR6 - Well 230	4/15/2011	Arkoma	840	35.0
GCR6 - Well 231	5/18/2011	Arkoma	72	3.0
GCR6 - Well 232	5/18/2011	Arkoma	72	3.0
GCR6 - Well 233	5/16/2011	Arkoma	120	5.0
GCR6 - Well 234	5/17/2011	Arkoma	96	4.0
GCR6 - Well 235	5/16/2011	Arkoma	168	7.0
GCR6 - Well 236	5/17/2011	Arkoma	144	6.0
GCR6 - Well 237	5/16/2011	Arkoma	168	7.0
GCR6 - Well 238	5/17/2011	Arkoma	168	7.0
GCR6 - Well 239	5/19/2011	Arkoma	144	6.0
GCR6 - Well 240	5/19/2011	Arkoma	144	6.0
GCR6 - Well 241	5/22/2011	Arkoma	120	5.0
GCR6 - Well 242	5/23/2011	Arkoma	96	4.0
GCR6 - Well 243	5/22/2011	Arkoma	120	5.0
GCR6 - Well 244	5/24/2011	Arkoma	72	3.0
GCR6 - Well 245	5/23/2011	Arkoma	96	4.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 246	5/24/2011	Arkoma	72	3.0
GCR6 - Well 247	5/2/2011	Arkoma	624	26.0
GCR6 - Well 248	5/9/2011	Arkoma	528	22.0
GCR6 - Well 249	5/25/2011	Arkoma	192	8.0
GCR6 - Well 250	5/26/2011	Arkoma	168	7.0
GCR6 - Well 251	5/25/2011	Arkoma	192	8.0
GCR6 - Well 252	5/25/2011	Arkoma	192	8.0
GCR6 - Well 253	5/26/2011	Arkoma	168	7.0
GCR6 - Well 254	5/25/2011	Arkoma	192	8.0
GCR6 - Well 255	5/27/2011	Arkoma	168	7.0
GCR6 - Well 256	5/27/2011	Arkoma	192	8.0
GCR6 - Well 257	5/28/2011	Arkoma	168	7.0
GCR6 - Well 258	5/27/2011	Arkoma	192	8.0
GCR6 - Well 259	5/28/2011	Arkoma	168	7.0
GCR6 - Well 260	6/1/2011	Arkoma	168	7.0
GCR6 - Well 261	5/31/2011	Arkoma	192	8.0
GCR6 - Well 262	6/2/2011	Arkoma	144	6.0
GCR6 - Well 263	6/1/2011	Arkoma	168	7.0
GCR6 - Well 264	5/31/2011	Arkoma	192	8.0
GCR6 - Well 265	6/3/2011	Arkoma	144	6.0
GCR6 - Well 266	6/2/2011	Arkoma	168	7.0
GCR6 - Well 267	6/2/2011	Arkoma	168	7.0
GCR6 - Well 268	6/1/2011	Arkoma	192	8.0
GCR6 - Well 269	6/3/2011	Arkoma	144	6.0
GCR6 - Well 270	6/3/2011	Arkoma	144	6.0
GCR6 - Well 271	6/7/2011	Arkoma	72	3.0
GCR6 - Well 272	6/6/2011	Arkoma	96	4.0
GCR6 - Well 273	6/6/2011	Arkoma	96	4.0
GCR6 - Well 274	6/6/2011	Arkoma	96	4.0
GCR6 - Well 275	6/6/2011	Arkoma	120	5.0
GCR6 - Well 276	6/7/2011	Arkoma	96	4.0
GCR6 - Well 277	1/26/2011	Arkoma	3336	139.0
GCR6 - Well 278	6/6/2011	Arkoma	192	8.0
GCR6 - Well 279	6/7/2011	Arkoma	168	7.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 280	6/5/2011	Arkoma	240	10.0
GCR6 - Well 281	6/4/2011	Arkoma	264	11.0
GCR6 - Well 282	6/5/2011	Arkoma	240	10.0
GCR6 - Well 283	6/4/2011	Arkoma	264	11.0
GCR6 - Well 284	6/13/2011	Arkoma	72	3.0
GCR6 - Well 285	6/15/2011	Arkoma	168	7.0
GCR6 - Well 286	6/14/2011	Arkoma	192	8.0
GCR6 - Well 287	6/20/2011	Arkoma	72	3.0
GCR6 - Well 288	3/28/2011	Arkoma	2088	87.0
GCR6 - Well 289	6/16/2011	Arkoma	168	7.0
GCR6 - Well 290	6/17/2011	Arkoma	144	6.0
GCR6 - Well 291	6/15/2011	Arkoma	192	8.0
GCR6 - Well 292	6/16/2011	Arkoma	168	7.0
GCR6 - Well 293	6/20/2011	Arkoma	96	4.0
GCR6 - Well 294	6/24/2011	Arkoma	96	4.0
GCR6 - Well 295	6/25/2011	Arkoma	72	3.0
GCR6 - Well 296	6/27/2011	Arkoma	120	5.0
GCR6 - Well 297	6/27/2011	Arkoma	120	5.0
GCR6 - Well 298	6/28/2011	Arkoma	96	4.0
GCR6 - Well 299	6/24/2011	Arkoma	192	8.0
GCR6 - Well 300	6/23/2011	Arkoma	216	9.0
GCR6 - Well 301	6/28/2011	Arkoma	96	4.0
GCR6 - Well 302	6/22/2011	Arkoma	264	11.0
GCR6 - Well 303	6/19/2011	Arkoma	336	14.0
GCR6 - Well 304	6/14/2011	Arkoma	456	19.0
GCR6 - Well 305	7/1/2011	Arkoma	48	2.0
GCR6 - Well 306	6/27/2011	Arkoma	216	9.0
GCR6 - Well 307	6/28/2011	Arkoma	192	8.0
GCR6 - Well 308	6/27/2011	Arkoma	216	9.0
GCR6 - Well 309	6/28/2011	Arkoma	192	8.0
GCR6 - Well 310	7/6/2011	Arkoma	72	3.0
GCR6 - Well 311	7/6/2011	Arkoma	72	3.0
GCR6 - Well 312	7/7/2011	Arkoma	48	2.0
GCR6 - Well 313	7/6/2011	Arkoma	168	7.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 314	7/8/2011	Arkoma	120	5.0
GCR6 - Well 315	7/6/2011	Arkoma	168	7.0
GCR6 - Well 316	7/7/2011	Arkoma	144	6.0
GCR6 - Well 317	7/8/2011	Arkoma	120	5.0
GCR6 - Well 318	7/7/2011	Arkoma	144	6.0
GCR6 - Well 319	6/25/2011	Arkoma	456	19.0
GCR6 - Well 320	7/8/2011	Arkoma	144	6.0
GCR6 - Well 321	7/11/2011	Arkoma	96	4.0
GCR6 - Well 322	7/16/2011	Arkoma	120	5.0
GCR6 - Well 323	7/15/2011	Arkoma	144	6.0
GCR6 - Well 324	7/14/2011	Arkoma	168	7.0
GCR6 - Well 325	7/20/2011	Arkoma	72	3.0
GCR6 - Well 326	7/27/2011	Arkoma	72	3.0
GCR6 - Well 327	7/27/2011	Arkoma	96	4.0
GCR6 - Well 328	7/22/2011	Arkoma	288	12.0
GCR6 - Well 329	7/23/2011	Arkoma	264	11.0
GCR6 - Well 330	7/21/2011	Arkoma	312	13.0
GCR6 - Well 331	7/25/2011	Arkoma	240	10.0
GCR6 - Well 332	8/1/2011	Arkoma	96	4.0
GCR6 - Well 333	8/2/2011	Arkoma	72	3.0
GCR6 - Well 334	8/1/2011	Arkoma	96	4.0
GCR6 - Well 335	8/2/2011	Arkoma	96	4.0
GCR6 - Well 336	7/30/2011	Arkoma	192	8.0
GCR6 - Well 337	7/31/2011	Arkoma	168	7.0
GCR6 - Well 338	7/31/2011	Arkoma	168	7.0
GCR6 - Well 339	7/29/2011	Arkoma	216	9.0
GCR6 - Well 340	7/30/2011	Arkoma	216	9.0
GCR6 - Well 341	8/6/2011	Arkoma	168	7.0
GCR6 - Well 342	8/4/2011	Arkoma	216	9.0
GCR6 - Well 343	8/5/2011	Arkoma	192	8.0
GCR6 - Well 344	8/6/2011	Arkoma	168	7.0
GCR6 - Well 345	8/5/2011	Arkoma	192	8.0
GCR6 - Well 346	8/8/2011	Arkoma	120	5.0
GCR6 - Well 347	8/9/2011	Arkoma	96	4.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 348	8/8/2011	Arkoma	120	5.0
GCR6 - Well 349	8/8/2011	Arkoma	168	7.0
GCR6 - Well 350	8/5/2011	Arkoma	240	10.0
GCR6 - Well 351	8/5/2011	Arkoma	240	10.0
GCR6 - Well 352	8/9/2011	Arkoma	168	7.0
GCR6 - Well 353	8/14/2011	Arkoma	72	3.0
GCR6 - Well 354	8/13/2011	Arkoma	96	4.0
GCR6 - Well 355	8/14/2011	Arkoma	96	4.0
GCR6 - Well 356	8/15/2011	Arkoma	72	3.0
GCR6 - Well 357	8/13/2011	Arkoma	120	5.0
GCR6 - Well 358	8/13/2011	Arkoma	144	6.0
GCR6 - Well 359	8/4/2011	Arkoma	384	16.0
GCR6 - Well 360	7/28/2011	Arkoma	552	23.0
GCR6 - Well 361	7/28/2011	Arkoma	552	23.0
GCR6 - Well 362	7/31/2011	Arkoma	480	20.0
GCR6 - Well 363	8/17/2011	Arkoma	72	3.0
GCR6 - Well 364	8/3/2011	Arkoma	408	17.0
GCR6 - Well 365	8/17/2011	Arkoma	168	7.0
GCR6 - Well 366	8/18/2011	Arkoma	144	6.0
GCR6 - Well 367	8/17/2011	Arkoma	168	7.0
GCR6 - Well 368	8/16/2011	Arkoma	192	8.0
GCR6 - Well 369	8/16/2011	Arkoma	192	8.0
GCR6 - Well 370	8/22/2011	Arkoma	96	4.0
GCR6 - Well 371	8/23/2011	Arkoma	72	3.0
GCR6 - Well 372	8/22/2011	Arkoma	96	4.0
GCR6 - Well 373	8/24/2011	Arkoma	72	3.0
GCR6 - Well 374	8/23/2011	Arkoma	96	4.0
GCR6 - Well 375	8/23/2011	Arkoma	120	5.0
GCR6 - Well 376	8/22/2011	Arkoma	144	6.0
GCR6 - Well 377	8/21/2011	Arkoma	168	7.0
GCR6 - Well 378	8/20/2011	Arkoma	192	8.0
GCR6 - Well 379	8/8/2011	Arkoma	504	21.0
GCR6 - Well 380	8/10/2011	Arkoma	456	19.0
GCR6 - Well 381	8/11/2011	Arkoma	432	18.0

Well Number	Date Well Completed	Basin	Flowback Duration (Hours)	Duration Days
GCR6 - Well 382	8/25/2011	Arkoma	216	9.0
GCR6 - Well 383	8/25/2011	Arkoma	216	9.0
GCR6 - Well 384	8/25/2011	Arkoma	216	9.0
GCR6 - Well 385	8/26/2011	Arkoma	192	8.0
GCR6 - Well 386	9/1/2011	Arkoma	144	6.0
GCR6 - Well 387	8/31/2011	Arkoma	168	7.0
GCR6 - Well 388	9/1/2011	Arkoma	144	6.0
GCR6 - Well 389	8/31/2011	Arkoma	168	7.0
GCR6 - Well 390	8/29/2011	Arkoma	240	10.0
GCR6 - Well 391	8/30/2011	Arkoma	216	9.0
GCR6 - Well 392	8/30/2011	Arkoma	216	9.0
GCR6 - Well 393	8/30/2011	Arkoma	216	9.0
GCR6 - Well 394	8/29/2011	Arkoma	240	10.0
GCR6 - Well 395	8/29/2011	Arkoma	264	11.0
GCR6 - Well 396	1/2/2011	East Texas	386	16.1
GCR6 - Well 397	1/28/2011	East Texas	451	18.8
GCR6 - Well 398	2/24/2011	East Texas	402	16.8
GCR6 - Well 399	4/11/2011	East Texas		

Commenter: Karen Ritter, API

Comment: *A key revision to the natural gas inventory for 2010 is a change in terminology from conventional and unconventional gas wells to wells with and without hydraulic fracturing. Although API appreciates the revisions to the terminology to be more consistent with industry convention and reporting under Subpart W, this nomenclature change highlights inconsistencies with the well counts reported by EPA.*

There seems to be a disconnect between the number of wells drilled and the number of new well completions. EPA"s draft national inventory indicates 20,962 gas wells drilled for 2010, while only 4,296 wells were completed. Based on EPA"s inventory data, it appears that only 20% of the gas wells drilled are completed, which is far lower than the ratio of wells completed to wells drilled in practice. API notes the following additional inconsistencies in the well counts: For the Southwest Region almost twice as many wells were completed than drilled. For the Rocky Mountain Region, there is a significant decline in the number of producing non-associated gas wells, even with 3,800 wells drilled in that region. The number of wells completed for the North East and Midcontinent regions is much lower than the increase in non-associated gas producing wells from 2009 to 2010. These discrepancies should be explained.

API recognizes that correcting these issues will increase the count of gas well completions used in the inventory, and therefore increase the estimate of GHG emissions for Natural Gas Systems. With the numerous inconsistencies between the number of wells drilled, wells completed and well workovers, it is even more critical to re-evaluate the emission factor that EPA uses for gas well completions and workovers with hydraulic fracturing. API and ANGA are continuing to collect activity information to develop a more appropriate emission estimation method and resulting emission factors for gas well workovers and completions, and will share this information in the future.

Commenter: Karen Ritter, API

Comment: *API requests that EPA document the standard conditions used to convert emissions data from volumetric basis (scf) to mass basis (Mg). In spot checking the emission calculations presented in Table A-122, API calculates values slightly less than are reported in the table, using industry standard conditions of 60 ºF and 14.7 psia. It appears that EPA is applying a temperature slightly higher than 60 ºF and/or a pressure slightly below 14.7 psia.*

Commenter: Karen Ritter, API

Comment: *For Natural Gas Systems, EPA provides the total sector emission reductions in Tables A-127 and A-128, for Natural Gas STAR and regulatory driven reductions, respectively, while the unadjusted emission factors (i.e. emission factors that do not account for emission reductions) are reported in Tables A-122 through A-125. On page 3-51, lines 26 through 28, EPA indicates that they are planning to revise the emissions tables in Annex 3.4 to show voluntary reductions broken out for key emission sources. API supports this proposed change.*

Commenter: Karen Ritter, API

Comment: *On page 3-51, lines 4 through 6, EPA indicates that they are planning to improve the emission estimates for hydraulic fracturing. As commented previously, API believes the emission factor for gas well completions and workovers with hydraulic fracturing is significantly overestimated. API offers to work with EPA to develop more accurate emission factors for these sources.*

On page A-158, EPA documents a well workover rate of 10% based on an assumption from Advanced Resources International and production opinion cited in a life cycle analysis study1. However, in reviewing the referenced report, a workover rate of 10% is not mentioned. Workover rates are provided for a total of 87 wells located in Trinidad & Tobago, Nigeria, Egypt, and Algeria based on 2006 data. As noted previously, API believes this re-fracture rate is too high. More precise information will be available through the Mandatory GHG reporting program, with 2011 data reported to EPA in September 2012.

EPA has noted that they intend to revisit the estimates for gas well workover frequency (Page 3-51, lines 4-6). The 2010 GHG inventory does not incorporate the revised workover rate that EPA provided for discussion in July 2011 which would have revised the annual workover frequency from 10% to 0.3% based on information provided by one Gas STAR Partner. API is also gathering information to improve this workover rate.

Commenter: Karen Ritter, API

Comment: *For consistency with the GHG reporting rule and for better clarity, API requests that EPA refer to this emission source as gas wells with liquids unloading. The terminology well clean ups for low pressure wells is carried over from the original GRI/EPA study and does not adequately describe this emission source.*

On page 3-51, lines 1 through 2, EPA indicates that they intend to evaluate additional data on emission reductions, particularly for gas well cleanups. API supports improvements to the emission estimates for this important source.

API is currently gathering data to improve the emission factor for gas well liquids unloading, and API will share this information with EPA when it is available. In the meantime, as API commented for the 2009 inventory and the expert review period for the 2010 inventory, EPA should publish the equation and the average characteristics used for developing the liquids unloading emission estimates for each basin. EPA should identify all artificial lift practices and other methods for reducing emissions from this source, and EPA should provide separate factors for controlled and uncontrolled liquids unloading activities.

Commenter: Karen Ritter, API

Comment: *The 2009 inventory included for the first time emission factors for centrifugal compressors by seal type (wet and dry seals, respectively) for the natural gas processing and natural gas transmission sectors. The emission factors for centrifugal compressors increased from 2008 to 2009, regardless of seal type. The resultant emissions increase was most significant in the gas processing sector. The 2010 inventory applies the same emission factors used for 2009.*

On page A-158, EPA documents the approach used to estimate dry seal and wet seal centrifugal compressors. A Gas Star presentation2 is cited as the source for 2003 data from compressor vendors reporting that 90% of new compressors are equipped with dry seals. The inventory document states Given that 90% of new centrifugal compressors since 2003 are equipped with dry seals, and that there were 0 dry seal compressors in 1992; EPA interpolated a straight-line estimate of the percentage of new compressors that were equipped with dry seals, based on pipeline mileage. More precise information will be available through the Mandatory GHG reporting program, with 2011 data reported to EPA in September 2012.

API has commented previously that the basis of the EPA wet seal emission factors is not clear and is inconsistent with Subpart W of the EPA"s GHGRP. API has also requested that EPA explain the derivation of the wet and dry seal emission factors and clearly state the reference of the emission factors for each segment. API requests that EPA address these comments.

Commenter: Karen Ritter, API

Comment: *On page A-157, EPA notes, The same emission factors are used for each year throughout this period (1990 through 2010) after adjusting for changes in methane content. If this is the case, one would expect a consistent increase or decrease in emission factors within a given NEMS region. However, exceptions are noted below for the well-based fugitive emission factors associated with hydraulically fractured gas wells (not to be confused with the venting emissions from workovers or completions on wells with hydraulic fracturing):*

- *Emissions in the North East and West Coast regions were previously shown as NE, or not estimated because there was no corresponding activity for that region. For 2010, these two sources apply the same emission factor as non-associated gas wells, though there is still no corresponding well activity data. There are some significant changes to this emission factor for other regions. For example, the emission factor for gas wells with hydraulic fracturing in the Midcontinent region nearly doubled from 2009, and the emission factor for the Rocky Mountain region increased from 6.97 scfd/well in 2009 to 40.03 scfd/well in 2010. The emission factor for non-associated gas wells in the Gulf Coast region decreased from 40.97 scfd/well in 2009 to 7.98 scfd/well in 2010. These changes are not explained.*
- *For the Midcontinent and Rocky Mountain regions, the emission factors decreased slightly from the values used in 2009, with the exception of the emission factors applied to gas well completions and workovers with hydraulic fracturing which increased. These changes are not explained and appear to conflict with a statement made on page 3-50, lines 25-27: EPA has held the 2010 estimate for emissions from hydraulically fractured gas wells constant at 2009 levels (i.e., maintained the same activity data and voluntary reductions for hydraulically fractured gas well completions and existing hydraulically fractured gas wells).*

Commenter: Karen Ritter, API

Comment: *EPA provides the CO2 content for different well types in Table A-133, but does not report the different CH4 contents used for each NEMS region. For transparency, API requests documentation of the CH4 contents used for each NEMS region.*

Commenter: Karen Ritter, API

Comment: *A footnote to Table A-133 indicates that the EPA inventory defines unconventional wells as those that are hydraulically fractured. As noted previously, API appreciates the revisions to the terminology associated with gas wells with and without hydraulic fracturing. However, API requests that the terminology be used consistently throughout the documentation for Natural Gas Systems in Annex 3.4. Specifically, the term unconventional is used in Step 4 on page A-159, Conventional Gas Wells is used for the North East workover emission source on page A-160, and the terms conventional and non-conventional are used in Table A-133.*

Commenter: Karen Ritter, API

Comment: *Although referenced in the first paragraph of Section 3.6 for Natural Gas Systems, the new table, Table 3-38 (starting on page 3-47), is not explained. It appears to present unadjusted total CO2e 7*

emissions for each sector of the Natural Gas Systems (i.e. before any emission reductions are accounted for) and the reductions reported in Tables A-127 and A-128. Then, Table 3-37 takes the Potential Emissions, and subtracts out the emission reductions. API suggests that EPA include an explanatory note for this table and revise the title of this table (potential emissions implies emission at their maximum theoretical capacity). It would also be useful for EPA to add total calculated emissions to Tables A-122 through A-125 to aid in comparing the results presented in the Annex to the discussion in Section 3.6 of the inventory report.

