Close to final

Lee-Ashley, Matt to: vhines, mcnutt 06/01/2010 07:46 PM

Cc: Julie_Rodriguez

History: This message has been replied to.

Dr. McNutt,

Per our conversation, I've highlighted the slightly different sentence structure in the first paragraph of the report. I have also attached a couple proposed edits to your edits to the modified press release.

Let me know if you are ok with these and I will work them through the process.

Thanks,

Matt 06-30-10 FRTG_updated_mla.doc Summary_Preliminary_Report_from_the_FR[illegible]_FIN[illegible].doc

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Updated: This version is updated to clarify that the preliminary best estimate is based on an overlap among three methodologies and that the plume modeling team's estimate is a lower bound estimate, as Dr. McNutt accurately reported in her press announcement on May 27, 2010.

Flow Rate Group Provides Preliminary Best Estimate Of Oil Flowing from BP Oil Well

USGS Director Dr. Marcia McNutt today announced that the National Incident Command's Flow Rate Technical Group (FRTG) has developed an independent, preliminary estimate of the amount of oil flowing from BP's leaking oil well.

In making the announcement, Dr. McNutt, who is the chair of the FRTG, established by Admiral Thad Allen, the National Incident Commander, emphasized that since day one, the Administration's deployments of resources and tactics in response to the BP oil spill have been based on a worst-case, catastrophic scenario, and have not been constrained by flow rate estimates.

~~Based on three separate methodologies, outlined below, the independent analysis of the Flow Rate Technical Group has determined that the overall best initial estimate for the lower and upper boundaries of~~~~All t~~The three methodologies considered by the FRTG are consistent with a preliminary best estimate of a flow rate~~s~~ of oil in the range from~~in the range of~~ 12,000 to~~and~~ 19,000 barrels per day. Higher flow rates are consistent with the data considered by one of the teams.

The FRTG used three separate methodologies to calculate their initial estimate, which they deemed the most scientifically-sound approach, because measurement of the flow of oil is extremely challenging, given the environmentally unique nature of the flow, limited visibility, and lack of human access to BP's leaking oil well.

Mass Balance Team

The first approach led by the Mass Balance Team analyzed how much oil is on the surface of the Gulf of Mexico. The Mass Balance team developed a range of values using USGS and NOAA analysis of data that was collected from NASA's Airborne Visible InfraRed Imaging Spectrometer (AVIRIS), an advanced imaging tool. USGS has previously used the AVIRIS tool to discover water on the moon. This is the first time it has been used to measure the volume of an oil spill.

Based on observations on May 17th, and accounting for thin oil not sensed by the AVIRIS sensor, the FRTG estimated that between 130,000 and 270,000 barrels of oil are on the surface of the Gulf of Mexico. It is important to note that the FRTG also estimated that a similar volume of oil to the amount AVIRIS found on the surface has already been burned, skimmed or dispersed by responders or has evaporated naturally as of May 17th.

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Given the amount of oil observed and the adjusted calculations for the amount of oil that has been burned, skimmed, dispersed, or evaporated the initial estimate from the Mass Balance Team is in the range of 12,000 to 19,000 barrels of oil per day.

This methodology carried several challenges, including the fact that the AVIRIS plane can only fly over a portion of the spill in a day, meaning that an assumption must be made that the area imaged is representative of the entire spill region.

Plume Modeling Team

The second approach led by the Plume Modeling Team used video observations of the oil/gas mixture escaping from the kinks in the riser and at the end of the riser pipe alongside advanced image analysis to estimate fluid velocity and flow volume. Based on advanced image analysis and video observations the Plume Modeling Team has provided an initial lower bound estimate of 12,000 to 25,000 barrels of oil per day. They continue to work to provide an upper bound.

This team faced several methodological challenges, including having a limited window of data in time to choose from, getting good lighting and unobstructed views of the end of the riser, and estimating how much of that flow is oil, gas, hydrates, and water.

Riser Insertion Tube Tool Estimate

Both estimates from the Mass Balance Team and the Plume Modeling Team were reality-checked with a basic calculation of the lower limit of possible oil that is spilling. The lower limit was calculated based on the amount of oil collected by the Riser Insertion Tube Tool (RITT), plus the estimate of how much oil is escaping the RITT, and how much oil is leaking from the kink in the riser.

