FROM THE PODIUM

BP'S MACONDO BLOWOUT

NONFICTION
BY

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A Note from the Author

This document is intended for use by those in the O&G industry; students and faculty of petroleum engineering; and all other interested, involved, and consequential parties who want or need to know about the CAUSE of BP's 2010 Macondo blowout in the Gulf of Mexico.

I offer this document free to all comers . . . with a few caveats:

(1) PLEASE apply the lessons learned herein throughout the rest of your career, to every problem, every project, and every well, onshore, offshore, around the world;

(2) PLEASE encourage each of your business colleagues, social connections, and fellow alums without limit, to *go to my website* (**JohnTurleyWriter.com**) and download his or her own free copy of this presentation, and remind them to encourage others to do the same; and

(3) PLEASE read the facts-based book: *THE SIMPLE TRUTH: BP's Macondo Blowout*, whether you borrow it from a workmate, get it from your library, or purchase it through Amazon.

After you've absorbed this document, and after you've read the book and shared it others, and perhaps after you've seen the movie *Deepwater Horizon* (the debut was 30 September 2016), I look forward to hearing from you.

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This is a work of nonfiction based on a true incident—BP's 2010 Macondo blowout aboard Transocean's *Deepwater Horizon* and the resulting oil spill in the Gulf of Mexico. Data used throughout has been extracted from the author's data-driven book *THE SIMPLE TRUTH: BP's Macondo Blowout* (2012). Public data about companies, equipment, the well, and the rig, though modified by the author for ease of reading, form the basis for the work. Opinions and errata are the author's.

For Jan

Forever My Love,

my best friend,

and still my CFOOE

ACKNOWLEDGEMENTS

I researched for two years and published *THE SIMPLE TRUTH: BP's Macondo Blowout* in September 2012. My first industry speaking engagement was to Murphy Exploration & Production Company in Houston, so my thanks go to Dave B. Perkins, who had read my book and extended the invitation. With that door open and other podiums waiting, my Macondo presentation took me around the world.

My sincere thanks to each entity and host who welcomed my message, including: a number of SPE (Society of Petroleum Engineers) sections across the U.S., Colorado School of Mines, Marietta College, Murphy ExP, Marathon Oil Company, SPE Houston, the Evangeline (Lafayette, Louisiana) Sierra Club, University of Louisiana at Lafayette, Louisiana State University, NETL/DOE, Chevron, Offshore Process Safety Conference, SPE Dallas, University of Oklahoma, Tulsa University, SPE Mid-continent, LAGCOE, Tulsa NPR, Pennsylvania State University, West Virginia University, Southern Ohio Oil Man's Association, IADC/SPE Dallas, Lafayette Geological Society, American Association of Drilling Engineers, Montana Tech University, University of Leoben Austria, Decom World, SPE in Amsterdam, and Encana Services Company.

After almost fifty such presentations, I was invited to be an SPE Distinguished Lecturer (DL) for 2015-16 and to make my presentation (same topic) to SPE sections on a global basis. I am especially grateful to those thirty SPE sections and their volunteer leaders who hosted me during my travels to St. John's Newfoundland, Boston Massachusetts, Washington DC, Canton Ohio, Lansing & Traverse City Michigan, Tyler Texas, Houston Texas, Hobbs New Mexico, Texas A&M University, SPE Denver, Bahrain, Abu Dhabi UAE, Dubai UAE, London England, Aberdeen Scotland, Great Yarmouth England, Madrid Spain, Lloydminster Canada, San Ramon California, Bartlesville Oklahoma, Duncan Oklahoma, Lafayette Louisiana, Tuscaloosa Alabama, Perth Australia, Adelaide Australia, Melbourne Australia, New Plymouth New Zealand, Sydney Australia, and finally to Brisbane, Australia where I finished my SPE-DL tour on 19 May 2016.