Commenter: Karen Ritter, API

Comment: *The number of oil well completions in Table A-138 and Table A-143 increased significantly from 11,804 in the 2009 inventory to 18,456 in the 2010 draft inventory. This large increase is not discussed. In addition, the number of oil wells drilled (20,794) and the number of oil well completions (18,456), both reported in Table A-138, are larger than the number of crude oil development and exploratory wells reported by EIA for 2010 (16,5793).*

Commenter: Karen Ritter, API

Comment: *As stated in comments during the Expert Review period, API appreciates the correction to the emissions from asphalt blowing. As noted in API"s comments on the 2009 national inventory and discussed during the webcast, the previous national inventory was applying an emission factor based on the volume of asphalt blown to the total amount of asphalt produced. This inconsistency in units was greatly overestimating emissions from asphalt blowing. The revisions incorporated in the 2010 inventory correct this error.*

Commenter: Karen Ritter, API

Comment: *API had noted in comments during the Expert Review period that there are a number of emission sources associated with the refinery sector that are included under the Industrial category of Fossil Fuel Combustion Emissions, consistent with the underlying energy consumption data from EIA and IPCC"s inventory methodologies. These include, in addition to combustion units, CO2 emissions from hydrogen production, catalytic cracking units, fluid coking units, catalytic reforming units and sulfur recovery units. There is some ambiguity – and a developing inconsistency – as to where CO2 emissions from flares, hydrogen production, and*

coke calcining units are reported, due to differences between the IPCC methods and source categorization as compared to EPA"s mandatory GHG Reporting Program (GHGRP).

EPA indicates in the Planned Improvements discussion (page 3-55, starting on line 37) that data collected through 40 CFR Part 98 (GHGRP) will be used as a source for potential improvements to the national inventory. Further, EPA stated that In particular, EPA will investigate whether certain emissions sources currently accounted for in the Energy sector should be separately accounted for in the petroleum systems inventory (e.g., CO2 process emissions from hydrogen production). API supports the continued improvement of the national inventory, and urges EPA to prevent inadvertent double counting of emissions due to the different methodologies and source classifications used in the „top down" national inventory versus the „bottom up" facility-by-facility reporting required by the GHGRP. API also recommends that EPA provide transparent justification along with a formal technical review for anticipated changes to the national inventory methodology and process.

Commenter: Karen Ritter, API

Comment: *API had previously requested that EPA provide additional information in the Annex that indicates the source of each activity value and the method used to develop the activity value. Under the Planned Improvements (page 3-55, starting at line 42), EPA indicates that they are considering including a table matching each emission factor and activity factor with its source or calculation methodology. API supports this added transparency.*

Commenter: Karen Ritter, API

Comment: *Page A-157, 4th paragraph, line 5: the parenthetical … previously referred to as unconventional) , has an extra space before the comma.*

Commenter: Karen Ritter, API

Comment: *Page A-157, 5th paragraph, line 3: need to add a period and space between content and To*

Commenter: Karen Ritter, API

Comment: *Page A-158, 2nd paragraph, line 1: need to add a space between region and by.*

Commenter: Karen Ritter, API

Comment: *Page A-158, The first line of paragraphs 3 and 5 are not indented.*

Commenter: Karen Ritter, API

Comment: *Page 3-15, line 43: A comma is missing between production sector and uncombusted.*

Commenter: Karen Ritter, API

Comment: *There is an inconsistency in the wording between the last sentence of the first paragraph on p. A-157 (Many emission factors determined by EPA/GRI (1996) were assumed to be representative of emissions from each source type over the period 1990 through 2010.) and the first sentence three paragraphs later (Each emission factor in the U.S. Inventory was assumed to be representative of emissions from each source type over the period 1990 through 2010) – one says many and one says each.*

Commenter: Karen Ritter, API

Comment: *There is a period missing at the end of the first paragraph on p. A-159, after Table A-128.*

Commenter: Karen Ritter, API

Comment: *The number of platforms shown in Table A-126 does not match the number of platforms shown in Table A-122. It appears the values shown in Table A-126 may be a sum of the number of gas platforms, as shown in Annex 3.4, and the number of oil platforms, as shown in Annex 3.5. Although, even using this summation, the number of Gulf of Mexico and Pacific OCS Offshore Platforms does not match (a calculated 3,420 platforms vs. the value shown in Table A-126 of 3,432 platforms). Also, if the numbers shown in Table A-126 are indeed combined oil and gas production platforms, a comment should be provided indicating this.*

Commenter: Karen Ritter, API

Comment: *A footnote should be added to Table A-129 to explain what the + symbol means.*

Commenter: Karen Ritter, API

Comment: *The value of 1.410.09 in Table A-132 should be represented as 1,410.09*

Commenter: Karen Ritter, API

Comment: *The reference to Table A- 5 on row 30 of p. A-176 needs to be updated.*

Commenter: Karen Ritter, API

Comment: *The reference to Table A-140 on row 8 of p. A-177 should instead reference Table A-142.*

Commenter: Karen Ritter, API

Comment: *Row 13, p. 3-47 references 258,000 miles in 1990, but according to Table A-126, the value should be 944,157 miles.*

Commenter: Karen Ritter, API

Comment: *The totals shown for Table 3-40 do not match the values shown in Table 3-2. It appears there is a summation error for Table 3-40.*

Commenter: Karen Ritter, API

Comment: *A comment we have provided previously, when a table is split onto multiple pages, it would be useful to add a table title to each subsequent page, for transparency.*

Commenter: El Paso Corporation

Comment: *EPA Methane Emissions Estimation Methods Are Not Transparent And Need Significant Improvement*

EPA national inventories employ a 6 step process to estimate net emissions from each segment. The methodology relies on computing uncontrolled emissions first and then backing out reductions that may have been achieved via voluntary and/or state/federal requirements. The uncontrolled emissions are the product of activity data and an emission factor for each source category.

EPA must provide greater clarity to the amount of reductions at a unit or component level achieved via voluntary and mandatory reduction programs. In other words, Tables A-127 and 128 must be more transparent, detailed and possibly resemble the format employed in A-122 to A-126 in Annex 3 of the DRAFT Inventory. It is impossible to assess whether EPA has accurately depicted the current state of reduction technologies employed by the industry based on the information provided in Tables A-127 and A-128.

Commenter: El Paso Corporation

Comment: *EPA and EIA Emission Estimates and Emission Methodologies Must Be Reconciled*

On March 31, 2011, the U.S. Energy Information Administration (EIA) published its 18th annual report on 2009 annual emissions of GHGs in the United States8. While EIA employs a different global warming potential (GWP) for methane, we believe that EIA has much more robust activity data estimates to estimate methane emissions from the production, processing and T&S sectors of the US natural gas system than the EPA. Table 2-1 compares the EIA estimates for 2009 and the EPA estimates, including the revised 2009 methane estimates in this DRAFT inventory and the initial 2009 estimates finalized on April 15, 2011. After adjusting the EIA methane estimates to a GWP of 21, the EPA estimates are higher than the EIA estimates by 66.8 to 67.5 million metric ton of CO2e. While EIA has stopped publication of the annual GHG reports, but we urge the EPA to coordinate and reconcile emissions with the EIA, especially for the natural gas sector and use expertise residing at the EIA and Department of Energy (DOE) to better characterize and analyze emissions data from the industry.

Commenter: El Paso Corporation

Comment: *EPA Emission Factors Should Be Developed After Accounting Of Emission Controls And Current Infrastructure To Avoid Mischaracterization Of The True Emissions Profile Of the Natural Gas Industry*

EPA first computes the uncontrolled emissions and then backs out the voluntary and mandatory reductions through a very opaque process. EPA should employ all available data, including the data that will be submitted by companies as part of compliance with Subpart W reporting rules, to develop appropriate emission factors. Some of the revisions in estimation methodologies instituted by the EPA in 2009 were in response to the fact that once Natural Gas STAR Partner reported reductions are subtracted, it suggested that emissions from these emission sources are negative. While we welcome improvements in emissions estimates, it is unclear why EPA ignores reduction data when both the uncontrolled and controlled emissions are available. An example of such a situation is the EPA's derivation of an emission factor for well completions and workovers. The EPA analysis takes the simple average of four sets9 of completion flowbacks for the unconventional well completion emission factor: 9,175 Mcf/completion. As noted in El Paso's comments on the DRAFT inventory submitted on March 23, 2011, the majority of data for the above EPA factors came from Williams10 and completion factor was rounded up by the EPA to 20,000 Mcf of natural gas per well.

As noted above, EPA first computes the uncontrolled emissions and then backs out the voluntary and mandatory reductions through a very opaque process. EPA should employ all available data, including the data that will be submitted by companies as part of compliance with Subpart W reporting rules, to develop appropriate emission factors. Some of the revisions in estimation methodologies instituted by the EPA in 2009 were in response to the fact that once Natural Gas STAR Partner reported reductions are subtracted, it suggested that emissions from these emission sources are negative. While we welcome improvements in emissions estimates, it is unclear why EPA ignores reduction data when both the uncontrolled and controlled emissions are available. An example of such a situation is the EPA's derivation of an emission factor for well completions and workovers. The EPA analysis takes the simple average of four sets9 of completion flowbacks for the unconventional well completion emission factor: 9,175 Mcf/completion. As noted in El Paso's comments on the DRAFT inventory submitted on March 23, 2011, the majority of data for the above EPA factors came from Williams10 and completion factor was rounded up by the EPA to 20,000 Mcf of natural gas per well. The relevant portion of the presentation is reproduced in Figure 1.

While the Williams data contained both the actual volumes of "completion gas generated" and "flowback gas recovered", the EPA chose to use the "completion gas generated". Had EPA used the flowback recovery data by Williams provided in the same data set, and conservatively assuming there was zero flaring - i.e. all non recovered gas was vented and nothing was flared, one would end up with a weighted emission factor of 2,633/completion employing a 2002-2006 vintage dataset. Table 2-2 shows a significantly lower emission factor when the actual completion gas released to the atmosphere is considered, rather than trying to estimate the emissions based on the amount of gas recovered from the green completion. Even the results shown in Table 2-2 are overestimating emissions, as Williams notes that some of the non-

recovered completion gas is flared rather than vented. A more significant difference results from excluding the 2002 data, which may demonstrate that Williams improved on the amount of gas recovered from a completion in recent years (from 61% in 2002 to 90% or more in recent years). In fact, a recent analysis by ANGA concludes that the "EPA's 9,175 Mscf/completion event for unconventional fractured wells is potentially overestimating emissions by 1,200%."

The above example clearly points out the weakness in EPA's computing methodology where the EPA first computes uncontrolled emissions and then backs out reductions even when data on emissions post application of controls is available from the same source. It is surprising that EPA reverts to this methodology for sources like workovers and well clean-ups while for condensate tanks, separate emissions factors to account for both controlled and uncontrolled tanks are used.

EPA seems to be reluctant to analyze trends in industry to employ more "reduced emission completions" or RECs as shale plays and gas infrastructure within these plays become more mature. As noted above, this phenomenon is reinforced in the Williams data (employed by EPA to develop the workover and completions emission factors) as the latest year (2006) of data indicates over 90% capture of emissions which is also consistent with a recent ANGA study. The ANGA study concluded from its dataset that 93% of 2011 well completions had "green completions" and of the remaining "7% that were non-green completed, 54% were flared rather than directly vented to atmosphere. This indicates that only approximately 3% of the well completions in the dataset were uncontrolled." In other words, EPA's emission factor for flowbacks is outdated and grossly over-estimates the emissions from well completion.

It is no surprise that many of the non-industry stakeholders perceive the uncontrolled emissions from the EPA inventories as a reflection of "normal operations" by the industry. EPA must characterize the emission factors for both controlled and uncontrolled sources. EPA has already done the same for emissions from condensate storage tanks associated with the natural gas industry. Vapor recovery units (VRUs) are commonly utilized to control emissions from condensate tanks in the natural gas sector. EPA assumes 80% emission reduction to account for VRU usage. Typical VRU control efficiencies are much higher but nevertheless, this approach results in improved estimates of condensate tank emissions. EPA should carry out the same methodology for other major emission source categories such as liquids unloading, well completions, well workovers, pneumatic devices, compressor seals etc. Control technologies such as plunger-lifts, RECs, low bleed pneumatics and dry seals that are widely applied must be incorporated into the emission factors. In summary, El Paso urges the EPA to develop emission factors from all relevant and recent data sources (such as data from Subpart W reporting) to characterize emissions from major source categories post emissions controls. The EPA should collect activity data that includes the number or percentage of sources employing emission controls and their types. The current methodology of first computing uncontrolled emissions and

then backing out natural gas reductions (a process that is very opaque) has already resulted in significant mischaracterization of the industry's actual emissions.

Well Clean Up Is The Largest Source Of Uncontrolled Emissions But Revised Methodology Employs Outdated Data And There Is No Transparency On Reductions From Emission Reduction Technologies

While there has been significant focus by various entities on methane emissions, especially related to "flowbacks" from unconventional well completions and workovers, the largest uncontrolled emission category per the EPA inventory is well clean up (liquids unloading) - an event associated with conventional low-pressure wells. Per the EPA well completions contribute approximately 4% of the total emissions from the combined production, processing and T&S sectors; well clean up contributes approximately 37% of the combined emissions prior to emission controls. Prior to the 2009 revisions, the EPA employed an emission factor of 49,570 standard cubic feet of methane per year from well clean ups and assumed three scaling factors at three points over the time a well is blown down. In the revised methodology, EPA uses data from well sites from 1992 to conclude that 41.3 % of conventional wells require liquid unloading and assumes this as a constant from 1992 to present - despite the trend of shale gas production accounting now for a larger share of the total gas production which should imply a decrease in the liquids unloading at low pressure convention wells. In addition, the EPA uses the 1992 data survey from 25 wells to conclude that there are "38.73 blowdowns per year per well" that require unloading – a precision to the second decimal point of the number of annual blowdowns per year per well! As noted in our 2011 comments, the most significant issue with the approach applied to quantify low pressure well clean up emissions, and also a universal issue with the EPA's national inventories, is that the methodologies are not transparent when first uncontrolled emissions are computed and then the reductions reported via voluntary or mandatory mechanisms are backed out. We recommend that the EPA provide separate factors for controlled and uncontrolled emissions, and compute actual emissions using data from Subpart W reports.

Comments and Recommendations – Transmission & Storage Sector a. Background - Dry & Wet Seal Centrifugal Compressors

In our 2009 comments, El Paso provided details related to estimates of emissions from centrifugal compressors. In our comments, we concluded that EPA incorrectly averaged12 the data from a 48 sample data set presented in a World Gas Conference paper (WGC 2009). If an emission factor calculated by using the correct average of the WGC data had been used in the draft inventory, the emissions due to compressor wet seal would be reduced to 58% of the current estimate for processing, 60% of the current estimate for transmission, and 66% of the current estimate for storage. This would have reduced the total inventory for the processing sector by approximately 10.4%, and the total inventory for the transmission/storage sector by approximately 4.2%.

To arrive at the dry seal emission factor, the EPA assumed that the midpoint (3 scfm) of the reported Lessons Learned13 range of up to 6 scfm adequately characterized dry seals. Since there are typically 2 dry seals per compressor, the total per-compressor emissions rate from dry seals is 6 scfm.

To arrive with a number of compressors using dry seals, EPA's main source was a presentation from 2003 on centrifugal compressors in the natural gas industry14 which showed that 90% of new compressors sold were equipped with dry seals. EPA assumed that all centrifugal compressors installed prior to 1992 were equipped with wet seals. Assuming that 90% of new centrifugal compressors since 2003 were equipped with dry seals, and that there were none dry seal compressors in 1992, the EPA interpolated a straight-line estimate of the percentage of new compressors that were equipped with dry seals. That is, the percentage of new compressors equipped with dry seals increased linearly between 0% in 1992 and 90% in 2003.

El Paso Actual Measurements

This section provides El Paso's measured emission factors and activity data for major "unit" level emission sources at its pipeline facilities. This data was collected as part of compliance efforts with Subpart W regulations.

El Paso's Pipeline Group is the nation's leading interstate natural gas pipeline franchise as measured not only by mileage, but more importantly, by access to key supply regions and major consuming markets as well as by unparalleled connectivity to those markets. We transport 17 billion cubic feet per day or 26 percent of the gas delivered to U.S. consumers each day through our 42,000 mile interstate natural gas pipeline system. Our pipelines have the capacity to transport up to 28 billion cubic feet per day, 13 percent of the total U.S. natural gas pipeline capacity.

Our pipelines reach deep into the traditional Gulf Coast supply areas, the prolific Rockies supply basins, and the shale plays that will play a significant role in meeting the nation's long-term natural gas supply. We serve the major consuming markets of the Northeast, Southeast, Rockies, and Southwest, as well as Mexico. Our pipelines are built deep into our markets, making us a critical part of the infrastructure of local distribution companies, storage operations, and industrial and power generation facilities. As of December 31, 2012, we have placed into service 1,800 miles of new pipelines as part of our $8 billion natural gas pipeline expansion program in the recent years.

Due to the above reasons, our pipeline network is a good reflection of the natural gas pipeline industry in the U.S. Hence, the results of our methane measurement program that surveyed over 200 facilities, provides a much more significant insight to the emissions profile of the industry

than outdated emissions estimation from the early 1990s derived from a significantly lower sample size and/or linear interpolation of data to arrive at best guess of the emissions.

El Paso's Pipelines Emissions Measurement & Estimation Program.

El Paso has been participating in the EPA Natural Gas Star program since 1993 and has been recognized as the "Partner of the Year" multiple times. Through the Natural Gas Star program and internal voluntary monitoring initiatives, El Paso gained superior technical knowledge on the capabilities and limitations related to fugitive emission monitoring and reductions in the natural gas sector. Since 1993, the El Paso Pipeline Group achieved GHG emission reductions of over 63 billion cubic feet of natural gas, or approximately 30 million tons of CO2e. El Paso has implemented fugitive and vented methane leak measurement and research programs dating back to the 1990s. We have experience in practical applications of various tools such as the Infra-red camera, Hi-Flow Sampler etc.

El Paso has been a member of the California Climate Action Registry (CCAR) since 2006 and has been reporting its GHG emissions since 2007. In August 2008, El Paso became the first company to file an emissions inventory covering all applicable GHGs, including methane, N2O and CO2 for its US operations. In addition, on December 31, 2007, El Paso reported its 2006 GHG emission estimates under DOE 1605(b) requirements. The CCAR inventories followed CCAR protocols and INGAA guidelines for estimation of emissions. The INGAA guidelines predominantly use the EPA/GRI data set from the 1990s. For El Paso's CCAR inventories, emissions were based on historical factors and actual activity data.

El Paso has developed a comprehensive monitoring and reporting program to ensure compliance with 40CFR Part 98 Subpart W (Subpart W) regulations. As part of this program, El Paso surveyed 193 compressor stations, 10 storage stations, 1 LNG plant and 7 processing plants. El Paso followed EPA survey and measurement protocols outlined in Subpart W. The data was then analyzed for each unit and component level emission source type. Table 3-1 provides a summary of the preliminary16 emissions data from El Paso's data collection efforts a (averaged at the 95% confidence interval) versus the EPA emissions data for the same source.

As illustrated in Table 3-1, El Paso factors are significantly lower than the EPA factors and have been developed from a sample size that is in general superior in terms of quantity and measurement techniques. Table 3-2 compares El Paso component level emission rates for the source category - a natural gas transmission facility operating reciprocating compressor engines. The sum of the individual component leakers provides the unit level emissions estimates as noted in Table 3-1.

For this emission source category, the EPA source of the data and associated factor that is employed in the DRAFT inventory is the EPA/GRI study17. The sum total of these components equates to with the 5,550 MSCF/YR or 15,205 scfd leak rate that the EPA uses in Table A-124,

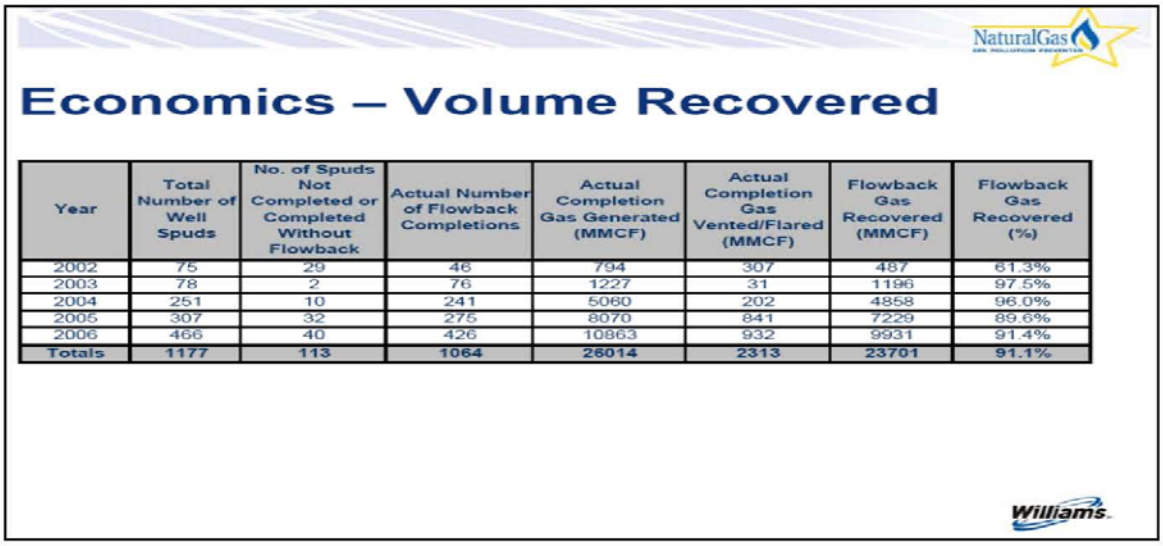
Annex 3 of the DRAFT Inventory to compute emissions from natural gas transmission facility operating reciprocating compressor engines.