On May 25, 2010, at approximately 17:[illegible]0 CDT, the RITT logged oil collection at a rate of 8,000 barrels of oil per day, as measured by a meter whose calibration was verified by a third-party. Based on observations of the riser, the team estimated that at least 10% of the flow was not being captured by the riser at the time oil collection was logged, increasing the estimate of total flow to 8,800 barrels of oil per day. Factoring in the flow from the kink in the riser, the RITTI Team calculated that the lower bound estimate of the total oil flow is at least 11,000 barrels of oil per day, depending on whether the flow through the kink is primarily gas or oil. The lower bound estimate calculated by the RITT Team is more than twice the amount of the earlier flux estimate of 5,000 barrels of oil per day and is independent of any calculations or model assumptions made by either team above.

On-going Calculations

The preliminary estimates provided by the FRTG are based on new methodologies being employed to understand a highly dynamic and complex situation. As the FRTG collects more data and improves their scientific modeling in the coming days and weeks ahead, they will continue to refine and update their range of oil flow rate estimates, as appropriate.

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The FRTG is working diligently to ensure all estimates are peer reviewed by independent experts and academics as expeditiously as possible. They will also establish a website to ensure this information is available and reported to the public in a timely fashion.

Response

Below are the resources surged to date to mitigate the impacts of the spill:

- Approximately 1,300 vessels are responding on site, including skimmers, tugs, barges, and recovery vessels to assist in containment and cleanup efforts—in addition to dozens of aircraft, remotely operated vehicles, and multiple mobile offshore drilling units.
- More than 1.85 million feet of containment boom and 1.25 million feet of sorbent boom have been deployed to contain the spill—and approximately 300,000 feet of containment boom and 1 million feet of sorbent boom are available.
- Approximately 11 million gallons of an oil-water mix have been recovered.
- Approximately 840,000 gallons of total dispersant have been deployed—700,000 on the surface and 140,000 subsea. More than 380,000 gallons are available.
- 17 staging areas are in place and ready to protect sensitive shorelines, including: Dauphin Island, Ala., Orange Beach, Ala., Theodore, Ala., Panama City, Fla., Pensacola, Fla., Port St. Joe, Fla., St. Marks, Fla., Amelia, La., Cocodrie, La., Grand Isle, La., Shell Beach, La., Slidell, La., St. Mary, La.; Venice, La., Biloxi, Miss., Pascagoula, Miss., and Pass Christian, Miss.

Background

The Flow Rate Technical Group is composed of federal scientists, independent experts, and representatives from universities around the country. It includes representatives from USGS, NOAA, DOE, Coast Guard, MMS, the national labs, National Institute of Standards and Technology, UC Berkeley, University of Washington, University of Texas, Purdue University, and several other academic institutions. BP is not involved in the FRTG except to supply raw data for the scientists and experts to analyze.

FRTG Members from the Federal Government appointed to date include:

Marcia McNutt, Director, USGS; William Rees, Jr., Los Alamos National Lab, Department of Energy; Darren Mollot, Department of Energy; Franklin Shaffer, Department of Energy; Victor Labson, USGS; Bill Lehr, National Oceanic and Atmospheric Administration; Austin Gould, US Coast Guard; Richard Brannon, US Coast Guard; Don Maclay, Minerals Management Service (MMS); Gerald Crawford, MMS; David Absher, MMS; and Bill Courtwright, MMS.

FRTG Members from academia and independent organizations appointed to date include:

Omar Savas, Professor of Mechanical Engineering, University of California Berkeley
James Riley, Professor of Mechanical Engineering, University of Washington
Juan Lasheras, Prof. of Engineering and Applied Sciences, University of California San Diego
Poojitha Yapa, Professor of Civil and Environmental Engineering, Clarkson University
Paul Boomer, Senior Lecturer, Petroleum and Geosystems, University of Texas at Austin

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Steve Wereley, Associate Professor of Mechnical Engineering, Purdue University
Peter Cornillon, Professor of Oceanography, University of Rhode Island
Ira Leifer, Assoc. Researcher, Marine Science Institute, University of California Santa Barbara
Alberto Aliseda, Assistant Professor of Mechanical Engineering, University of Washington
Pedro Espina, National Institute of Standards and Technology.