To ensure a correct comparison with the El Paso data, since the EPA Subpart W protocol does not include direct measurements and related calculations of leak rates from pressure relief valve and other miscellaneous components (but which were measured as part of the EPA/GRI study), those two leak rates are backed out from the EPA/GRI factor for comparison purposes. As such, an "adjusted" unit level EPA Leak rate excluding these two sources is 4,998 MSCF/YR or 13,693.2 scfd per compressor unit instead of 15,205 scfd. Whereas, the average El Paso unit level factor at the 95% confidence interval is 1,427 ±265MSCF/YR or 3,909.6±726 scfd.

Figure 3 is a histogram that depicts the El Paso the "unit level" emission rates from the above source category using data measured and calculated at 811 units (reciprocating compressor engines) using the EPA Subpart W protocol. The calculated unit level leak rate distribution clearly shows that El Paso compressor fugitives for this source category are significantly lower than EPA's estimates and there are only a handful of compressor fugitive emission rates (from a unit population size of 811) that exceeded the EPA factor.

Similarly, Figures 4, 5 and 6 are histograms of El Paso's calculated unit values versus EPA's unit level factors for compressor station fugitives (storage), centrifugal compressor station (wet seal) and centrifugal compressor station (dry seal). As noted above (with reciprocating compressor station fugitives), the summary data is presented in Table 3-1. In all cases, the measured value from El Paso results in significantly lower emissions than the factors employed by the EPA. It should also be noted that the El Paso sample size is statistically much more significant than the EPA sample size and unlike some EPA factors is not a linear interpolated or assumed value.

Figure 1 – Williams Flowback Data



NaturalGas

Economics – Volume Recovered

Year	Total Number of Well Spuds	No. of Spuds Not Completed or Completed Without Flowback	Actual Number of Flowback Completions	Actual Completion Gas Generated (MMCF)	Actual Completion Gas Vented/Flared (MMCF)	Flowback Gas Recovered (MMCF)	Flowback Gas Recovered (%)
2002	75	29	46	794	307	487	61.3%
2003	78	2	76	1227	31	1196	97.5%
2004	251	10	241	5060	202	4858	96.0%
2005	307	32	275	8070	841	7229	89.6%
2006	466	40	426	10863	932	9931	91.4%
Totals	**1177**	**113**	**1064**	**26014**	**2313**	**23701**	**91.1%**

Williams

Table 2-2 – Analysis of Williams' Flowback Estimates

	Actual Number of Reported Flowback Completion	Actual Completion Gas or Natural Gas Flowrate Prior to Recovery or Flaring		Rounded Average Employed by EPA for Emission Factor Development	Reported Vented or Flared Emissions		Rounded Average Computed for Actual Vented or Flared Emissions
Source, Year		MMCF	MCF/Completion	MCF/ Completion	MMCF	MCF/Completion	MCF/Completion
Williams, 2002	46	794	17,261		307	6,674	
Williams, 2003	76	1,227	16,145		31	408	
Williams, 2004	241	5,060	20,996	20,000	202	838	2,633
Williams, 2005	275	8,070	29,345		841	3,058	
Williams, 2006	426	10,863	25,500		932	2,188	

Reported or computed directly from Williams Data
EPA Analysis
El Paso Analysis

Figure 2 – El Paso Pipeline Network

Table 3-1: Comparison of EPA Unit Level Emission Factors versus El Paso Factors

Emission Rates (standard cubic feet per day (scfd) per compressor unit)			Unit Population Size and Sample Size of Direct Measurements	
Source Category	**EPA**	**El Paso (average @95% CI)**	**EPA**	**El Paso**
Transmission Station Reciprocating Compressor Station Fugitives	15,205	1,427± 266	?	811 Units Calculated using EPA Subpart W protocol based on 350 Blowdown valve , 438 Rod Packing, and 336 Unit Isolation Valve Unit Level Direct Measurements
Transmission Centrifugal (Wet Seal) Compressor Fugitive	50,222	626± 314	48	138 Units Calculated using EPA Subpart W protocol based on 38 Blowdown valve , 11 Wet Seal, and 155 Unit Isolation Valve Unit Level Direct Measurements
Transmission Station Centrifugal (Dry Seal) Compressor Fugitive	32,208	401± 89	Assumed 3 scfm and converted to annual rates based on 30% operating factor	116 Units Calculated using EPA Subpart W protocol based on 38 Blowdown valve , 35 Dry Seal, and 155 Unit Isolation Valve Unit Level Direct Measurements
Storage Station Reciprocating Compressor Station Fugitive	21,116	1558± 358		54 Units Calculated using EPA Subpart W protocol based on 350 Blowdown valve , 438 Rod Packing, and 336 Unit Isolation Valve Unit Level Direct Measurements

Table 3-2: Comparison of 2011 Unit Average and Component Level Emission Factors – EPA and El Paso Pipelines

	Transportation Station Reciprocating Compressor Station Component Emission Factor	
Component Name	**EPA[a]**	**El Paso (@95% Confidence Interval)**
Compressor Blowdown Open-Ended Line (Combination of Idle-Pressured Blowdown Valve and Idle-Unpressurized Unit Isolation Valve Sources)	3,683 MSCF/YR = 10,090 scfd	720±255MSCF/YR = 1,972.6±698scfd
Pressure Relief valve	372 MSCF/YR = 1,019scfd	Not Measured as Part of Subpart W
Miscellaneous	180 MSCF/YR = 493 scfd	Not Measured as Part of Subpart W
Compressor Seal	1,315 MSCF/YR = 3602 scfd	707±87MSCF/YR = 1,938±238 scfd
EPA/GRI Total (Factor used in the DRAFT Inventory)	5,550 MSCF/YR = 15,205 scfd	
Adjusted EPA/GRI (Total – PRV – Misc.)	**4998 MSCF/YR = 13,693 scfd**	**1,427 ±266 MSCF/YR = 3,910±728 scfd**

Figure 3: Histogram of El Paso Pipeline Group (EPPG) 2011 Transmission Station Reciprocating Compressor Fugitive Emissions in MSCF/YR

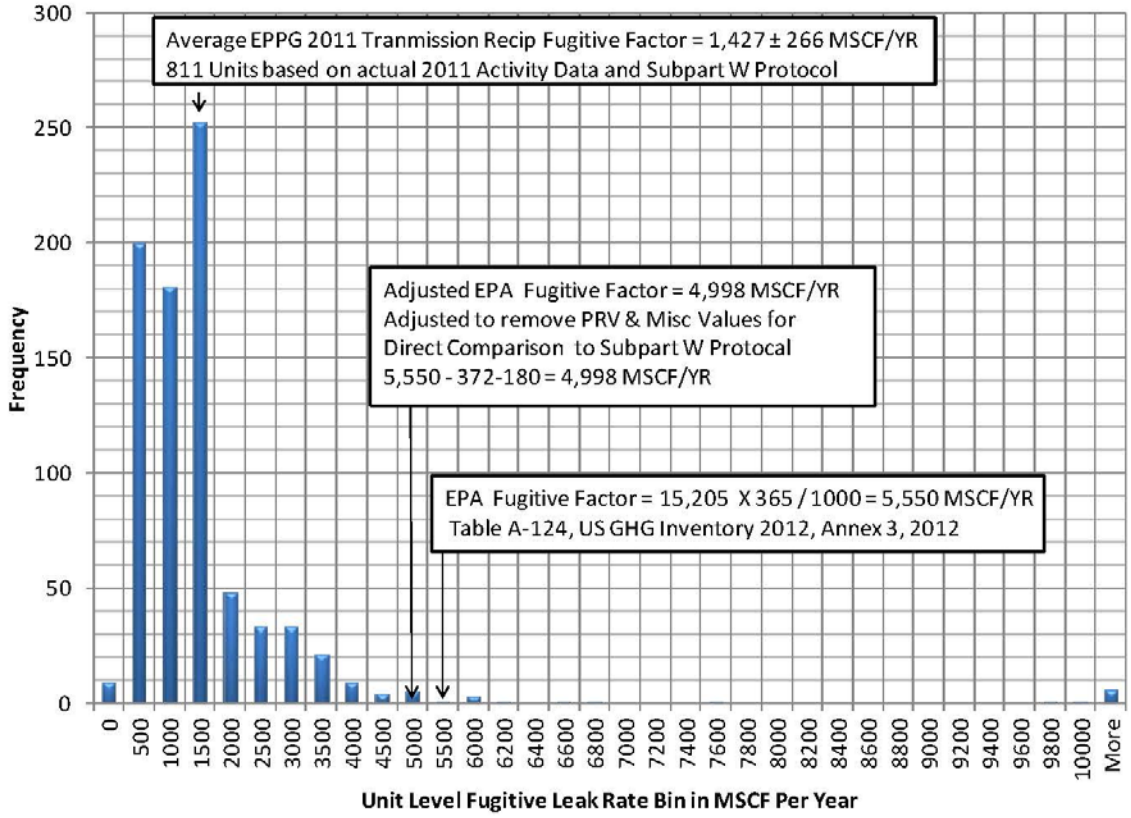


Figure 4: Histogram of El Paso Pipeline Group (EPPG) 2011 Storage Station Reciprocating Compressor Fugitive Emissions in MSCF/YR

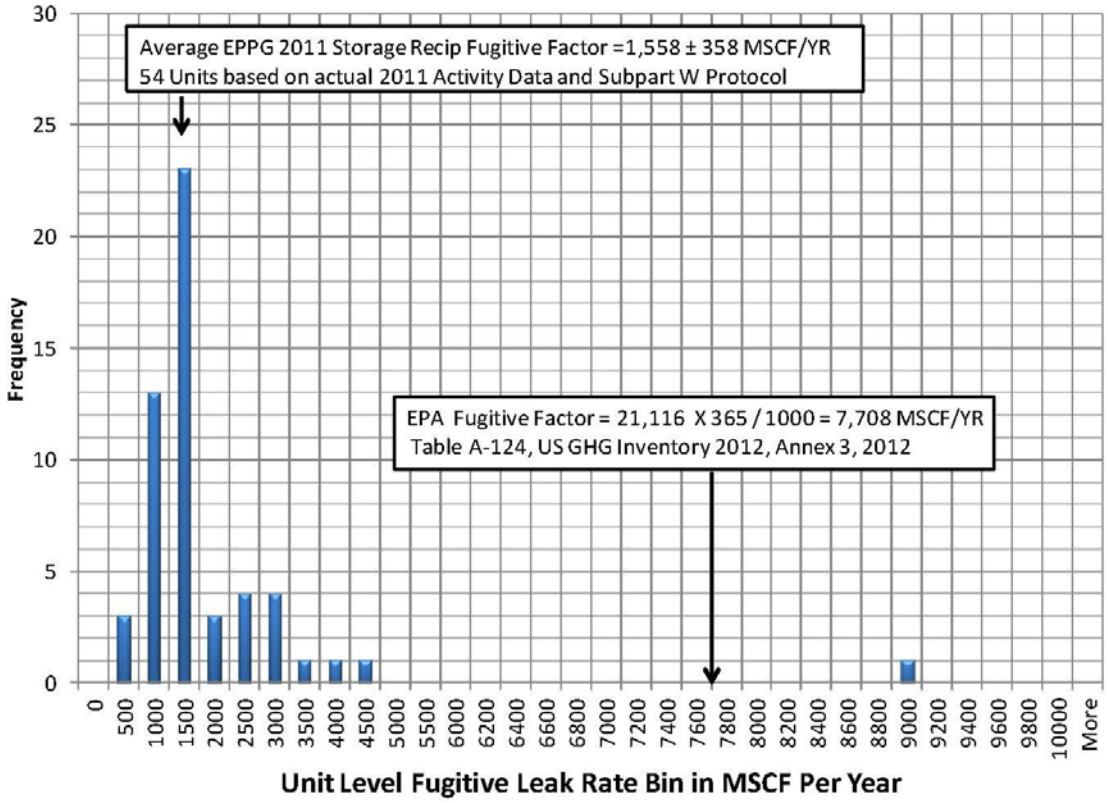


Figure 5: Histogram of El Paso Pipeline Group (EPPG) 2011 Transmission Station Centrifugal (Wet Seal) Compressor Fugitive Emissions in MSCF/YR

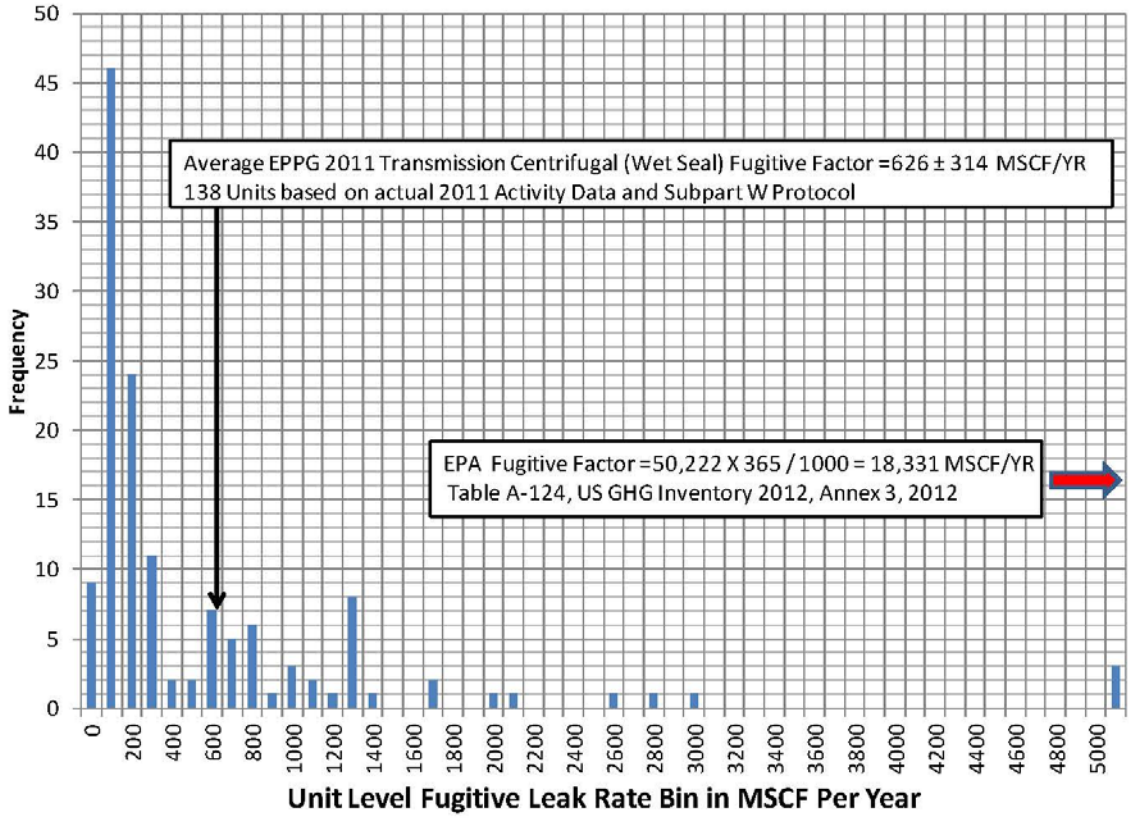
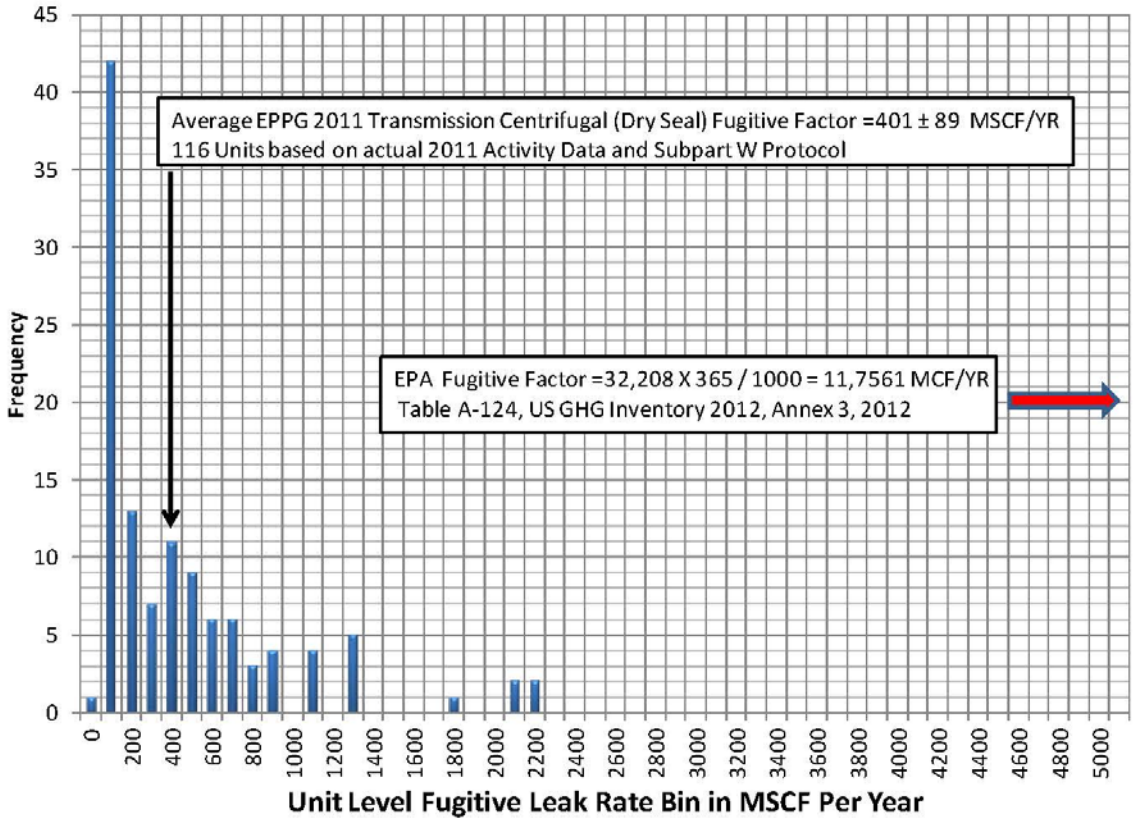


Figure 6: Histogram of El Paso Pipeline Group (EPPG) 2011 Transmission Station Centrifugal (Dry Seal) Compressor Fugitive Emissions in MCF/YR



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dry seals. EPA assumed that all centrifugal compressors installed prior to 1992 were equipped with wet seals. Assuming that 90% of new centrifugal compressors since 2003 were equipped with dry seals, and that there were none dry seal compressors in 1992, the EPA interpolated a straight-line estimate of the percentage of new compressors that were equipped with dry seals. That is, the percentage of new compressors equipped with dry seals increased linearly between 0% in 1992 and 90% in 2003.

Commenter: NAFO

Comment: *The IPCC Guidelines Appropriately Include Emissions From All Woody Biomass Products, Including Energy Feedstocks, in the LULUCF Sector Because They Are Part of the Forest Carbon Cycle*

First, and most importantly, the GHG Inventory – and the IPCC Guidelines on which it is based – recognizes the critical difference between biogenic and fossil CO2 emissions. Biomass that is combusted for energy is part of the natural forest carbon cycle and must be accounted for in a manner that reflects the natural balance between forest growth and harvest. As the GHG Inventory recognizes, carbon "is continually cycled among these storage pools and between forest ecosystems and the atmosphere as a result of biological processes in forests (e.g. photosynthesis, respiration, growth, mortality, decomposition, and disturbances such as fire or pest outbreaks) and anthropogenic activities (e.g. harvesting, thinning, clearing, and GHG Inventory at 7-12. Thus, at the same time that biomass combustion emits CO2 into the atmosphere, replanted and regenerating forests sequester CO2 from the atmosphere. Because the net impact that forest ecosystems have on atmospheric CO2 concentrations depends on the amounts of carbon sequestration and emission that occur over a given time period, it can be measured in an accurate and practical manner by monitoring changes in forest carbon stocks over time.

Recognizing the interrelated nature of the biogenic carbon cycle, the IPCC Guidelines wisely account for all biogenic carbon fluxes – including biomass energy emissions – in the LULUCF sector. This sector includes all terrestrial carbon stocks including forests, croplands, grasslands, and urban areas. By measuring the carbon stocks in each forest carbon pool over time, the IPCC Guidelines permit EPA and other agencies tasked with implementing the United Nations Framework Convention on Climate Change ("UNFCCC") requirements to determine whether carbon sequestration and emissions in the forest sector are balanced. As EPA explained in a previous GHG Inventory:

The combustion of biomass fuels such as wood, charcoal and wood waste and biomass-based fuels such as ethanol from corn and woody crops generates CO2. However, in the long run, the CO2 emitted from biomass combustion does not increase net atmospheric CO2 concentrations,

assuming that biogenic C emitted is offset by the uptake of CO2 that results from the growth of new biomass. As a result, CO2 emissions from biomass combustion have been estimated separately from fossil fuel-based emissions and are not included in U.S. [energy sector] totals.

EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 at Energy 3-59, available at http://epa.gov/climatechange/emissions/usgginv_archive.html. The IPCC Guidelines, as described by EPA, accurately reflect the practices of private forest managers, who manage their forests to maintain stable carbon stocks and produce a constant supply of harvestable forest products over an extended period of time. The success of these forest managers in balancing regeneration and harvest is evident in the GHG Inventory as forest carbon stocks have been increasing since the GHG Inventory began in 1990. See GHG Inventory at 7-14-16. Thus, the atmosphere does not see any increase in CO2 concentrations as a result of U.S. forestry practices, even though some forest products are combusted for energy. In contrast, fossil fuels, which are formed on geological time scales, are not part of a natural cycle that operates on climate-relevant time scales and fossil CO2 emissions cannot be naturally sequestered on climate-relevant time scales. Because the combustion of fossil fuels always produces a net increase in atmospheric CO2 concentrations, fossil fuel emissions are appropriately measured within the energy sector at the point of combustion.

Further, the GHG Inventory appropriately recognizes that forest products themselves play an important role in maintaining forests as carbon sinks. As NAFO has previously explained, strong markets for forest products are essential for maintaining or even expanding forest carbon stocks and, in fact, have been responsible for much of the growth in forest carbon stocks over the past half-century. See National Alliance of Forest Owners' Comments to the Science Advisory Board Carbon Emissions Panel (March 16, 2012) at 6-7 ("NAFO SAB Comments") (attached as Exhibit A). But aside from this climate benefit, forest products continue to store carbon for decades after harvest while the products remain in use. Thus it is inappropriate to simply assume that all forest carbon is emitted immediately upon harvest. NAFO fully supports EPA's efforts to model and quantify the harvested forest carbon that is transferred into long-term storage pools and thus does not increase atmospheric CO2 concentrations. By doing so, EPA can more accurately assess what the atmosphere sees as a result of forest management practices in the United States.

Use of the IPCC Guidelines Produces Accurate and Consistent Results with Minimal Transaction Costs and Additional Resource Burdens

Second, reliance on the IPCC Guidelines ensures that the GHG Inventory produces consistent and accurate data that can be used in a variety of policy contexts while providing certainty and apples-to-apples comparisons for key stakeholders. EPA's annual GHG Inventory is produced in accordance with the United State's obligations under the UNFCCC. A primary purpose of the GHG Inventory is to provide a common and consistent mechanism that enables UNFCCC Parties to make comparisons regarding GHG emissions between countries and over time. This

purpose cannot be achieved without the consistent use of a uniform accounting methodology. The IPCC Guidelines have been used both domestically and internationally since the GHG Inventory process began. EPA's continued use of the IPCC Guidelines as the starting point for its accounting methodology will safeguard its past investments in developing the GHG Inventory and ensure that the UNFCCC's goal of creating comparative GHG data will continue to be met.

Aside from its role under the UNFCCC, the GHG Inventory is an important resource that can be used in the development of domestic policy. As the GHG Inventory explains, "[a] national land-use categorization system that is complete both temporally and spatially" is required to provide accurate comparisons and guide policy-makers. GHG Inventory at 7-4. NAFO agrees that the climate benefits of biomass can be most accurately observed on broad spatial and temporal scales and supports EPA's efforts to expand upon the IPCC methodologies in order to produce "a more comprehensive and detailed estimate of emissions," at appropriately broad spatial and temporal scales. See GHG Inventory at ES-1; see also NAFO SAB Comments at 5-8. NAFO also supports EPA's efforts to improve the accuracy of the GHG Inventory by incorporating improvements in existing databases as they become available. E.g. GHG Inventory at 7-4, 11

The GHG Inventory's reliance on existing data sources also streamlines implementation by avoiding the need for costly and time consuming data collection and analysis. While EPA is certainly capable of developing a single comprehensive approach to accounting for carbon stocks in the LULUCF sector, it has appropriately recognized that all of the necessary data is already being collected at the national level through the US Forest Service's Forest Inventory and Analysis ("FIA") database, the Department of Agriculture's National Resources Inventory ("NRI"), and the U.S. Geological Survey's National Land Cover Dataset ("NLCD"). By relying on national-scale data that is readily available though existing federal databases, EPA has been able to develop an accounting framework at minimal costs to the Agency or the land owners that comprise the LULUCF sector. In this way, the GHG Inventory serves as a model for other federal programs. In fact, EPA has proposed to reply on the same annual FIA data in its Accounting Framework for Biogenic CO2 Emissions from Stationary Sources (Sept. 2011).

While review of this proposed accounting framework is ongoing, NAFO continues to support EPA's use of nationally available data in developing policies for regulating CO2 from stationary sources.

Despite the fact that biomass combustion represents one part of the continuous carbon cycle, some organizations assert that biomass emissions can be measured more accurately and effectively at the point of combustion. These approaches rely on a complicated chain-of-ustody approach that tracks biomass feedstocks from the point of harvest to combustion. Not only would such a complicated chain introduce considerable uncertainty due to its complexity, it would prove practically infeasible due to the significant recordkeeping costs that would be imposed upon EPA, biomass energy facilities, and others in the biomass supply chain. Furthermore, such approaches also run the significant risk of significantly distorting the atmospheric consequences

of biogenic CO2 emissions by applying spatial and temporal scales that are too narrow or that rely on arbitrary and often complex baseline assumptions. There is simply no reason to adopt a more complicated methodology that will produce less accurate results. The GHG Inventory's 20-year track record proves that this national-scale forest carbon stock approach provides practical, accurate, and efficient measurements of the climate impact of the entire forestry sector, including biomass energy.

Conclusion

As explained above, NAFO supports EPA's use of the IPCC Guidelines in the GHG Inventory. Not only do the IPCC Guidelines produce meaningful data that can be compared over time and across nations, they also distinguish biomass emissions and fossil fuel emissions and demonstrate that biomass is a carbon neutral energy source. Despite some calls for EPA

to adopt a different accounting method for biomass energy combustion, NAFO strongly encourages EPA to continue its current practice of conforming to established international guidelines, which in turn produces accurate and efficient GHG data for the forestry sector.

Commenter: NAFO

Comment: *As NAFO and its members have explained in earlier comments and presentations to the Panel and EPA, critical to NAFO's mission in reducing GHG emissions is supporting the use of biomass as a renewable energy supply that offers important climate and energy security benefits. EPA's decision to reconsider its approach to regulating biogenic CO2 emissions from stationary sources offers an opportunity to encourage the continued development of climate-beneficial bioenergy capacity. It is NAFO's goal that, with the assistance of the Panel's expertise, EPA will develop a regulatory framework that accurately reflects the climate benefits offered by biomass, encourages its continued development, and promotes appropriate distinctions between bioenergy and other types of energy such as fossil fuel combustion. We believe that the Panel can achieve these goals by making recommendations that avoid unnecessary complexity and by using its expertise to apply scientific theories to real- world scenarios.*

First, we applaud the Panel's commitment to distinguishing between scientific and policy questions and leaving the latter category to EPA. However, the Panel need not retreat to the consideration of purely abstract and theoretical issues detached from real world considerations relevant to forest management and bioenergy production. It is not enough for the Panel to verify that a particular model or approach to carbon accounting is scientifically valid at an abstract level. Instead, the model's assumptions must be rigorously evaluated to ensure that they are consistent with the way that forests are managed and biomass energy is actually produced in the United States. When the Panel finds that multiple alternatives accurately reflect the forestry and

forest products sectors and are capable of efficient implementation, it is appropriate to include such an assessment in the final report and allow EPA to make an informed policy choice among such alternatives. At the same time, when, as a result of its experience, expertise, and investigation, the Panel finds that a model's assumptions do not accurately reflect real- world domestic forestry practices, it must include that information in the final report, and recommend against adoption of the model. For example, the Panel should make clear that the assumptions underlying stand-based accounting methodologies, as well as other assumptions or methodologies that constrain temporal and spatial scales, are inconsistent with U.S. forest management practices and thus are inappropriate for inclusion in an accounting framework.

Similarly, the Panel should not merely defer consideration to EPA of factors and conclusions that can inform EPA's policy decisions. Again, as a result of its expertise and experience, the Panel is uniquely qualified to assess the costs and benefits of various approaches and determine whether they can be successfully implemented from both a technical and practical perspective. The Panel must bring its experience to bear and inform EPA's decision-making process with sound, objective, and reliable information. It is appropriate, after identifying the pragmatic challenges, costs, and benefits of alternative approaches, to defer a legitimate policy choice for EPA with the benefit of the Panel's analysis of the underlying considerations. It is also appropriate for the Panel to conclude that the benefits of an alternative cannot be achieved without increasing transaction costs to the point that the proposal becomes technically or practically infeasible. These circumstances arise, for example, in facility-based chain-of-custody approaches that require the collection of detailed data from countless landowners and suppliers. In such circumstances, the Panel should inform EPA that the alternative is not viable and recommend against its adoption.

Finally, above all, the Panel must strive to reduce uncertainty and complexity. The Panel's conclusions will serve as the foundation for EPA's regulatory decisions, which, in turn, will have a critical and long-lasting influence on the future of sustainable bioenergy in the United States. As the Panel has noted, the Framework proposed by EPA presents "daunting technical challenges" for implementation due to its complexity. Report, at 6. Unfortunately, NAFO remains concerned that the Panel's efforts to provide greater scientific precision and accuracy threaten to increase rather than decrease that complexity. In our prior comments, we provided a series of ways in which the Panel could reduce the complexity of the EPA's proposed regulatory program.2

Those suggestions are summarized below. First, NAFO urges the Panel to limit its analysis to actual rather than hypothetical biomass energy feedstocks in order to develop generally applicable principles that could be applied uniformly to all biomass energy feedstocks without introducing complex analyses into the regulatory framework. Second, we urge the Panel to focus on spatial and temporal scales that are relevant to U.S. forestry practices in order to avoid complex analyses that are simply irrelevant to biomass energy production. Third, we urge the Panel to avoid consideration of factors that are beyond the scope of EPA's regulatory review.

Fourth, we urge the Panel to accept the limits of science in resolving uncertainty and avoid recommending impractical data collection processes that produce diminishing returns in improved accuracy. After reviewing the revised Report, it is clear that the Panel has addressed some of these suggestions and has made efforts to reduce the complexity in its recommendations. However, on the whole NAFO remains concerned that the recommendations still are so complex that, if adopted, they unfortunately would have the perverse effect of discouraging or foreclosing the development of biomass energy due to the high transaction costs of compliance.

By applying the principles described above and focusing on the pragmatic realities of the forestry and biomass energy sectors, NAFO believes that it is possible to develop a simple and straightforward approach to accounting for biogenic CO2 emissions from woody biomass that can be efficiently and effectively implemented. As described below, such an approach would be based on three threshold determinations, as informed by scientific theory and an understanding of the forestry and biomass industry sectors: (1) the adoption of a national scale; (2) a reference point baseline; and (3) a 100-year time scale. Once these three principles are adopted, the Report's conclusions will properly inform EPA on appropriate and scientifically sound alternatives, including the option of a categorical exclusion for biogenic CO2 emissions. While a conclusion on how to treat biogenic emissions in a regulatory regime ultimately entails some policy choices for EPA, this recommended approach will enable EPA to make sure decisions based on the strongest possible scientific and technical considerations and, for that reason, should be included in the Panel's recommendations to EPA.

Biogenic CO2 Regulations Must Be Based on a National Scale

Before an accounting methodology can be developed, there are a number of threshold issues which must be resolved, including the appropriate spatial scale for regulations. A national scale is the only alternative identified by EPA and the Panel that is supported by science, consistent with actual U.S. forest management practices, and practical to implement. While the ultimate selection of a spatial scale may entail policy considerations, the strong scientific and technical support for a national scale warrants its inclusion in the Panel's recommendations to EPA.

A Broad Spatial Scale is Required to Reflect Domestic Forest

Management Practices

In order to properly reflect the way in which forests are managed and biomass feedstocks are produced, the Panel must recommend and EPA adopt a broad spatial scale. Because the goal of forest management is to produce a continuous supply of forest products, it is fundamentally inconsistent with forestry practices to isolate a single stand and arbitrarily choose a starting point for the carbon cycle. By choosing to start the carbon cycle at the time of planting or harvest such an approach creates an arbitrary carbon credit or debt.3 While it is theoretically valid to view the carbon cycle in a linear fashion, tracking the movement of a single carbon atom or the carbon stocks on a single plot of land, this approach is inconsistent with the way that

forests are managed in the United States. Thus, even if the stand-based accounting principles included in Walker (2010) and Biomass Energy Resource Center (2012) are scientifically valid in an framework as their primary assumptions are at odds with the established practices of the forestry sector as a whole.

Forest owners and managers do not treat each stand independently, but instead develop broad management plans at a landscape level. These plans are designed to produce diverse age classes and a constant supply of harvestable forest products over an extended period of time. As a result, the processes of CO2 emission and sequestration occur simultaneously within the landscape. Therefore, as NAFO has previously explained, the emissions associated with harvesting are offset on a continuous basis by regeneration that is occurring on the many other stands that are not harvested and forest stocks remain stable. By focusing on the simultaneous emissions and regeneration, it is also apparent that a broad spatial scale is consistent with the science of the carbon cycle. While the carbon cycle is often viewed linearly, focusing on the growth, harvest, and regeneration of a single tree or stand, it can also be viewed in a single temporal plane as emissions and regeneration take place in different portions of a single, managed landscape. Thus adopting a broad spatial scale would be consistent with both the science of the carbon cycle and domestic forest management practices.

In the same manner, the forest products industries – including biomass energy – are integrated at a national level as individual producers also obtain supplies from a vast and ever-changing array of forest owners and suppliers.6 Moreover, the producers compete with each other in the marketplace making it impossible to isolate impacts on small spatial scales. Indeed, as the Panel noted, a national scale is necessary to model forestry markets and the economic behavior of landowners. Report at 32-35. Thus, individual forest owners continually respond to market signals that are sent at national or even global scales, and shift their plans in anticipation of and response to new market demands. While geographic constraints may fix the location of forests and biomass energy facilities, the markets that they serve are unconstrained and treat all forest owners and suppliers equally. Thus, both market demands and the response from forest owners is best captured at a national scale. Indeed, this relationship can be readily observed in historical data as forest owners have repeatedly responded to new market demands, increasing national forest carbon stocks in the process. Thus, the nature of forest products markets also requires that biogenic CO2 emissions be considered on the broadest scale possible.

A National Scale is the Most Appropriate Choice Among Broad Scales

A national scale is clearly superior from a technical standpoint among other options such as a broad landscape-based spatial scale. First, a national scale responds most closely to the global nature of climate change and EPA's regulatory authority under the Clean Air Act to implement air policies at a national level. Thus, it avoids the problems of scale sensitivity and domestic leakage that plague regional approaches. See Report at 6. It also has the advantage of treating all biomass facilities equally and allowing market forces to dictate their location based on

considerations such as supply, demand, and market efficiency. Second, a national scale will prove the most practical, predictable, and least burdensome approach to implement. As EPA and NAFO have noted, data from the U.S. Forest Service's Forest Inventory and Analysis (FIA) program and other sources are readily available and can be incorporated into a regulatory framework at little cost to EPA or the regulated entities. Framework at 31-32. Thus adopting a national scale would serve the important purpose of reducing complexity and transaction costs and thereby promote climate-beneficial biomass energy.

The application of a national scale is also consistent with the Panel's own recommendations in its discussion of alternatives. The Panel's endorsement of the development of default BAFs for feedstock categories as an alternative to facility- specific BAFs would necessarily be applied at a national level. Report at 45. While the necessity of distinguishing among feedstocks is addressed below, the Panel's inclusion of this alternative shows that a national, rather than facility-based, approach to accounting for biogenic CO2 emissions is consistent with scientific theory and would be appropriate in practice.

While EPA might consider the alternative of incorporating a broad spatial scale by adopting a facility-based fuelshed approach, this does not withstand close scrutiny of sound science or pragmatic forest management considerations. As NAFO has previously explained, while a facility-based approach would theoretically allow EPA to treat each biomass facility independently for attribution purposes, such an approach would prove technically and practically infeasible. First, applying such an approach at the landscape level would be technically infeasible as individual facilities have overlapping fuelsheds and obtain feedstocks from a vast and constantly changing array of landowners. Thus there is no way to distinguish between facility fuelsheds based on geography. The only alternative would then be a complex stand-based chain-of-custody approach, but such an approach would prove practically infeasible due to the high transaction costs.

While the selection of a spatial scale ultimately entails some policy considerations by EPA, such policy decisions must be supported by reliable, credible, and sound scientific conclusions. Under that standard, it is not a choice where all options are equal. As the Panel recognizes, a national scale offers a number of important benefits that could ensure that the final regulations adopted by EPA can be successfully implemented. Having noted the shortcomings in EPA's proposed regional scale, Report at 26-27, the Panel should likewise assess the alternative choices and inform EPA of its conclusions. NAFO is confident that, if the Panel were to do so, a national scale approach would emerge as the only alternative that is fully supported by scientific and technical considerations and capable of efficient implementation.

A Reference Point Baseline Must Be Adopted Because No Other Alternative Is Capable of Implementation

One of the most challenging issues related to the development of an accounting framework for biogenic CO2 emissions is the selection of a baseline. After considering several alternatives, EPA selected a reference point baseline because it provided "a straightforward way to assess an individual stationary source's emissions using existing data." Framework at 42. NAFO supports this conclusion as a sound policy decision. In contrast, the Panel has proposed an anticipated future baseline that seeks to isolate the positive impact of biomass energy and determine what would have happened in the absence of additional biomass energy demand. Despite its theoretical logic, the Panel's attempt to describe such an approach only confirms the inherent complexity associated with anticipatory future baselines and demonstrates why EPA's straightforward and accurate approach must be applied.

As NAFO has noted in previous comments to the Panel, it is virtually impossible to isolate the impact of biomass energy and determine what would have happened without demand for biomass energy. In reality, biomass energy is a small segment of the forestry sector and is intimately related to other forest products in both time and space. First, in most cases, biomass is not produced and harvested as a separate product for energy production. Instead, the forestry residues and milling residuals that are combusted for energy represent co-products that are produced alongside more valuable primary products. Indeed, even when roundwood is harvested and used directly for biomass energy, it is harvested as part of a thinning process that is designed to improve the quality of the remaining trees that will be harvested later for other, more valuable forest products. It is simply not economical to grow and harvest mature trees for energy. Instead, biomass co-products provide incremental economic value to the forest owner producing subtle, yet important, market signals that encourage biomass production and increase forest carbon stocks. As a result of this close relationship between forest products and the long time frames over which forest rotations occur, there is no simple and straightforward way to strip out biomass energy demand and determine what would have happened in its absence.

As the Panel is well aware, developing an anticipated future baseline is a daunting, although ultimately unnecessary, task. The approach described in the revised Report, which seeks to "combine the economic behavior of landowners with the associated dynamics of forest management and growth while allowing for competing uses of land for forestry, agriculture, and other activities," Report at 33, is a marked improvement over the approach described in the initial report. Importantly, this approach seeks to account for the decision-making processes of forest owners and reflects the anticipatory nature of investments in forests. Report at 34-35. By doing so, it moves closer to identifying and attempting to account for all of the factors that can influence forest management decisions and the quantity of forest carbon stocks.

But even the inclusion of anticipatory investments and other market forces is not enough to produce a comprehensive model of the impact of biomass energy. As the Report notes elsewhere, the purpose of an accounting methodology is to account for the changes that "the atmosphere sees" as a result of biogenic CO2 emissions from stationary sources. E.g., Report at 15. But as currently formulated, the Panel's anticipated future baseline only considers what the

forest sees, as it focuses solely on "changes in forest stocks." Id. at 2.3. This ignores the primary climate benefit of biomass energy – the displacement of fossil fuel emissions. Thus, the assertion that "a reduction in the rate of increase of carbon stocks is equivalent to an increase in emissions," id. at 4, is incorrect. A reduction in the rate of increase in carbon stocks that results in a reduction in fossil fuel emissions could actually reduce total emissions. In other words, the anticipated future baseline described by the Panel, which is already hopelessly complex, must either become even more complex in order to accurately reflect what "the atmosphere sees" or remain fundamentally flawed for failing to fully capture the carbon cycle associated with forest-based biomass energy.