For more information, visit www.deepwaterhorizonresponse.gov.

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Summary Preliminary Report from the Flow Rate Technical Group
Prepared by Team Leader Marcia McNutt, U.S. Geological Survey

Three independent methods considered by the FRTG place the minimum oil flow rate at greater than 12,000 barrels per day. Two of the methods determine that the flow rate could be as high as 20,000 barrels per day. The team using video to analyze the plume believes that the flow rate could be at least 12,000 to 25,000 barrels per day. Therefore, the area of overlap of all three methods ranges between **12,000 to 19,000 barrels per day**. These are all preliminary estimates.

In arriving at this preliminary range of values, the FRTG pursued entirely independent strategies, each of which yielded it own range of values. The values from the independent methods were combined to find the mostly likely flow rate for the well from the intersection of different methods. The Plume Team pursued the approach of observing video of the oil/gas mixture escaping from the kinks in the riser and the end of the riser pipe, using particle image velocimetry analysis to estimate fluid velocity and flow volume. The Mass Balance Team used remote sensing data from deployment of the Airborne Visible InfraRed Imaging Spectrometer (AVIRIS) and satellite to calculate the amount of oil on the ocean surface on a certain day. The team then corrected the value for oil evaporated, skimmed, burned, and dispersed up to that day and divided by time to produce an average rate. Each method has its own limitations and biases as described below.

Mass Balance: 12,000 to 19,000 barrels per day

The mass balance team used data from the AVIRIS airborne sensor flown over the Gulf of Mexico on May 17, 2010. The sensor can map both the aerial extent and thickness of oil by observing changes in reflectance that occur in the near infrared because of absorption is less in that waveband. AVIRIS can only observe a portion of the total spill area in one day and there is some uncertainty in estimating what proportion of the total spill area is represented in the scene that is imaged. On May 17, the mass balance team calculates that they observed 15% of the total spill, and assumes that the portion they observed is representative of the total spill. An adjustment is made for additional dull oil and sheen that coat the surface in fairly uniform layers too thin to be sensed by AVIRIS but from other sensors have been shown to persist in known ratios to the area of the thick oil (88:10:2 for sheen to dull oil to thick oil). On May 17, the amount of thick oil was 70,000 to 150,000 barrels. Bounds on the contribution of sheen and dull oil that need to be added to those totals are 60,000 to 120,000 barrels depending on reasonable thicknesses chosen for sheen and dull oil. Therefore, lower and upper bounds on the oil spill on May 17 are between 130,000 and 270,000 barrels of oil. This is the amount of oil that poses the largest threat to the coastal environment, and a large proportion of the oil released after this date was either disperser subsea or collected with the riser insertion tube tool (RITT).

Corrections are then made for the amount of oil that was evaporated, skimmed, burned, and dispersed either subsea or on the sea surface. These corrections nearly double the total amount of oil as of May 17th. The total oil is then divided by the number of days to get an average rate. This method is not without its biases that might not be captured by formal uncertainty bounds as well. For example, all of the corrections made to the surface oil were to add in losses of oil to the system. To the extent that there are other unknown processes that remove oil naturally from the system that are unaccounted for, there may be "unknown unknowns" in this analysis as well. Therefore, further scientific investigation could push these estimates higher. For example, a correction was made for anthropogenic dispersion of oil subsea (assuming that none of it arrived at the surface), but current expeditions underway may

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determine that there is more oil in the subsurface than can be accounted for from surface and subsea dispersion. Note that while the plume team's analysis yields an "instantaneous" rate for flow of the well at that time that the video was taken, the calculation based on mass balance is an average rate for the first 27 days of the spill, assuming that the 5 days that sea-bottom dispersants were being applied did not contribute to the observable spill.

Plume Modeling: at least 12,000 to 25,000 barrels per day (range of lower bounds)

The plume modeling team observed video from both the end of the riser where the majority of the flow is escaping and from the kink in the riser where a smaller amount exits through small slits in the top of the riser. The main method employed to make their estimates was through a common fluid dynamic technique called particle image velocimetry (PIV). While difficult in practice, it is simple in principle. In this method a flow event, e.g. an eddy or other identifiable item, is observed at two consecutive video frames. Distance moved per time between frames gives a velocity, after adjustment for viewing angle and other factors. Repeated measurement over time and space give an estimated mean flow. Flow multiplied by cross-section area of the plume gives a volume flux.