Further, the adoption of an anticipated future baseline would raise significant legal concerns and add uncertainty to the implementation process. By requiring forest owners to continue to increase forest carbon stocks at current rates, applying an anticipated future baseline to stationary source regulations would transform what is a voluntary, climate-friendly practice into a mandatory duty. If such a regulatory program were in place the baseline could also be applied elsewhere, for example in carbon offset programs. If these regulatory programs make carbon sequestration a mandatory duty concerns associated with an anticipated future baseline would add further uncertainty and make implementation even more difficult.

In light of this complexity, and ultimately the uncertainty surrounding these future projections, see Report at 35-36, it was certainly appropriate for EPA to propose a reference point baseline. While it cannot entirely isolate the impact of biomass energy, a reference point baseline does describe what "the atmosphere sees" as a result of the forestry sector as a whole. As EPA recognized in the Framework, as long as forest carbon stocks are stable or increasing, the atmosphere does not see any increase in CO2 concentrations as a result of the forestry sector. Framework at 25-26.16 Indeed, when fossil fuel displacement and long-term storage in forest products are considered, the atmosphere is likely to see a reduction in CO2 concentrations when forest carbon stocks remain stable.

This is not to say that the predictive models referenced by the Panel have no purpose, but only that they are too complex, uncertain, unmanageable, and inaccurate in their current form to be included as a part of a regulatory program. Given these concerns over implementation, the Panel should support EPA's conclusion that a reference point baseline is appropriate and instead recommend ways that EPA can use these predictive models to monitor forest carbon stocks and perhaps refine its regulatory approach over time.

The Climate Impact of Biogenic CO2 Emissions Must Be Assessed on a Policy-Relevant 100-Year Time Scale

Finally, as the Panel appropriately recognizes, the selection of a time scale is an important policy decision that will have a significant effect on the final regulations adopted by EPA. But, despite the Panel's clear preference for a 100-year time scale see Report at 10-13, it declines to

make a recommendation, asserting instead that the choice of time scales is a policy decision that must be resolved by EPA, Report at 44.

While there are certainly tradeoffs between different time scales, sound science reflecting pragmatic considerations squarely favors a 100-year time scale. While other time scales may also be scientifically correct, Report at 11, only a 100-year time scale is consistent with EPA's regulatory goals, domestic forestry practices, and the administration's mandate promoting climate-beneficial renewable energy.

First, a 100-year time scale is consistent with EPA's regulatory goals for biogenic CO2 emissions. EPA decided to defer regulation of biogenic CO2 emissions, in part, to "conduct a study of the science surrounding biogenic CO2 emissions and their role in the carbon cycle." 76 Fed. Reg. 43,490, 43,499 (July 20, 2011). Further, to understand how biogenic CO2 emissions affect the climate, the time scale must help explain what "the atmosphere sees" as a result biogenic CO2 emissions. A 100-year time scale can answer these questions. First, as the Panel notes, climate modeling studies have demonstrated that "the peak warming in response to greenhouse gas emissions is primarily sensitive to cumulative greenhouse gas emissions over a period of roughly 100 years, and is relatively insensitive to the emissions pathway within that timeframe." Report at 11. Thus adopting a 100-year time scale will allow EPA to consider the biogenic carbon cycle over time periods that are relevant to the global climate system. In contrast, as the Panel notes, shorter time periods such as those relied upon by Walker (2010) and others, focus on irrelevant intermediate time scales and do not provide an appropriate analysis of the biogenic carbon cycle because these intermediate effects prove transient and disappear over longer time scales. Report at 11.19

Second, a 100-year time scale is consistent with the manner in which forestry is practiced in the United States. As the Report notes "it is important to consider the turnover times of different biogenic feedstocks in justifying how they are incorporated into the framework." Report at 10. Although, as described above, the forest carbon cycle is best considered spatially on a landscape scale, it is nevertheless instructive to also consider it in a linear fashion for purposes of conducting a thorough scientific review. While in theory it would be possible to adopt a different time scale for each feedstock corresponding to its turnover time, such an approach is unnecessary as few, if any, forests are managed with turnover times longer than 100 years. Thus by adopting a 100 year time scale, EPA would simplify the regulations while ensuring that, for any given feedstock, the landscape would have turned over at least once during the relevant time period and avoid the potential for short-term, transient carbon fluxes that could skew the analysis of the carbon cycle. In contrast, if a shorter time period – on the order of 30 to 50 years – were adopted, some feedstocks may not undergo a complete turnover during the study period. Thus, a 100 year time scale offers a simple, uniform approach to carbon accounting that is consistent with forestry practices.

Third, adoption of a 100-year time scale will provide appropriate incentives for biomass energy that are consistent with the administration's commitment to promoting renewable fuels, such as biomass.20 As the Panel recognizes, the climate benefits of biomass, as compared to fossil fuels, become more pronounced as time scales increase. Report at 13. In other words, as NAFO has explained, the climate benefits of biomass energy continue to grow over time as each successive rotation used for biomass displaces more fossil fuels. While a time scale of 100 years is likely sufficient to create the incentives needed to promote biomass energy, shorter time frames may have the perverse effect of discouraging biomass energy due to the differences in energy produced by equivalent amounts of biomass and fossil fuels. Thus, adopting a shorter time frame that discourages biomass energy produces the wrong kind of tradeoffs as it would lock in the continued combustion of fossil fuels in lieu of biomass, despite the recognized long term benefits biomass offers.

Recommendations for a Regulatory Approach to Biogenic CO2 Emissions

In the event that a national scale, reference point baseline, and 100-year time scale are adopted, EPA can develop a scientifically accurate, predictable, and straightforward regulatory framework for woody biomass. First, within this framework, a categorical exclusion can be implemented as a practical matter because domestic forest management practices and sound science demonstrate that biomass energy will not result in a net increase in atmospheric CO2 concentrations on a policy-relevant spatial or temporal scale. Second, the continued applicability of the categorical exclusion will depend solely on the continued use of sustainable forestry practices, which can be monitored on a continuous basis through the comparison of carbon stocks over time.

A Categorical Exclusion is Appropriate as a Practical Matter as Woody Biomass Feedstocks Do Not Increase Net Atmospheric CO2

Concentrations

When considered in the context of a national spatial scale and 100-year time scale, the scientific conclusions in the Report fully support a categorical exclusion for biogenic CO2 emissions from woody biomass, even if such position cannot be accepted a priori. As NAFO noted in its previous comments, the Panel must rigorously test and apply the best science to determine the climate impacts of biogenic CO2 emissions, but must do so with the goal of producing an accounting framework that is simple to implement and provides reasonable certainty to EPA and stakeholders. As NAFO previously observed, this can be accomplished by using sophisticated scientific models to confirm broadly applicable regulatory approaches. Indeed, the Panel has already started down this path by endorsing feedstock-based BAF values as an alternative to facility-specific BAFs. However, this recommendation does not go far enough. Taken to its logical conclusion, it supports a categorical exclusion for woody biomass as all feedstocks derived from woody biomass would have a BAF of zero.

First, when the carbon cycle is applied on a national spatial scale, a categorical exclusion is warranted because carbon stocks are stable and are expected to remain so for many years to come. Unless and until carbon stocks decline on a national scale, there will be no net biogenic CO2 emissions from woody biomass because emissions will be balanced by carbon sequestration on a regular and continuous basis. As the Panel is aware, projecting forest carbon stocks far into the future is fraught with uncertainty, but even the most conservative models suggest that domestic forests will remain a net carbon sink for decades into the future. Since the near-term trajectory of forest carbon stocks remains positive, it makes no sense to incorporate complex regulatory processes to address hypothetical concerns about events that may happen decades into the future. A more prudent approach is to incorporate a monitoring program, as described below, so that EPA can , if necessary, modify its regulatory approach in the future.

Second, the Panel's own analyses based on a time path of decay or recovery confirm that biomass energy will not increase net atmospheric CO2 concentrations over the relevant temporal and spatial scales. As discussed above, peak warming is insensitive to short-term carbon fluxes that occur on time scales shorter than 100 years. Report at 10-13. Thus, the question that the Panel, and ultimately EPA must answer is which, if any, biomass feedstocks that are used (or are expected to be used) for biomass energy will increase atmospheric CO2 concentrations over time scales that exceed 100 years. There are none.

In this Report the Panel reverses course and asserts that forestry residues are not "anyway emissions" when combusted for energy because they do not decompose instantaneously. Instead, the Panel asserts that forestry residue emissions must be modeled through a complicated process that estimates a time path of decay. Report at 18-20 & App'x A. Even if the Panel's approach were accepted in theory, it is simply irrelevant when considered on an appropriate time scale. Regardless of the type of forestry residue considered, these models show that decomposition would be nearly complete after 100 years. Thus emissions from forestry residues are "anyway emissions" on a 100-year time scale, and there is no net increase in atmospheric CO2 concentrations as a result of the combustion of these feedstocks. As a result, a categorical exclusion for forestry residues is warranted.

Further, as NAFO has previously explained, a regulatory approach that promotes biomass energy is likely to increase, rather than decrease forest stocks by creating incentives for individual landowners to maintain or even increase forested acres. NAFO Deferral Rule Comments at 3-4; NAFO December SAB Panel Comments at 2. Even if domestic forests were to become a net carbon source, the appropriate regulatory response is far from certain. For example, to the extent that the change is attributable to stochastic events such as fires and disease or increased urbanization, EPA may conclude that it need not alter its approach to regulating bioenergy.

By the same token, the scientific models endorsed by the Panel for evaluating the time path of recovery for long-recovery feedstocks confirms that these products will produce no net change in

atmospheric CO2 concentrations on policy-relevant time scales. Here, the Panel relies primarily on Cherubini (2012) and the GTPbio factor.26 As the Panel notes, under Cherubini's model this factor initially increases after harvest, but for all feedstocks used in biomass energy, it will return to zero within 100 years. Report at 11-13. Thus, these models confirm that the biomass feedstocks that are currently used (or expected to be used in the future) will have no effect on peak warming and, on policy relevant time scales, will not alter what "the atmosphere sees." Because there are few, if any, commercial forests managed on time scales longer than 100 years, all woody biomass would have a BAF of zero, meaning that a categorical exclusion would also be warranted for long-recovery feedstocks.

Thus, contrary to the Panel's current recommendations, which would require the application of a time path of decay or recovery for all woody biomass, Report at 11, 18- 20, 44 a categorical exclusion can be applied instead. This demonstrates a fundamental flaw in the Panel's recommendations, which is not supported by the content of the Report. In the Report, the Panel appropriately recognizes that the relevance of these time path functions is dependant on the time scale, and that concepts such as carbon debt are not relevant when long time scales are considered. Report at 11. Thus, while these concepts, without doubt, are valuable tools for understanding the carbon cycle and the impact of biogenic CO2 emissions on net atmospheric CO2 concentrations, there is no a priori basis for including them in a final regulatory framework as the Panel suggests. Instead, as NAFO has previously suggested, these models can simply be used to confirm that, under all circumstances and for all feedstocks, biomass energy does not increase atmospheric CO2 concentrations. While NAFO urges the Panel to replace its current recommendations with a categorical exclusion for woody biomass, the Panel should, at a minimum, note that its recommendations to incorporate time paths of decay and recovery are in fact scale dependent and provide alternative recommendations that can be incorporated if EPA chooses to adopt a longer time scale.

Continuous Monitoring Program Can Be Used to Ensure that Forest Carbon Stocks Remain Stable Over Time

While a categorical exclusion is supported by the science included in the Panel's Report, it is also based upon the fact that forest carbon stocks are – and will continue to be – stable or increasing. Given the critical role that sustainable forestry practices play in supporting a categorical exclusion, it would be appropriate to include a monitoring component into a regulatory framework to ensure that current trends continue. This is what EPA proposed by requiring short-term comparisons of carbon stocks over time. Framework at 25-26.

Contrary to the Panel's assertions, continuous monitoring using, for example, annual FIA data is not inconsistent with the adoption of a 100-year time scale as the two time frames address different issues. The 100-year time scale addresses the relevant time period over which emissions should be considered. But the assumption that there will be no net increase in

atmospheric CO2 concentrations is implicitly dependant on the fact that the forests under consideration will be managed sustainably. Indeed, the

Panel recognizes this in its alternative proposal for a certification program based on carbon neutrality and "sustainability" principles. Report at 7, 45-47.29 Thus, even under a 100-year time scale, a monitoring approach is needed to ensure that forestry is practiced sustainably and that harvested stands are regenerated.

While the monitoring approach included in EPA's Framework is national in scale and cannot establish stand-based linkages, that is not necessary to demonstrate sustainability over time. A national scale approach that incorporates annual FIA data offers a practical and cost effective method to ensure that forestry is practiced sustainably in the aggregate. While small changes can take place on the stand level as individual owners make management changes, a national scale monitoring system will ensure that, as a whole, forestry is practiced sustainably and that there is no net increase in atmospheric CO2 concentrations as a result of biogenic emissions from woody biomass. By including such a monitoring system, EPA can implement a categorical exclusion with the assurance that it can take further regulatory action if the factual circumstances supporting a categorical exclusion change.

Conclusion

NAFO continues to support EPA's decision to seek an independent peer review of its proposed accounting methodology for biogenic CO2 emissions and applauds the Panel's efforts to assess this complex field. We urge the Panel to keep implementation at the forefront as it formulates its recommendations and hope that our comments will assist the Panel in identifying means to simplify its final recommendations to EPA. NAFO is standing by to provide further information or answer any questions that the Panel may have.

Commenter: Center for a Competitive Waste Energy

***Comment:** Include in the table showing each sector's responsibility for anthropogenic greenhouse gas emissions the applicable value when current instead of obsolete Global Warming Potential multipliers are used.*

To use a GWP for methane in 2010 of 21, when the most reliable value today is 62% greater, has the effect of grossly undercounting the impacts of sources of anthropogenic methane emissions compared to sources of other greenhouse gases. That cannot but gravely distort society's response to a much more serious threat and result in a misapplication of resources to avert climate change, especially in the context of near-term impacts described next.

Therefore, we recommend that the final inventory include the existing table that shows a consistent time series from 1990 to 20008 (as modified by the other comments that follow below)

to comport with the Guidelines. But, then the table should include an additional right-hand column showing the 2008 data converted to the current data on GWPs. Nothing in the Guidelines precludes or discourages more accurate supplementation.

There is an enormous value in incorporating the most reliable data into decision-making, and the Draft fails to accord this need its due. If the definition of "authoritative" were somehow to be twisted to mean "hopelessly out-of-date," the practical utility of the entire exercise would be called into in question and resemble nothing so much as "fiddling while the world burns." The difference between 1996's very preliminary state of knowledge then, which was largely ignorant of methane's indirect effects, and today, more than 15 years later, is simply too great to ignore on the grounds of nothing more substantive than bureaucratic inertia.

Each GHG has a different residence time in the atmosphere before they decay or are absorbed, from 0.38 years for methylene chloride to 50,000 years for PFC-14, with 12 years for methane. In order to equate each GHG to CO , the same residency must be assumed to perform the calculation, even though, in fact, the gases remain airborne for vastly different periods. The current convention for that common denominator is 100 years, which initially was the proxy for CO2's duration in the atmosphere.

However, global warming does not proceed linearly over time, but rather, accelerated by positive feedback loops, changes in climate can ramp up rapidly and irreversibly in the near term as tipping points are crossed.7 In response to this implacable reality, a growing body of scientific opinion has more recently urged a two-pronged strategy to address those points of no return. This is not to suggest either ignoring or demoting the long-term consequences. Rather, the recommendation is only to recognize that, in order to sustain the viability of human institutions until that far-off day arrives, we must first insure that quick action is taken to avert crossing key tipping points, after which further remedial action is no longer possible:

"Policy must evolve and incorporate the emerging science in order to be effective. There is a growing need to create a two-pronged framework capable of not only mitigating long-term climate change but also managing the magnitude and rate of change of near-term R[adiative] F[orcing]. Short-lived pollutants (black carbon and tropospheric ozone) and medium-lived pollutants (methane) account for more than half of the positive RF generated in years 1 to 20."

Once the need for such a two-pronged strategy is understood, then attention quickly turns to methane as the most important GHG for that approach, as Dr. Jackson alludes to in his above statement. According to climate scientists at the National Aeronautics and Space Administration (NASA), the combination of methane's warming potency, and its short lifetime in the atmosphere, plays an especially critical role in the near term when we confront those critical tipping points. Methane's residency is 12 years, and, when measured in the next 20 instead of 100 years, is 105 times as powerful as CO2:

"[F]easible reversal of the growth of atmospheric [methane] and other trace gases would provide a vital contribution toward averting dangerous anthropogenic interference with global climate. [Methane] deserves special attention in efforts to stem global warming. Given the difficulty of halting near-term CO2 growth, the only practical way to avoid [dangerous interference] with climate may be simultaneous efforts to reverse the growth of [methane].

Similarly, Robert Watkins, the co-chair of the IPCC's Third Assessment, recently wrote in the disappointing aftermath of Copenhagen:

"This month's Copenhagen talks focused on the leading climate change culprit: CO2. But reversing global temperature increases by reducing carbon emissions will take many decades, if not centuries. Even if the largest cuts in CO2 contemplated in Copenhagen are implemented, it simply will not reverse the melting of ice already occurring. The most obvious strategy is to make an all-out effort to reduce emissions of methane. Methane's short life makes it especially interesting in the short run, given the pace of climate change. If we need to suppress temperature quickly in order to preserve glaciers, reducing methane can make an immediate impact. Compared to the massive requirements necessary to reduce CO2, cutting methane requires only modest investment. Where we stop methane emissions, cooling follows within a decade, not centuries. That could make the difference for many fragile systems on the brink."

Indeed, EPA, itself, has long observed methane's critical importance for addressing short term climate impacts:

"This relatively short lifetime makes methane an excellent candidate for mitigating the impacts of global warming because emission reductions could lead to stabilization or reduction in methane concentrations within 10-20 years."

For these reasons, we strongly urge the Draft to include an additional chapter on short- term impacts (i.e. the next twenty years), along with the 100-year inventory values, and the GWP factors that are applicable to that time frame, along with reference to the greenhouse gases most important to short term climate action plans. In the case of methane, as noted, that would be a multiplier of 105 times CO2's warming potential when using the latest data, and 72 times CO2's, when using the data from AR4. This would enable decision-makers to assess where their short-term climate action plans should be most effectively directed.

This additional supplementation also comports fully with the IPCC protocols. The Second Assessment stated that while the UN Framework held there should be one set of consistent 100 year based GWP values across reporting nation's inventories, it also specifically provided that "[p]arties may also use other time horizons."

As discussed in Chapter 8 of the Draft, along with Annex 3.1, landfills are among the significant sources of GHGs associated with climate change, because organic discards, which are half or more of total discards, if not separated at the source, are most often buried. In the oxygen-

starved environment of a sealed landfill, food scraps, soiled paper, grass clippings, leaves, brush and other organic matter decompose anaerobically under the influence of methanogenic microbes. These thrive in the absence of oxygen, and create methane as a byproduct of decomposition.

Because modern lined landfills can extend for hundreds of acres in extent and rise hundreds of feet above grade, gas generated inside the waste body flows out into the atmosphere through myriad routes that defy measurement. This includes not only through cracks, tears and broken seams at the surface and along the sides and top, but also conveyed along the bottom of a facility following leachate collection gravel trenches and piping, wherever there is a path of least resistance.

In an attempt to overcome this lack of data, the process underlying the Annex's description purports to use the following mass balance equation that is calculated for each year:

(1) $$\left| Gas\ released = Gas\ generated - Gas\ captured - Gas\ oxidized \right|$$

As discussed below, the problems with this attempt to represent reality are:

(1) Incorrect Modeling. Only one of the three terms to the right, Gas Captured, is known. Two are only modeled, not observed, values, namely Gas Generation and Gas Oxidized.15 To estimate the unknown Gas Generation in order to then estimate Gas Released, a model is used which is inapplicable to the particular and unique conditions of a lined landfill and fails to include a coefficient for the most critical independent variable involved in decomposition of buried wastes, the level and distribution of essential moisture. Moreover, many of the landfill input data appears to be incorrect.

(2) Incomplete Landfill Phases. Gas generation from wastes interred today continue for decades into the future at a rate that varies with five different phases in a landfill's life that affects the level and distribution of essential moisture, all of which is ignored by the Draft's methodology.

(3) Oxidation Misapplied. The studies used to estimate oxidation are inapplicable to lined landfills.

Most of the controverted modeling turns on the equation used in the Draft to estimate Gas Generated, which is explained first.

EPA first estimates the amount of annual Gas Generated based upon modeling by using a First Order Decay (FOD) equation, which in its simplified form is expressed:

(2) $$Methane = \sum_{i=1}^{n} M \times L_o \times k \times e^{-k \times t_i}$$

Unfortunately, this simplified model, and all of its variants, was derived from, and is only applicable to, a continuous decay phenomena acting upon a declining mass, where the decay rate is independent of the availability of limiting pre-conditions that otherwise would impede particle disintegration. An example would be the radioactive decay of a uranium isotope that is represented by a constant decay rate multiplied by the mass, which declines each year as the original mass is reduced by the prior year's decay.

Moisture pre-condition. Anaerobic decomposition in a landfill suffers far too many complications for such a simplified model to be valid. In particular, first, as discussed in this section, the model does not account for whether the distribution and quantity of essential moisture is adequate to sustain the near optimal levels of decomposition assumed by the model. Yet, inexplicably, the Draft's list of relevant factors for methane formation ignores the necessity for their being very high moisture levels.

Along with heat, microbes and pH, which generally are not limiting conditions, decomposition in a landfill cannot comprehensively proceed as the model predicts unless there is a continuing adequate supply of moisture greater than 50%. However, the entrained moisture in the incoming wastes is less than 25%,18 and the very act of collecting gas from a landfill quickly dehydrates a covered site in a few years because half of the gas removed (by weight) is water vapor.

In addition, the liquids need to be evenly distributed. Unfortunately, moisture is not dispersed throughout landfills. Municipal solid waste is exceedingly heterogeneous, heavily compacted in a landfill to about eight times its original volume, interspersed over each day's lift with daily cover, and often confined in splayed open plastic bags, all of which creates highly preferential paths of flow. Earlier estimates from the 1990s are that liquids only reach 23% to 34% of the mass,20 and, with in-place densities more than 50% greater today, the dispersion of moisture is presumably significantly less now.

Typically, then, and at best, only limited volumes of gas is actually generated at an operating landfill, before it is closed tight. Even for that short period, decomposition is essentially restricted to isolated pockets where there are aggregations of food scraps and grass clippings that transport their own moisture with them, as well as at the bottom where hydraulic heads accumulate above clogged leachate lines and gravel beds. Differences in cover and operational practices implicate whether there is any replenishment or supplementation of moisture levels in situ that, in some cases, increases gas generation. After closure, and for as long as the cover seal maintains its integrity, gas generation rapidly tapers off as the site, for a time, takes on the intended characteristics of a "dry tomb." After the cover eventually fails, gas generation resumes until the residual carbon is exhausted and the site is biologically stabilized.

None of this wide moisture related variation in the rate of decomposition, and gas generation, is accounted for by FOD modeling, which represents a continuous function and that divergence underlies the irrational outputs the model generates.

Anomalous outputs. The extreme inexplicable and anomalous variability of the results the FOD model produces, which is widely reported in the literature, undermines its credibility at the outset. Even the EPA AP-42 background paper acknowledged that in its analysis:

"The recommended defaults k and Lo for conventional landfills, based upon the best fit to 40 different landfills, yielded predicted CH4 emissions that ranged from ~30 to 400% of measured values and had a relative standard deviation of 0.73."

The most recent survey by Thompson of the results of FOD modeling in landfills concluded that:

"Landfill gas models continue to receive criticism due to their poor accuracy and insufficient validation: most model results have not been evaluated against methane recovery data. A few studies have compared methane recovery data to estimates of methane generation from models, but only for a few landfills. This limited approach is inadequate to validate the model for a wide, rather than site-specific application."

Similar: "Results of this study suggest that the first order model cannot always be applied to full-scale landfill gas collection data with statistical significance"

Another published paper that performed a random verification of related modeling of California landfills found a dispersion of 25 major landfills of predicted compared to actual values for gas collection efficiency, which ranged from 7% to 100%.

A more recent unpublished survey of 46 California landfills by the California Air Resources Board reproduced in Table 1 found implied gas collection efficiency from gas generation estimated with LandGEM first order equations ranging from 6% to 225% gas captured, which is an exceedingly impressive engineering feat. California Air Resources Board, Staff Spreadsheet Titled Landfill Survey Data Public (2010), released in response to a Public Records request by Californians Against Waste. Similarly, the Wisconsin Department of Natural Resources did a comparison of actual gas collected to estimate gas generation in the State's landfills and found a wide and physically impossible outputs like those found in California's study. See on-line at http://dnr.wi.gov/org/aw/wm/solid/gas/gas.htm#art6.

Landfill Survey Response Data			Survey CH4 Captured/Model CH4 Generation (%)						
Landfill	2006 WIP (%)	Avg. CH4 (%)	2000	2001	2002	2003	2004	2005	2006
1	9.4%	35%	109%	120%	107%	108%	112%	140%	140%
2	3.7%	46%	87%	108%	114%	109%	107%	135%	130%
3	3.2%	52%	61%	63%	73%	68%	52%	51%	83%
4	3.0%	39%	63%	73%	66%	79%	76%	90%	87%
5	2.7%	36%	91%	91%	91%	91%	84%	98%	92%

6	2.3%	34%	121%	121%	121%	121%	121%	121%	121%
7	2.2%	42%	99%	105%	109%	111%	105%	107%	104%
8	2.2%	14%	6%	5%	4%	6%	5%	6%	6%
9	1.9%	16%	66%	65%	65%	57%	59%	76%	76%
10	1.8%	25%	125%	113%	100%	97%	112%	124%	124%
11	1.8%	50%	64%	69%	71%	69%	66%	63%	63%
12	1.8%	42%	127%	127%	127%	127%	127%	146%	117%
13	1.4%	32%	121%	137%	128%	123%	119%	126%	126%
14	1.3%	49%	124%	119%	105%	102%	102%	76%	72%
15	1.3%	50%	59%	51%	41%	54%	54%	54%	54%
16	1.3%	43%	351%	261%	231%	226%	172%	166%	165%
17	1.2%	40%	45%	45%	45%	45%	53%	46%	44%
18	1.1%	39%	118%	118%	118%	118%	133%	118%	109%
19	1.1%	47%	78%	54%	96%	103%	90%	90%	116%
20	1.1%	44%	64%	63%	65%	40%	51%	39%	37%
21	0.8%	51%	89%	90%	103%	82%	81%	83%	108%
22	0.7%	50%	74%	73%	76%	88%	75%	94%	121%
23	0.6%	48%	152%	180%	140%	109%	104%	96%	91%
24	0.5%	48%	28%	35%	42%	50%	62%	70%	64%
25	0.4%	59%	57%	57%	57%	57%	57%	57%	57%
26	0.4%	29%	22%	22%	20%	21%	21%	25%	21%
27	0.4%	48%	23%	23%	23%	23%	15%	21%	34%
28	0.3%	38%	20%	26%	23%	21%	19%	14%	16%
29	0.3%	40%	111%	111%	116%	102%	114%	99%	98%
30	0.3%	43%	104%	104%	104%	104%	104%	93%	114%
31	0.3%	37%	29%	29%	29%	30%	33%	28%	25%
32	0.2%	42%	31%	31%	31%	31%	31%	28%	34%
33	0.2%	41%	22%	22%	19%	20%	21%	24%	30%
34	0.2%	48%	103%	85%	80%	91%	124%	123%	135%
35	0.2%	17%	6%	6%	5%	6%	6%	6%	6%
36	0.1%	48%	78%	78%	78%	102%	74%	66%	79%
37	0.1%	32%	35%	40%	38%	54%	62%	62%	50%
38	0.1%	33%	38%	17%	20%	16%	17%	27%	23%
39	0.1%	38%	257%	257%	341%	234%	234%	216%	257%
40	0.1%	37%	44%	38%	33%	18%	33%	33%	33%
41	0.0%	45%	76%	76%	76%	85%	78%	65%	76%
42	0.0%	37%	69%	66%	63%	59%	56%	52%	49%
43	0.0%	30%	46%	41%	37%	32%	27%	23%	19%
44	0.0%	27%	165%	161%	157%	138%	137%	138%	126%
45	0.0%	31%	38%	38%	38%	38%	38%	22%	47%
46	0.0%	30%	18%	17%	14%	14%	14%	14%	10%

Statistical validation failed. Initially, attempts to support the validity of FOD models was based upon a putative statistical test using regression equations of a sample that purported to show its predictions were a good fit.

The regression analysis prepared for EPA by Peer was intended to validate the FOD model's applicability to the approximately 2,000 MSW landfills in the United States, but it failed to do so. The Peer study used too small a sample of only 21 landfills, or only 1% of the population, which is too few degrees of freedom for statistical significance. Also, none of those selected for the sample were chosen randomly, which removes the normal distribution essential for regression equations to estimate a population.

Furthermore, not only was the selection process not random, it was also chosen with a specific bias that has the effect of significantly skewing results to appear to show high capture rates. This was done by limiting the sample to landfills with energy recovery. These facilities typically recirculate leachate, which accelerates decomposition and gas generation, in order to boost the profitability of electricity sales. That has been shown to increase near term gas generation very significantly, while only moderately increasing the volume of gas captured.

Since the model is blind to the fact that gas generation was augmented, the uptick in gas collected makes it seem appear that capture rates have significantly improved, even though they most probably have significantly declined.

Moreover, in addition to all those limitations, circular reasoning was used in performing the model's attempt at a statistical validation. In an attempt to assess the reasonableness of the model's estimates of Gas Generation, Eq. (3) is used to provide a putative independent estimate.

$$\left| Gas\ captured = Gas\ generated \times Gas\ capture\ rate \right|$$

Solving Eq. (3) for Gas Generated is shown in Eq. (4):

$$Gas\ generated = \frac{Gas\ captured}{Gas\ capture\ rate} \quad (4)$$

But, since only one of the two independent variables is known, this exercise rests on a house of cards. For the Gas Capture Rate is also unknown and an unsupported guesstimate is used, defeating the attempt to provide a solid foundation for the calculation. Thus, to solve the equation for Gas Generation, the study just assumed that Gas Capture Rate was 75% at all times during a landfill's life. Recalling that one of the purposes of the entire exercise was to establish a factual basis for assuming 75% capture rates in the first place, this led to a circular exercise with no statistical value. As a tautological statement, it establishes nothing about Gas Capture Rates anymore than it does about Gas Generation.

Moreover, the problem is not just that the provenance of the 75% assumption is neither an observed value nor, in view of its definition as the best systems during the limited period of their peak performance, even a reasonable assumption. In addition, in order to perform the Pearson calculations, the analysis assumed that every single landfill in the study (i) exhibited identical performance, even though operating practices significantly affecting collection efficiency vary widely among landfills, as well as (ii) achieved that same high capture rate during all phases of each sites' biologically active or latent life, including the challenging times when there is no installed or functioning gas collection system. However, US EPA has never asserted that its 75% assumption was intended to apply for each landfill at all times. Rather, to the contrary, it only purported that 75% was intended to be an average value when considered across peak times and among all landfills.

Finally, in view of the fact that moisture, which is a limiting condition for decomposition landfill decay behavior obviously reflects complex interactions, which are especially difficult to model in a heterogeneous waste mass that goes through multiple phases some of which when prerequisite moisture levels are absent. The reason given to justify the paucity of other explanatory variables in the model to explain that complex environment, such as critical internal moisture levels, is that the excluded variables had statistically insignificant estimated coefficients in earlier versions of the regressions.

But, the problem of statistically insignificant coefficient estimates arises for many reasons other than the authors' claimed lack of importance. One of the reasons for insignificant coefficients is a small sample size that leads to limited degrees of freedom, which is evident in the study. Other problems include poorly formulated equations, data measurement errors, and inappropriate error term distribution specifications and related estimation procedures. Each of these problem s exist.

This points towards an unreliable and questionable estimation process known as data mining or fishing, and not to the lack of importance of things, such as moisture, needed for a valid model. With these fishing procedures, various fuller models are formulated and discarded, not because they are not well formed or include inappropriate variables, but because the analysts did not want to confront the substantial complexities or consequences that more complete modeling would entail.

The exclusion of variables merely on the basis of low levels of estimated coefficient significance is not statistically justified, as dramatically shown by the irrational scattergun outputs it produces. For, if the excluded data are truly relevant, their exclusion leads to estimation bias and unreliable results. Coefficient significance is not an appropriate means for deleting variables from a regression model. Various appropriate tests exist for testing overall significance of a set of variables – in particular maximum likelihood ratio tests. The Peer paper does not show that these forms of significance testing were performed.

Due to all of the deficiencies discussed above, the results of the regression analyses cannot be relied upon to provide credible annual methane production quantities, anymore than the putative validation of the FOD model can corroborate that the model conforms to statistical norms. In addition to all of the problems discussed above, the low levels of R2s in the Peer study (one measure of the explanatory power of estimated regression equations) do not support a conclusion that the regression analyses provide reliable results.

The reason why the FOD model's outputs are anomalous is that its coefficients, variables and structure are incomplete and its input variables are wrong.

The most recent attempt by Thompson to validate FOD models through modifying its architecture is similarly flawed. Thompson searches for the best FOD model to validate for estimating gas generation in order to solve the mass balance equation. It uses the Pearson

correlation to compare the modeled estimates of gas generation to what it construes to be observed values among six variants of the FOD model at 35 non-randomly selected Canadian landfills with alternative assumptions about one of the factors, namely the assimilated organic fraction in the landfill, and adjustments to the values for Lo and k that are irrelevant to gas generation.

The problems with this attempt are, first, that this so-called calibration approach is more akin to correlation fishing with a torn net. The study does not present a rational conceptual solution to errors that it identified in past modeling practices. Instead, by trial and error, it iteratively examines for each landfill the modeled gas generation estimates from each of the six variations on the same core equation, along with alternative input values, until it finds a best fitting Pearson correlations among historic landfill data.

However, the Pearson correlation does not show causality, but only a correlation that might be due to chance – a possible explanation whose probability increases markedly as the number of different values for variables and model permutations multiply, which more accurately resembles shooting fish in a barrel for correlates. In addition, the Pearson correlation is a process that says nothing about whether all critical explanatory variables, such as critical moisture levels, have been included in the model. As such, the Study's procedures are not a valid statistically appropriate procedure to derive reasonable estimates useful for future predictions of gas behavior among the population of municipal solid waste landfills.

Second, like Peer, the Thompson study is also circular. Pearson's correlation looks for linear associations between observed values and the parallel modeled estimates, here of gas generation. However, there are no observed values of gas generation to search for correlations with modeled generation outputs. In the three-term simplified mass balance equation above, only gas captured was known. In order to perform the Pearson analysis, the study resorts, at p. 2088, to the use of Eq. 4 to model further what is intended to be observed gas generation.

But, again, this equation with three terms, which is used in an effort to provide an observed value for gas generation, also has two unknowns. To produce a value for the desired observation for gas generation, the study is forced to make another assumption, which is not based upon any observations, about the gas capture rate. In this study, collection efficiency is assumed to be the average of 75%, which is the oft-cited US EPA assumption based upon the questionable decision to focus on the best systems at the limited time of their peak performance, and 85%, which is the claimed, but disputed, Spokas assumption,31 or 80%. However, the EPA view is based upon a literature review that simply ignored low reported values in the published literature. As regards Spokas' claimed 85% value, as noted previously, it was even rejected by EPA and also by Thompson.

Again, too, like Peer there is the further problem that, in order to perform the Pearson calculations, the analysis assumed that every single landfill in the study (i) exhibited identical performance during all phases of each sites' life, which is something that EPA never claimed for the assumption.

By way of comparison, incidentally, the Intergovernmental Panel on Climate Change (IPCC) states that the average lifetime capture rate equivalent to EPA's best instantaneous rate is actually as low as 20%.

Thus, when the Thompson study rejected several scenarios because they seemed to "consistently produce much higher estimates than the [observed] methane generation rates," the calculated large standard errors it thought the analysis found were actually due to its arbitrary assumption about high capture rates rather than a real statistical deviation. Had the study used the lower IPCC assumption, the findings about which model showed the best fit would probably have been reversed.

As to the intention to improve upon the Lo and k values by localizing them to the conditions in the Province in which the landfill is located, those only create the illusion, but not the substance, of refinement. Using Provincial waste audits to derive Lo is a meaningless gesture because audits are just visual inspections with very wide and unknown bands of uncertainty no better than the three-fold dispersion, from 100 to 310 m3/Mg., currently in the literature.

Similarly, the attempts to refine the k value by more closely correlating it to the Province's annual precipitation is also meaningless because the relevant criteria is moisture inside the landfills at different points in a landfill's life, not rainfall outside the facility. Directly intervening between surface and interior conditions at any given time are the permeability of any cover, any re-injection of leachate or outside liquids, in-situ compaction ratios, waste composition, the functionality of the leachate collection system, site geometry and surface grading practices. At times, in fact, after the final cover is installed and for as long as it is maintained, the waste mass will go bone dry and therefore generate very little gas (hence the moniker, "dry tomb landfills"), even if there is a monsoon raging at the surface.

But, most important for the model's structure, those factors affecting interior moisture levels vary over time. To illustrate, there is no low permeable cover until 5 to 15 years after first waste emplacement (when significant gas is generated), and then a barrier to infiltration installed and remains for as long as the cover is maintained (when very little gas is generated), after which its performance will decline and rain will re-infiltrate the site (when gas generation resumes). Therefore, the operative decay rate is not the same in those three different phases.

If the model is to reflect the critical limiting conditions for decomposition to occur, such as internal moisture levels, then the value for k also must be appropriate, and different, for those distinct time periods. That would be higher in the first and the last phase and much lower in the middle phase of a landfill's biologically active or latent life. Slightly modifying the value for k by

site location, rather than by the landfill's phase, and as a constant value under all of these conditions, fails to rectify the fundamental flaw in the first order decay model as it is presently constructed. The use of a constant k value, more closely tied to a largely irrelevant factor, fails to correct the flaws in FOD models current contemplation of k.

Data Problems. The underlying data for the analysis is not transparent, but, we continue to believe that the data inputs used for Gas Captured and Methane Destroyed, systematically understate not only Gas Generation for the reasons described above, but also Gas Captured and destroyed.

From past experience, we believe that the aggregated data for Gas Captured continues to be grossly inflated. In the past when we last consulted for EPA, the landfill owners and vendors refused to provide actual data on gas collected at each landfill for the purpose of compiling a national data base, even though this data is typically available buried in the files of state regulators. In lieu of actual data, the nameplate capacity of the permitted flares were multiplied by the number of hours. This fails to account for subpar performance, maintenance and unexpected downtime. States should be queried to compile actual data, or if that is not possible, a statistical sample of landfills should be selected and state records reviewed to estimate the deviation from manufacturers' claimed values for the different equipment.

On a related note, while the high methane destruction values used are appropriate for flares, state enforcement officials report seeing performance for internal combustion engines below 95%. Field data should be compiled from actual state reports to improve the reliability of long-held assumptions. It is unfortunate that AP-42 continues to fail to provide any of the data that it collected in a form from which more reliable estimates might be developed.

B. First Three Phases. As noted, decomposition, and gas generation, are not a continuous function but rather are moisture dependent. In turn, the level, and distribution, of moisture depends primarily upon when the final cover is installed, and whether leachate is recirculated (and/or outside liquids added), as well as waste composition, in-situ compaction ratios, precipitation and transpiration, the presence of active gas collection wells, and surface grading.

Typically, after first waste emplacement, the gas collection system is not installed for five years in large landfills (though not in smaller ones), but it does not function to its design standards until the final cover is installed soon thereafter that creates a necessary seal for the system's vacuum forces to work properly and to prevent oxygen infiltration from the surface when it fully draws. Before the cover is installed, moisture is brought to the landfill entrained in food discards, grass clippings and left over liquids at the bottom of containers, which is supplemented by infiltrating rainfall while the top remains open while the cell fills up. Following capping, the residual moisture is quickly dehydrated by the gas systems, because half of the extracted gas by weigh is water vapor.

In wet cell landfills, discussed later, leachate is recirculated soon after first waste emplacement in order to accelerate decomposition, and often the final cover is delayed for several more years to extend the time when infiltrating rainfall can replenish moisture levels.

Thus, through the period of time that the cover is maintained, which may be approximately 30 years following closure, the landfill proceeds through three phases:

- *Pre-installation of the gas collection system*
- *Post-gas collection installation but pre-installation of the final cover*
- *Post-installation of the gas system and final cover but prior to the end of post-closure maintenance*

This is not controversial. These different phases are accepted by EPA, and, indeed, the structure is reflected in the GHG Reporting Rule, and by the landfill industry.34 These phases directly implicate how a landfill GHG inventory needs to be calculated. For, each of these phases evinces very different characteristics for the gas generation and gas collection, that varies significantly what is assumed in the First Order Decay model used in the draft inventory:

Three Phases of Landfill Life Actual Landfill Characteristics Compared to First Order Decay Model		
	Gas Generation	Gas Collection
Pre Gas Collection Dry Tomb Wet Cell	 Same Higher	 Lower Lower
Post Gas/Pre Cover Dry Tomb Wet Cell	 Same Higher	 Lower Lower
Post Cover-Pre Maintenance Ends	Lower	Higher

Comparing the second to the third column shows the point that Prof. Hans Oonk made to the draft version of AR4. It convinced the IPCC that the average lifetime capture rate that was equivalent to EPA's 75% assumption of what the best systems might achieve at the point of their peak performance is as low as 20%.