The challenges this team faced in getting reliable results were many. First, they only had a limited window of data in time to choose from. They had to select data from before the RITT was inserted into the riser as that tool captured a variable amount of flow. They needed a time window when application of subsea dispersant was not perturbing the flow. They required footage from after the period when a trench was excavated at the end of the riser to better expose the end of the plume. Most challenging was getting good lighting and unobstructed views of the plumes from work-class ROV's not intended to capture research-quality footage and occupied doing other tasks at the time.

Second, perfecting the methodology for predicting multiphase flow (oil, water, gas, hydrate in poorly known ratios) under very high pressure is worthy of a research effort. This is not a turn-key project, and yet the team did not have the luxury of time to try many alternative approaches or calibrate methods with deep-sea tests using known fluxes of fluids in prescribed ratios. A key parameter was the average ratio of gas to liquid. This was seen to vary over the time period of the spill. Increasing gas increased the velocity of the plume but decreased the mass flow. Lacking independent estimates, the group took the average values provided by BP at face value. Analysis of the available short movies of the raiser flow shows the existence periods when the flow oscillates from pure gas to seemingly pure oil. This appears to be an indication of Slug Flow Regime. These periods of gas-oil flow fluctuation are in the range of minutes but could also be in the range of hours or even as long as days. In order to properly determine the effect of the intermittency of the gas/oil composition in the total estimate of the oil discharged from the riser leak, the analysis should be extended to long video records spanning several days.

Not all of the experts engaged in PIV analysis. Some simply reviewed the work of those that did, while still others provided additional verification by checking the PIV answers with their calculations using other techniques. Given the challenges in applying the methods in to this particular problem, team members concluded that formal statistical error bounds on upper and lower limits on flow volume derived from a rigorous estimation of the uncertainty in model parameters would fail to capture all possible sources of error in this approach to recovering the true flow rate. It would only account for the known unknowns, but not the unknown unknowns that might be revealed if one could actually calibrate these methods against a known flow rate given the complex multiphase and flow behaviors at high pressure. The experts concluded that the effect of the unknown unknowns made it more difficult to

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produce a reliable upper bound on the flow rate. Therefore, they chose to simply produce a range of lower bounds from their independent analyses, all of which they thought were defendable. A formal error analysis by one member of the plume team estimated that the uncertainty in any one estimate (e.g., from the "known unknowns") would be ±40%.

Reality Check: at least 11,000 barrels per day

To these independent estimates, a lower bound on the flow rate can be provided as a reality check by observing the behavior of the plume as a function of how much oil can be pulled up the RITT (Riser Insertion Tube Tool) from the leaking riser. On May 25, 2010, at approximately 1630 CDT, the RITT was yielding oil at the rate of 8000 barrels per day. The flow meter on the *Enterprise* vessel has been independently calibrated by a third party and thus this value is deemed reliable. We can revise that lower bound upwards by noting that a trickle of oil was still escaping out the end of the riser. If we assume that flow represents 15% of the original flow, then the lower bound on the flow rate rises to about 9000 barrels per day. At the same time, flow was moving through holes near the kink in the riser. It is difficult to estimate the proportion of oil versus gas escaping from the slits in the riser at this position. If the slits in the kink represent 1/6th of the flow, a lower threshold on the flow from observing changes in flow after insertion of the RITT is about 11,000 barrels per day of oil. Note that this lower bound alone is more than twice the earlier flux estimate of 5000 barrels per day. We consider this lower bound close enough to the 12,000 barrels per day determined from the other two methods to be consistent with those lowest low bounds.

FRTG Members from the Federal Government appointed to date include:
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Paul Boomer, Senior Lecturer, Petroleum and Geosystems, University of Texas at Austin
Steve Wereley, Associate Professor of Mechnical Engineering, Purdue University
Ira Leifer, Assoc. Researcher, Marine Science Institute, University of California Santa Barbara
Alberto Aliseda, Assistant Professor of Mechanical Engineering, University of Washington
Pedro Espina, National Institute of Standards and Technology.

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