While the EPA and landfill industry have recognized the fact of these three phases of a landfill's life, they do not seem to appreciate the paradox that Oonk first raised, namely gas capture is only good when there is scant gas production, and when most gas is generated, there is little or no gas collection.

The draft inventory, however, recognizes neither, not the existence nor the phases or the paradox that they create. Indeed, by performing the first order decay model on total estimated landfill tonnages in each prior year, instead of on each individual landfill as a function of which phase it

is in that year, the calculation ignores all of these very significant distinctions. In aggregate, the effect, again, is to grossly understate landfill GHG emissions.

C. Second Wave

To further complicate matters, there is a critical fourth time period in a landfill's life-cycle that is critical to include in the GHG inventory, yet is currently ignored in both the draft inventory and the GHG Reporting Rule. That is the second wave of gas generation, after postclosure maintenance ends, when the majority of a landfill's lifetime gases are generated, and, with the site abandoned, are released unabated.

Moisture restrictions. The second wave occurs because of three factors. First, as noted, the organic material in solid waste require 60% or more moisture to decompose, while incoming wastes contains less than 25% moisture. Absent additional liquids, decomposition will be minimized.

Distribution limited. Second, moisture is not evenly distributed in landfills. Solid waste is highly heterogeneous, heavily compacted to eight times its original density, inter-leafed with daily cover, and often confined in partially splayed open plastic bags, all of which combine to create highly constricted preferred paths of flow. Field studies, undertaken in the late 1990s when waste densities were only two-thirds of their current ultra-high compaction levels, show that entrained and infiltrating liquids only reach 23% to 34% of the mass.35 With in-place densities today 50% to 66% greater than when the study was done, dispersion of liquids will tend to be significantly less.

Essentially, prior to the site closing and being covered with a low permeable liner, decomposition is confined to a few areas. It only occurs where there is moisture entrained with the incoming food scraps and grass clippings and leaking out the bottom of bottles containing fluids, as well as where rain travels through cracks and fissures and then pools in pockets where food is decomposing and in voids between large particles.

After installation of the final cover, however, infiltration largely ceases and any residual moisture is quickly extracted with the gas, half of which is condensate (by weight) in the collection system, rapidly dehydrating the waste mass. From the data, probably more than half of the original carbon content in the organic discards remains upon closure.

Cover ultimately fails. Third, the final cover has a finite life. After closure, at best financial assurance regulations only provide funds for routine maintenance and for only 30 years. As EPA repeatedly stated during the 1980's leading up to the promulgation of Subtitle D in 1991, even composite liners "will ultimately fail" within decades after the agency's post-closure care requirements have expired, "and when they do, "leachate will migrate out of the facility."

the EPA recognized, the duration of a landfill's hazardous loadings that needs to be isolated may be "many thousands of years," long after the time when discharges will occur.

The early warnings from EPA were more recently reinforced from an investigation and field study conducted by the agency's Inspector General –

"EPA officials have stated that based on current data and scientific prediction, the release of contaminants may eventually occur, even with the application of best available land disposal technology. There is concern that these barriers will merely postpone the inevitable release of contaminants until after the 30-year liability has expired. As previously stated, some sites contain materials which are highly resistant to decomposition or which remain toxic forever. There have been several studies to determine the expected life span of landfill liners, and opinions on this issue vary widely. The bottom line is that not even the manufacturers claim that their liners will last forever."

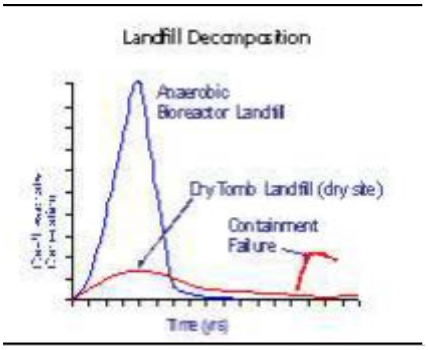
Why, then, did the EPA proceed to adopt liner-based regulations in 1991, when they were fully informed that engineered barriers will eventually fail? That question was answered by the EPA Inspector General a decade later in 2001. Extensive interviews with the agency's staff established that the reason was political, not technical–

"Landfill design requirements and post-closure maintenance for both Subtitle C and Subtitle D facilities are expected to prevent leakage in the short term; however, their long-term effectiveness in controlling releases of contaminants is unknown. EPA and others have stated that it is likely that some disposal facilities will leak at some period after they close. "However, some who commented were concerned that an extended time frame would place an economic burden on smaller businesses. Therefore, EPA officials acknowledge the lack of criteria or scientific basis for establishing the 30-year post-closure time frame. EPA made the decision to establish the time frame at 30 years, seemingly based on a compromise of these competing interests. EPA officials we spoke to agreed that the 30-year time frame was not based on specific scientific criteria or research studies."

State environmental agencies reached the same conclusion about the fact that the covers would eventually fail and lead to a second wave of gas generation after maintenance ends at closed landfills. The California Integrated Waste Management Board stated:

"However, the initial term of 30 years for P[ost] C[losure] M[aintenance] is unlikely to resolve all the environmental issues related to a closed landfill in California. Since Subtitle D was promulgated, research shows that certain wastes in some landfills stabilize in a short period of time and that,at those landfills, the potential to impact the environment may only last for a short portion of the conventional 30-year PCM period. On the other hand, some landfills may remain a threat to the environment for longer than 30 years. For example, stakeholders have reported to Board staff that landfill gas control systems have had to be installed at landfills that had not operated for up to 60 years. Dry tomb landfills (favored by Subtitle D and 27CCR) indefinitely

suspend and/or retard the decomposition process such that a breach in containment (e.g. extreme climate or earthquake event or inappropriate land use, or simply failure of equipment or containment barriers) could trigger uncontrolled production and release of landfill gas and leachate, and public contact with waste. The state of the science thus indicates that municipal solid waste landfills will in many cases pose a significant threat to the environment well beyond the conventional 30-year PCM period." (See accompanying FIGURE showing a second wave of gas generation denoted as "containment failure.")



Similarly, Washington state's Department of Ecology has stated:

"The extent to which today's landfills adequately protect human health and the environment is a subject of debate, however. Requirements that govern siting, operation, closure, and post-closure are stringent and extensive. While the newest landfills are state-of-the-art facilities, they are far from benign in their impacts. Landfills may still affect the air, land, and water but to a significantly lesser degree than before today's standards went into effect. As waste decomposes in landfills, methane and other hazardous gases are generated. Methane is a greenhouse gas concern because its impact is twenty-three times that of carbon dioxide (EIA). Leachate from decomposing matter in landfills can contain hazardous constituents. If landfill liners and/or leachate collections systems fail, then groundwater and surface-water pollution can occur. No liners are engineered to be 100 percent impenetrable or to last forever without some sort of failure. In fact, US EPA officials have stated that problems can occur more than thirty years after closure of a landfill, pointing out that 'even the best liner and leachate collection system will ultimately fail due to natural deterioration.'"

In addition, the Wisconsin Department of Natural Resources has also pointed to the same inherent flaw in dry tomb designs for landfills:

"The problem with dry tomb landfills is that the organic wastes in them remain largely undecomposed. They represent a continuing and large potential source of methane gas, as well as a potential source of groundwater pollutants. The essentially perpetual management of these problems represents a long-term financial liability to the waste management industry, and potentially to the state, if public monies have to be used to clean up future problems."

Furthermore, in the last three years, many in the landfill industry have conceded these basic facts, as well. The Executive Director of the Solid Waste Association of North America (SWANA), John Skinner previously headed EPA's Office of Solid Waste where he had a major role in drafting Subtitle D. Dr. Skinner has recently written:

"The problem with the dry-tomb approach to landfill design is that it leaves the waste in an active state for a very long period of time. If in the future there is a breach in the cap or a break in the liner and liquids enter the landfill, degradation would start and leachate and gas would be generated. Therefore, dry-tomb landfills need to be monitored and maintained for very long periods of time (some say perpetually), and someone needs to be responsible for stepping in and taking corrective action when a problem is detected. The federal Subtitle D rules require only 30 years of post-closure monitoring by the landfill operator, however, and do not require the operator to set aside funds for future corrective action. Given the many difficulties of ensuring and funding perpetual care by the landfill operator, the responsibility of responding to long-term problems at dry-tomb landfills will fall on future generations, and the funding requirements could quite likely fall on state and local governments."

Dr. Skinner's predecessor at SWANA, Lanier Hickmanexpressed the same view more forcefully:

"Currently many policymakers view F[inancial] A[ssurance] for landfills from the perspective, 'If it ain't broke, don't fix it.' However, the question is not 'if' there will be future landfill problems, but 'when.' Since FA requirements are the last line of defense before the public winds up with the costs for corrective action, it is critical that an FA mechanism be able to guarantee coverage of expected landfill costs."

Or from Peter While, an environmental scientist with Procter & Gamble – "...The dry containment method of operating a landfill has been described as long-term storage of waste rather than waste treatment or waste disposal, and does have some significant drawbacks. There will always be pockets of moisture within waste, and it is generally accepted that all lining and capping systems will eventually leak so rain and/or groundwater will eventually enter the site. Thus, the decomposition of the organic fraction of the waste will eventually occur, with resulting emissions of landfill gas and leachate. Since pipes and pumps buried within the waste eventually clog up and fail, there will be less chance of collecting and treating these emissions if they occur in the distant future."

Or from John Pacey, one of the premier landfill engineers –

"The containment provided by these landfills offers environmental protection initially; however, at some point beyond the 30-year [postclosure] period, there may be partial failure(s) of the containment lining system (underlying and overlying the waste). The primary environmental issue associated with partial containment system failure and moisture infiltration is the potential associated increase in gas and leachate production and the resulting impact of uncontrolled leachate and/or landfill gas releases to the environment. The nature and magnitude of the

releases exiting the landfill and their resulting impacts are directly related to the amounts of organic waste not yet decomposed."

Thus, a very substantial fraction and quite possibly a significant majority of the carbon in the incoming wastes remains when the landfill is closed due to insufficient and unevenly distributed moisture while open. Also, eventually the cover will fail after maintenance ends, reigniting a second wave of gas generation that will probably be larger than the first wave. At that time, there will be no gas collection and all of the future gases from the residual decomposables will escape into the atmosphere.

Not only is it vital that the fifth phase of a landfill's life be acknowledged, but also it is necessary to include the future emissions that will flow from today's discards in the annual GHG inventories. Yet, for the organic discards buried in the year for which the inventory is prepared, EPA's current practice purports to track each landfill's actual performance only in that annum.

However, in fact, we understand that the agency does not even recognize the fact that a not insignificant fraction of the gases generated that year are from open or not fully closed cells

where there is either no gas collection or no low permeable cover. In those cells, the Gas Capture Rate is zero or a fraction of collection system's peak performance, while EPA's calculations presumes capture rates are a constant and optimal at all times, belying any claim that it is tracking each landfill's behavior in that year.

Even if the new four-phase protocols included in Table HH-3 of the GHG Mandatory Reporting Rule were followed in the inventory – which we do not believe it was – that would still ignore the fifth phase when, most likely, a majority of the gases are generated and, since none of those are captured, most of the fugitive emissions occur.

Accounting for future emissions. EPA has previously defended the inventory's omission of the vast majority of postponed GHGs that arising from the residual carbon in the wastes buried today. It has argued that the inventory only encompasses emissions estimated to occur in that year.

However, this view produces a result that ignores the majority of the delayed emissions associated with wastes deposited in that year, which, under EPA's protocols will never be counted for in the relevant future. This result is akin to assessing a person's dose absorption of a

24-hour time release pill in the first hour after its being swallowed, and ignoring the further uptake in the following 23 hours.

Moreover, EPA's opinion is fundamentally inconsistent with the IPCC principles that the agency has itself restated in its reports:

"CH4 emissions from landfills are counted [under the IPCC guidance in inventories of anthropogenic GHG emissions.] Even though the source of carbon is primarily biogenic, CH4 would not be emitted were it not for the human activity of landfilling the waste, which creates anaerobic conditions conducive to CH4 formation. Note that this approach does not distinguish between the timing of CO2 emissions, provided that they occur in a reasonably short time scale relative to the speed of the processes that affect global climate change. In other words, as long as the biogenic carbon would eventually be released as CO2, it does not matter whether it is released virtually instantaneously (e.g., from combustion) or over a period of a few decades (e.g., decomposition on the forest floor)." Finally, the refusal to acknowledge the future stream of methane emissions that inevitably will follow from the burial of organic discards today is also in fundamental conflict with other practices used elsewhere in the inventory. In order to compute the equivalent warming effects of other greenhouse gases to CO2, each of which has different residence times, the accepted convention uses an assumed common 100-year period for the time each gas, released today, will remain in the atmosphere before it decays or is absorbed. Since methane actually only remains in the atmosphere for 12 of those 100 years, its actual impacts are diluted by being spread over 88 years when it is no longer present.

In the event EPA's decision is to bar recognition for those delayed impacts, then, to be consistent, the protocols also must use a single-year basis for calculating the different gases' warming potential, something that would increase methane's carbon-equivalence by more than 100 times. But, the protocols cannot responsibly use a century long frame of reference in one chapter and an instantaneous snapshot in another and produce a coherent analysis in the conclusion.

As to the complaint that there is no nomenclature to properly account for the future stream of emissions in the inventory for the current year, there is a well-trod analogous mechanism to do this. Accounting routinely incorporates into the present a future stream of income flows that derive from an investment made today to best pick from various options. This directly resembles continuing gas emissions from decaying wastes discarded in that year. That technique is the net present value analysis, long used in economic planning and decision-making.

As to the complaint that present value type of calculations require making projections about future events that are not precisely known, that, too, is a red herring. For one thing, the current present-only analysis is already replete with made up assumptions without any factual basis, such as the gas capture rate. For another, ignoring future consequences that will follow from today's actions does not eliminate uncertainty. To the contrary, ignoring the future is a palpable decision that there will be no future decomposition activity from today's discards, which is a totally absurd result. Tomorrow's uncertainty cannot be eliminate by pretending it does not exist.

Of note, a present-value type of calculation attributing future emissions from wastes buried today to the current year is a practice that the IPCC has used elsewhere. The estimation

technique of compressing into the present the future emissions from today's sources has more recently been specified as the appropriate methodology in the IPCC's Clean Development Mechanism program.

E. Oxidation

The draft inventory continues the practice of continuing to assume that 10% of escaping methane is oxidized in the cover soil. Previously, EPA has effectively rested its case on the Czepiel study, which found in field and laboratory studies during 1994 that 10% of the methane generated in a landfill, was oxidized in the cover soil over the course of a year.

When the gases that are emitted are diffused throughout the overlying soil blanket, as would have been the case with most landfills constructed before 1991, this study would be applicable. However, modern landfills gases are not diffused at the surface throughout that earthen layer, because, since 1991 a composite cap has been required under that soil blanket, including in practice a 60-mil (or 1 / ") high density polyethylene plastic membrane that effectively impedes the passage of gases from the waste into that cover soil.

This is key. It means that instead of the methane diffusing throughout the topsoil for maximum oxidizing effect, the gases that are released above the landfill are concentrated in high fluxes at a handful of cracks and tears in the plastic sheet. Concentrated high flux emissions quickly overwhelm the capacity of the topsoil to oxidize the escaping methane through these hot spots.

Czepiel expressly stated that not only was his study not done at a landfill with a synthetic geomembrane, but also, "[p]eriodic maintenance of the cover materials has minimized significant surface cracks" in the clay layer, as well. That is to say, nothing in his study can be used to describe what happens to the methane that flashes through a small number of hot spots on the top face of the landfill.

He further reemphasized again in his conclusion that his findings did not apply when gases are released in high fluxes through narrow cracks:

"Waste settlement, surface erosion and soil dessication often promote significant surface cracking, providing paths of minimal resistance to gas flow, effectively bypassing microbial influence. Our study generally lacked surface cracks, although his characteristic may not be representative of the entire spectrum of landfill surfaces."

Furthermore, a consultant for the U.K. Department on the Environmental conducted a comprehensive study involving 250 measurements at a landfill with a composite cover and found that there was no oxidation effect:

"Methane oxidation is only observed where the diffusion gradient through the cap is very small, and therefore the methane oxidizing bacteria can cope with the rate of supply of gas. When higher fluxes predominate there is little evidence either for or against methane oxidation being a significant component of emission control."A similar field examination by researchers at a Swedish landfill corroborated the U.K. findings.

Other Technical Constraints on Oxidation

Even if, for the sake of argument, methane oxidation were able to occur landfills with plastic liners, there are many other limitations of Czepiel's findings when attempting to apply them without limitation to the typical landfill and across time.

For one thing, in northern climates, oxidation is improbable during cold winters. Also, in addition to the small cracks in the geomembrane, similar problems can afflict the clay liner as well. In the northern climatic zones, the freeze/thaw cycle is a constant source of cracking, and in hot,arid climates, clay is susceptible to cracking from dessication.

For another, remembering that landfill gas is heavier than air and seeks the path of least resistence, no one has yet been able to satisfactorily determine what proportion of landfill gases escape through the top of the landfill–where any oxidation that occurs would take place – and, through the bottom and even the sides of the site or through the leachate collection system – where it would not, as EPA has previously pointed out. Then, too, there is the practical complications of maintaining optimized laboratory conditions for methanotrophs to oxidize methane over the long term at a real site.

In any case, even if for the sake of argument it were considered appropriate to give the benefit of oxidation for the period of time prior to the installation of the final cover when there emissions might diffuse through any soil layer, EPA itself has stated that a concomitant reduction in collection efficiency would have to be registered to account for the lack of a seal necessary for efficient gas collection.

For the foregoing reasons, it is no longer rational or responsible to continue conducting the waste section of the GHG inventory exactly as it has done so in the past only because it has always done it this way, regardless of the fact that its foundations have been vitiated by the EPA's reports.

With kinetics experts as part of a team, we stand ready to accept a commission to revise the present first order decay model to properly reflect the things that we know make its present formulation useless.

Commenter: American Gas Association (AGA)

Comment: *The Draft Inventory indicates that overall lifecycle emissions for the natural gas value chain are low, and they are getting lower. While the new EPA methodology significantly increased the estimated emissions from production, the rest of the natural gas lifecycle experienced large reductions in emissions per unit of gas consumed. Natural gas processing experienced a 15% decline, transmission and storage experienced a 26% decline, and distribution experienced a 27% decline. These emission reductions from processing, transmission and distribution more than offset the increase that EPA estimates in the Draft Inventory for natural gas production. Even accepting EPA's inflated estimate of emissions from production, the natural gas lifecycle has experienced an overall reduction in emissions per unit of gas consumed.*

Commenter: American Gas Association (AGA)

Comment: *We do have significant concerns about EPA's methodology for estimating production emissions. The methods used to derive the emissions factors and population counts for well completions that do or do not capture methane using reduced emissions completions (RECs) are seriously inaccurate and are at odds with the EPA's goals and proud history of data-driven policy and regulation. The EPA's strong reputation means that this anomaly has been given undue credibility in the public debate over shale gas production and the lifecycle carbon footprint of natural gas. According to the analysis performed by URS Corporation for America's Natural Gas Alliance (ANGA), it appears EPA has estimated that only 15% of the hydraulically fractured well completions in 2010 used REC technology to capture methane in the flow back phase. EPA assumes that the other 85% of hydraulically fractured well completions in 2010 must have released substantial amounts of methane to atmosphere or flared it and emitted carbon dioxide (CO2). In contrast, ANGA submitted the results of a survey in January 2012 showing that eight major shale gas producers completed almost 1500 hydraulically fractured wells in 2011, and 93% of these were green completed. Only 7% were vented or flared.*

Commenter: American Gas Association (AGA)

Comment: *In comments on the Draft Inventory, El Paso Corporation also submitted extensive data based on actual field measurements using methods dictated by EPA's GHG reporting rule at natural gas transmission compressor stations, LNG terminals and storage facilities. This data indicates that the Draft Inventory has also over-estimated the amount of GHG emissions from other sectors of the natural gas value chain. In light of ANGA's and El Paso's data, we urge EPA either to update the emissions estimates for natural gas cleanups, unconventional well completions and workovers and other sources to reflect the actual data that has been submitted in comments, or to exclude them from this year's Inventory until more robust data and*

methodologies have been developed. At a minimum, we strongly urge EPA to include a statement at the beginning of Chapter 3 of the Final Inventory, and in a footnote to every table and figure that includes natural gas emissions indicating that the EPA has received data relating to the natural gas emissions estimates that indicates that the methodology should be revised, the Agency is reviewing and revising its methodology, and that, until this process has been completed and EPA has developed an appropriate methodology based on robust data, that the emissions estimates for natural gas production should not be relied upon for analysis or regulatory action.

Commenter: American Gas Association (AGA)

Comment: *In September 2012, producers will also submit reports under the mandatory GHG reporting rule, 40 C.F.R. Part 98, Subpart W, that will provide the number of hydraulically fractured shale gas well completions in 2011 that are either green completed, vented or flared. AGA urges EPA to incorporate this new Subpart W data on 2011 well completions and other Subpart W sources when EPA drafts the next Inventory for the period 1991-2011. The new Subpart W data will be reported by Sept. 28, 2012. This will allow plenty of time for EPA to include the new data before issuing a new draft Inventory of 2011 emissions in January 2013.*

Commenter: Pioneer Natural Resources

Comment: *Specifically, in the 2011 draft inventory, EPA made limited, specific changes to the Natural Gas Systems Section 3.6 that dramatically increased emissions from field production 9 times between the 2010 and 2011 Draft Inventory and more than doubled the previous estimate for all natural gas system emissions. Pioneer's comments below focus on two of these major alterations: a revised methodology for calculating emissions from natural gas well cleanups (also called liquids unloading) and a new category of gas well completions and gas well workovers (re-completions) with hydraulic fracturing. EPA's 2010 Inventory estimated 2008 methane emissions from natural gas field production at 14.1Tg C02 Eq. In the 2011Draft Inventory, estimated methane emissions in 2008 were 122.9 Tg C02 Eq (revised to 118.6 Tg C02 Eq during the QA/QC process for the 2012 Draft Inventory), a 9 fold increase. No other emission source underwent such a striking adjustment. These changes remain in this 2012 draft inventory and Pioneer would like to take this opportunity to outline discrepancies and omissions in the data and analysis, and offer accurate in-house numbers as a comparison tool for EPA to use in revising their inventory.*

EPA must develop accurate, peer-reviewed emissions and activity estimations that are based on valid data, assumptions and calculations. Transparency in data sources is critical for industry, regulators, as well as the public nationwide who all have a vested interest in these published

GHG emissions estimates. Accuracy in this inventory is of the utmost importance as state and federal regulators will inevitably rely in some aspect on this data for future regulatory initiatives. In light of serious concerns with respect to the methodology and the quality of the data generated for the Draft Inventory, Pioneer mirror's ANGA's request and asks that EPA either update the emissions estimates for natural gas cleanups and unconventional well completions and workovers or exclude them from the inventory until more robust data and methodologies have been developed and subjected to public review and comment. At a minimum, EPA should include a statement at the beginning of Chapter 3 of the Inventory, and in a footnote to every table and figure that includes emissions from Natural Gas Systems, indicating that it has received information and data related to Natural Gas System emissions estimates that indicates that the methodology needs to be revised (as EPA itself has pointed out in the text), that the Agency is in the process of revising its methodology, and that until such time as the methodology has been revised an implemented, and new emission estimates based on the revised methodology are available, the emissions estimate sin the inventory should not be relied upon or otherwise used as the basis for any analysis or regulatory action.

Commenter: Pioneer Natural Resources

Comment: *Additionally, Pioneer, as well as ANGA and other trade associations, commented on EPA's proposed Oil and Gas Sector New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants proposed rule in November 2011 in regard to EPA's unconventional well completions and workover data, pointing out the flawed activity and emission factors and offering realistic estimates. However, despite these and previous requests for correction, faulty estimates and methodologies remain the same in this Draft Inventory as in EPA's 2011 Draft Inventory. EPA seems to recognize that their methane emissions estimates do not accurately reflect emissions from the industry and point out this fact, however further steps must be taken to publicize the unreliability of this data.*

Commenter: Pioneer Natural Resources

Comment: *In the QA/QC and Verification Discussion, Recalculations Discussion, and Planned Improvements discussions of Section 3.6 in the 2012 Draft Inventory, EPA states*

The natural gas inventory is continually being reviewed and assessed to determine whether emission factors and activity factors accurately reflect current industry practice. EPA has received information and data related to the emissions estimates through the inventory preparation process and the formal public notice and comment process of the proposed oil and gas New Source Performance Standards {NSPS} for VOCs. EPA plans to carefully evaluate this and all other relevant information provided to us. Subsequently, all relevant updates will then be

incorporated, as applicable, in the next cycle of the Inventory. In light of this current review of information and data, for the 1990-2010 Inventory, emissions for the natural gas sector were calculated using the same methodologies, emission factors and sources of activity data, as the 1990-2009 Inventory. Additionally, EPA has held the 2010 estimate for emissions from hydraulically fractured wells constant at 2009 levels (ie: maintained the same activity data and voluntary reductions for hydraulically fractured gas well completions and existing hydraulically fractured gas wells). For the production sector, EPA intends to evaluate additional data on emissions reductions, particularly those related to gas well cleanups and regulatory reductions from well completions and if appropriate, will incorporate revisions into future inventories. Additionally, accounting for the uncertainty of emissions reductions to more accurately provide upper and lower bounds within the 95% confidence interval, will be investigated. EPA also intends to investigate improvements to its estimates of emissions from hydraulic fracturing, including revisiting the estimates for workover frequency.

Regardless of EPA's recognition of the receipt of data based on actual operations form natural gas operators and adequate time to assess this data, they have failed to modify their estimates and have included the same overstated, fundamentally flawed data in the text, tables, and annex of the Draft Inventory as if it were accurate information that should be accepted as true and correct. TO further compound Pioneer's concern, this data will inevitably be relied upon by regulators for future rulemaking. Pioneer requests that the operational data that was submitted in the NSPS comments be considered by EPA as well as the Pioneer-specific information provided below in these comments. Further, Pioneer is concerned that EPA's release of this emissions data does not meet the Information Quality Act requirement that information disseminated by EPA be accurate, complete, reliable and unbiased.

Commenter: Pioneer Natural Resources

Comment: *The change in the methodology for estimating emissions from natural gas well liquids unloading (referred to by EPA as cleanups) account for the majority of the increase in emissions from natural gas production from the 2010 Draft Inventory to the 2011 and 2012 Draft Inventories. First, in the Methodology section of 3.6, EPA states that the emissions factors do not take into account the use of technologies that reduce emissions. To take into account the use of such technologies, data is collected on regulatory and voluntary reductions, according to EPA. The revised methodology contains a critical flaw in its failure to include emissions reductions from the use of artificial lift systems, such as plunger lifts, among others, that are not reported under the Natural Gas STAR Program. It is not sufficient that EPA utilized results from the Natural Gas STAR Program to account for these technologies since not all Natural Gas STAR partners report all emission reduction activities. In fact, artificial lift is underreported even among Natural Gas STAR partners as it is often regarded as an economic recovery technology as opposed to an emissions reduction technology. The omission of emissions reductions from the*

application of these technologies results in a worst-case scenario approach that is not appropriate for an emissions inventory, and dramatically overestimates the emissions from natural gas production.

Commenter: Pioneer Natural Resources

Comment: *Further, EPA appears to have developed their methodology for calculating emissions from liquid unloading events based on two sources. The first source, an EPA/Natural Gas STAR report "Lessons Learned: Installing Plunger Lift Systems in Natural Gas Wells" provides an equation for estimating the volume of gas vented during a blowdown. EPA states that it used production and permit data obtained from HDPI in October 2009 for at least part of the data to run the equation. HOPI supplied information of well depth, shut-in pressure, well counts and well production data. However more detail on the data actually used, particularly the data used to calculate shut-in pressure (which is needed to ensure that EPA focused on low pressure wells where liquid unloading is more prevalent), is necessary to adequately evaluate the methodology and results. The equation only provides the volume vented fore each blowdown. To complete the inventory, EPA needs to know how many wells required cleanups and how many blowdowns are required annually at those wells. The documentation for the inventory does not indicate what data were used to estimate these two variables. EPA must provide greater transparency in the data upon which they base their calculations. While the HPDI data would have provided the total number of wells, it is unlikely that HPDI's production data would have provided information of which wells perform cleanups and number of blowdowns performed each year at those wells. EPA has estimated these two variables - Appendix B of the TSD developed in support of Subpart W of the GHGMRR uses data from a 1992 survey conducted by GRI to estimate that 41.3% of conventional wells require cleanups. Pioneer believes that hits figure is dramatically overstated. The 1992 survey was of 25 well sites. To determine the average number of blowdowns at each well, the TSD uses a simple average of 31 blowdowns per well based on publicly available data from two Natural Gas Star partners. These estimates are based on outdated well estimates and two isolated data points to determine the average annual number of blowdowns at each well. EPA's lack of adequate data sets and transparency is concerning and these emissions estimates that EPA has assumed based on this extremely limited data set are not reasonable and should not be relied upon. EPA should work further with industry to acquire more accurate activity and emission factors to run their calculations and estimate emissions. Based on Pioneer's actual operational experience for company gas wells in 2010, less than 1% were blown down to the atmosphere during liquid unloading operations.*

Pioneer mirrors ANGA's request and ask that the emissions should be estimated per event using approaches similar to the EPA MRR Subpart W and then apply the emissions estimates to wells that 1) use cleanups and 2) do NOT use an emission reduction technology of any kind. Then the emissions should be adjusted for reasonable estimates on the amount of gas that is flared v.

vented. In general, Pioneer feels that the methodologies between the Draft Inventory and Subpart W should be concurrent for consistency in calculating, reporting, and disseminating information

Commenter: Pioneer Natural Resources

Comment: *In the 2011 GHG Inventory, EPA added two new categories: unconventional gas well completions and unconventional gas well workovers.10 The addition of these two categories accounted for 28 percent of the increase in estimated 2008 emissions from natural gas field production from the 2010 to the 2011 GHG inventory. The TSD prepared in support of Subpart W outlines the approach EPA used to develop the emission factor. The TSD uses only four data points to develop an estimate of emissions from completions. EPA took these four estimates and calculated an emissions estimate of 9,175 Mcf/completion for unconventional wells. EPA applied the same number to workovers (and recompletions as EPA uses these terms interchangeably).*

Not only is the emission factor based on only 4 data points, but none of the data points were purported to be representative estimates of emissions from completions or recompletions. Rather they are case studies from a voluntary EPA program aimed at reducing emissions and, as such, they are reporting the results of a handful of projects in the field. They are not based on standardized and audited protocols and were into intended to be the basis of inventory-grade information disseminated by EPA. Moreover, case studies, by their nature, are typically based on projects that will provide statistically significant results and are not based not he average project. So, it follows that since notable projects are the ones that capture the greatest amount of emissions, using these captured emissions to estimate average uncontrolled emissions will lead to grossly inaccurate results.

Commenter: Pioneer Natural Resources

Comment: *In regard to the activity factors used by EPA for completion and recompletion estimates, in the Annex EPA states that, 10% of the total fractured gas well count is the number of gas well workovers with hydraulic fracturing in a given year. In addition, EPA states that due to the lack of publicly available data, 51% of hydraulically fractured gas well completion and workover emissions are assumed to be flared across the 1990-2010 time series, even though it is likely that some fraction of these required reductions are recovered for sale. EPA assumes this estimate because of regulations in some states, such as Wyoming, require completion emissions to be controlled and not vented and therefore, emissions in these states must be either recovered or flared. Pioneer believes that this assumption is not valid. Again, Pioneer urges EPA to work with industry for a realistic representation of the industry operational practices and when capturing gas with Reduced Emissions Completions (REC) is performed. For example, in 2010,*

Pioneer operated approximately 4600 natural gas wells, of which over 98% were stimulated through hydraulic fracturing. Of these hydraulically fractured wells Pioneer refractured less than one-percent. This percentage varies significantly from EPA's ten-percent refrac figure. Further, in regard to RECs, currently Pioneer performs green completions at all Barnett Shale wells and flares instead of venting as in the company's South Texas and Eagle Ford operations when gathering lines are not available.

Commenter: TJ Blasing, ORNL

Comment: *Appendix, Table A-35, Electric Power Coal sems to nose dive from 25.96 in 1990 to values around 17 between 1995-2010.*

Commenter: Linda Heath

Comment: *Forest carbon stocks dropped 15% but carbon sequestration estimates relatively unchanged. In Table 7-8, in comparison to last year, the total live tree biomass carbon (above and below), using the year 2010 as an example, was 84.7 percent of what it was last year, dropping from 20,552 TgC to 17,417 TgC, a loss of 3,135 TgC or 11,495 TgCO2e. This relative difference as well as magnitude is pretty much the same throughout the period.*

Page 7-21, lines 5-10 says that a new method was used to calculate this pool, and that the carbon stocks in this pool is lower, but that the relative effect on the net annual stock change was minimal. Indeed, using the year 2009 as an example, in comparison to last year the change in net annual stock change was 0.9% greater sequestration, which is 5 Tg CO2e or .36 TgC for that year. This is well within the range of uncertainty. Does the given explanation mean that if the change in sequestration had not been minimal that the new set of equations would not have been adopted? What is the scientific basis for choosing to switch to the new set of equations?

Commenter: Linda Heath

Comment: *New forest biomass equations are from gray literature but urban forest tree biomass equations remain unchanged. The reason for asking is because the biomass equations used for many years now were published in Forest Science, the premier peer-reviewed scientific journal of the Society of American Foresters. (The EPA inventory urban tree estimates also are said to be based on equations similar to these.) The forest biomass equations used in these new estimates were published in a gray literature proceedings paper. The original methodology was*

updated in a compilation of all the necessary volume equations needed to calculate biomass estimates for all trees of the US, recently released as a Forest Service General Technical Report. It is unclear how gray literature-based equations are more accurate and more scientific than peer-reviewed scientific literature. Further, this newer set of biomass equations appears to not be based on any new field-collected tree-biomass data.

Commenter: Linda Heath

Comment: *Individual-tree error reduced? In what way? Line 21, page 7-21 of the GHG inventory draft says that this approach appears to reduce the level of individual-tree error. However, it is not totally clear what evidence this statement is based on. For example, in this new set of equations, based on the description of this approach, it sounds as though trees growing on one side of, say the Indiana-Ohio state border, will have a certain biomass estimate, and the same size and species tree on the other side of the border will have a different biomass estimate, simply because the different FIA units are using different volume equations. How does having two estimates for the same tree in the same database contribute to a reduction in uncertainty at the individual tree level, or even the perception of a reduction of uncertainty?*

Commenter: Linda Heath

Comment: *Plot level updated estimates are based on what? The Forest Service apparently only recently initiated a coordinated study to collect new biomass field data for biomass model development, and when that study is*

completed the equations will presumably change again. It is not clear in this US EPA GHG Inventory chapter or cited literature what the scientific reason is for adopting an interim set of equations. For some of the states in the early years of these inventories there is only plot-level data anyway, and conversion estimators for those always have to be revised for this analysis in order to calculate the change between inventories. In what document is it shown that this new group of estimators is better than the previous group of estimators for plot-level change?

Commenter: Linda Heath

Comment: *What message does this send to other countries about how to conduct forest carbon estimation? Because there is so little change in the GHG inventory estimates due to these equations, one would think the real story must be about estimating carbon stocks. If CO2 was worth $5 per ton, in terms of the difference since last year's estimate in terms of money in hand would be $25million, but in terms of stocks, $57.475 billion dollars disappeared since last year.*

How does this change in carbon stocks compare to the stated uncertainties? What would experts from other countries think of such a notable change? What is the scientific basis for the change to these equations, given that other pools remain to be updated too?

Commenter: Linda Heath

Comment: *A commentary on continuous improvement as the reason. Although not noted in this text, an explanation of this drop in carbon stocks is explained in not a research article, but a commentary in the March issue of the Journal of Forestry, the journal for the Society of American Foresters, a professional society. It came out very late in March. The explanation given there is that this is a result in the pursuit of scientific rigor to do better. If scientific rigor was used in this updating, then where is the peer-reviewed, thorough analysis on which the new biomass equations is proven scientifically more accurate than the last set? What are the accuracy and/or precision improvements from these changes? Why update the standing dead tree when the down dead wood in the same pool is not being updated this year but will be updated soon, which will again change the dead wood pool? IPCC discusses accuracy, comprehensiveness, consistency, transparency, etc. It is unclear how continual improvement relates to these characteristics. Including new recently collected data that has undergone a quality assurance process into the system is one thing. Continually fiddling with methodology of the system is another.*

Commenter: Linda Heath

Comment: *Update some pools and not others which may have been calibrated based on the old biomass estimates? That new standing dead tree data was added is a laudable goal, although the biomass equations are untested. But the dead wood pool contains both the standing dead trees and down dead wood, and the down dead wood is still modeled even though the data has existed for years. Why update the dead wood pool now, only to have to update it again with the new data in the next year? It is unclear how the soils information is calibrated. One would think it would be more defensible in a policy relevant framework to focus on a thoroughly peer reviewed system for all the pools, publish in peer-reviewed journals, and then change the estimates one time.*

Commenter: Linda Heath

Comment: *In summary, the scientific basis for making the change is not well-stated. It is necessary and an important goal to ensure the estimates are based on the best scientifically-based methodologies, which are implemented correctly as needed for the GHG inventories, and*

so it is expected that the approach and results will indeed change over time. My comments are not to question whether the best intentions went into these estimates. I am sure all parties involved have the best of intentions. Rather, my comment is that the scientific basis for making this change at this time is not well stated and does not appear to be well-supported in the GHG inventory text. Other countries could now constantly change their forest GHG inventories, following the US lead. Having to make continual improvements is not always an indication of sound scientific advancements, just as adopting a process of continual improvements is not automatically evidence of a sound scientific process. If someone was auditing the estimates of countries to ensure that cheating in reporting was not occurring, just what would they think of this? What would people think of the national GHG inventory reporting system if all countries, Annex I and non Annex I, constantly changed their estimates in a manner similar to this? Please consider providing a clear reasoning for adopting this approach at this time, especially in light of the notable drop in carbon stocks.

Commenter: Robert J. Kopka

Comment: *I believe a summary of total global emissions of the various greenhouse gases could be useful, especially as the climate changes of GHG sources shift to another part of the world. These global emissions should be further divided as natural sources or those directly induced by humans on a world wide basis to better document what is being emitted world wide and how the United States might influence worldwide emissions. Some examples of natural sources that should be tracked over time as the world warms are the release of methane from the ocean sediments and permafrost, and the release of carbon dioxide from the soil. The location of sources of man-induced GHG (by country) may change over time as well. Future policies that may be enacted in the United States, may influence GHG emissions from another country or vise cersa. The change in the location should be documented over time in this and future reports, so we can be aware of how U.S. policies may influence global GHG emissions.*

Commenter: Robert J. Kopka

Comment: *I also believe that the amount of carbon dioxide released during the production of solar panels should be a separate line iten in many of the GHG source tables. The production of solar panels may become asignificant source of GHG emissions, if solar becomes a major future energy source because the production of these panels requires the use of a great quantity of energy.*

Commenter: Department of Transportation

Comment: *Transportation estimates in Tables such as 2-15 and 3-12 could include tailpipe biofuel combustion estimates as an italicized item similar to the wood biomass and ethanol consumption estimate currently presented in Tables ES-2 and 3-1. It would also be worthwhile to include a footnote explaining why these emissions are not included in the total, and point to the Renewable Fuel Standard literature for details on upstream analysis of transportation fuels.*

Commenter: Department of Transportation

Comment: *DOT recommends that EPA include italicized biofuel consumption estimates in Tables A-1 and A-2 of the Annex. This could eliminate the need for a separate Table A-3.*

Commenter: Department of Transportation

Comment: *The increased biofuel consumption (and the related accounting issues) could also be discussed in the transportation narratives of Sections 2.1 and 3.1, which could also point to the RFS literature for details on upstream analysis of transportation fuels.*

Commenter: Department of Transportation

Comment: *p. 12, lines 32-33: Should acknowledge the increase in fuel prices, including the spike from 2006-2008 and increases since prices bottomed in late 2008 / early 2009.*

Commenter: Department of Transportation

Comment: *p. 14, Table 1-12: the Residual Fuel Oil footnote refers to FHWA definitions of vehicle classification. We believe that this footnote is misplaced or an additional footnote was intended for Ships and Other Boats.*

Commenter: Department of Transportation

Comment: *Ship/boat residual fuel energy consumption and CO2 emissions have some odd fluctuations---particularly between 2009 and 2010—that do not appear to be consistent with current EIA fuel oil & kerosene sales data, either adjusted or unadjusted. DOT staff are not*

aware of any substantive reason to believe domestic or international shipping fuel consumption increased substantially in 2010.

The inventory report shows a 64-percent increase domestic shipping fuel consumption (and hence CO2 emissions), from 205 TBtu in 2009 (Table A-12) to 337 TBtu in 2010 (Table A-11). Summing domestic + international bunkers, the inventory shows an increase of 18-percent, from (205 + 605 = 810 Tbtu) to (337 + 620 = 957 TBtu) in 2010 (Table A-11, A-12, and A-33). The Energy Chapter Table 1-12 provides summary information.

*The EIA's adjusted fuel oil and kerosene sales show vessel bunkering of 5.46 billion gallons (821 TBtu, assuming 6.317 *10^6 Btu/bbl) in 2009, rising to 5.93 billion gallons (891 TBtu), an increase of only 8 percent. The unadjusted EIA fuel and kerosene sales data shows a 7.5-percent decline between 2009 and 2010. The EIA data should be the source of (or at least consistent with) the sum of domestic + international bunkers.*

http://www.eia.gov/dnav/pet/pet_cons_821rsda_dcu_nus_a.htm

We would recommend re-checking the source data and its conversion into energy units.