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FROM THE PODIUM

BP's Macondo Blowout

J. A. (John) Turley

On April 20, 2010, the major energy company BP was blasted into the headlines by a disastrous blowout in the Gulf of Mexico aboard a deep-water drilling rig named *Deepwater Horizon.*

At the time, I had retired from my engineering and management career in oil and gas and started a new venture—writing fiction. My learning curve was steep, but I won a couple of contests and finished four novels. In the middle of drafting my fifth book, I heard about the catastrophe in the Gulf, the thought of which threatened to consume me. I immediately quit writing and answered the call.

Why? Because that tragic event led to what I've now long described as *one of the most lethal, costly, manmade environmental disasters in history*, which will forever be known in the industry as **BP's Macondo Blowout**. But because the blowout took place aboard Transocean's *Deepwater Horizon* drilling rig, the media have sold the disaster to the public as **BP's *Deepwater Horizon* Blowout**. In fact, the 2016 Hollywood film about the tragedy is named, simply: ***Deepwater Horizon***.

By definition, a *blowout* is the loss of control of a drilled well, wherein naturally occurring formation fluids—oil, gas, water—flow into the wellbore and to the surface without control. Further, *Macondo* is BP's chosen nickname for the deep geologic structure targeted by the exploration well; hence, the "Macondo well," and later "BP's Macondo blowout."

As a result of BP's Macondo blowout, eleven good men lost their lives. The half-billion-dollar *Deepwater Horizon* burned, capsized, and sank in the mile-deep Gulf. An estimated five million barrels (200 million gallons) of crude oil spilled into the Gulf during a media feeding-frenzy that lasted 86 days. The cleanup operation, using a toxic dispersant, hid the floating crude oil but put the Gulf in jeopardy for years to come. Costs skyrocketed, eclipsing $60 billion—pushed by failed businesses, open-ocean cleanup, coastline and estuary rejuvenation, and litigious fines and penalties that do not yet include the results of ongoing civil trials.

So, where do I, John Turley, fit in? Offshore operations, and drilling operations in general, occupied much of my professional career. In retirement, I was the neighborhood "oil guy," which led family and friends—inundated by TV and Internet news—to ask, "John, what the hell happened to that rig in the Gulf?"

My inability to answer that single question led me to give up writing and start digging. I returned to the world of research and gathered publicly available data wherever I could find it. I scouted thousands of pages of USCG depositions, investigative reports, engineering procedures, published studies, court transcripts. The more I looked for and found hard data, the more hooked I became at filling in the blanks, completing the puzzle, as to what caused the blowout.

During the interim, as the media continued to saturate the listening/watching/reading world with the best information they'd gleaned from pontificating experts often with vested interests, I made a two-part decision.

First, I committed myself to ignore finger pointing, politics, he-said-she-said, oily beaches, opinions, media headlines, court findings, company cultures, journalists, attorneys, and—albeit with great difficulty—the people involved, whether victims, survivors, or involved leaders.

Second, I would focus on only one thing—hard data. Specifically, I would gather available engineering and operating data from the rig, from the well, from the entities involved. The data would tell me the story I needed to know. The kind of story engineers can put to good use when working to help minimize the chance of ever losing control of another well.

My mantra, while gathering data and since, has been and remains: *Only if we understand and care about the cause of the Macondo blowout, will we know why it should not have happened and why it should never happen again*.

The data I unearthed was compelling, but I knew it would mean little to those friends and family who still wanted to know "what happened to that rig in the Gulf?" To answer their question, I let the hard data define a chronologically accurate skeletal framework, which allowed me to write a book—*THE SIMPLE TRUTH: BP's Macondo Blowout.*

A key element of my writing goal was to include and use all the data I'd gathered, so as to explain the technical cause of the disaster for readers across the entire oil-and-gas arena, but in a way, for example, my long-deceased, non-engineering, non-oil-and-gas father might have appreciated.

For that reason, and because 11 key personnel from the rig perished that dreadful night and could not speak for themselves, I wrote the book as fiction. The result is a data-driven novel, with made-up characters as surrogates for those who survived and those who died.

More than a hundred literary agents turned down my query letters and manuscript submissions. Many didn't respond, perhaps because they didn't like my writing. A number of others turned me down using reasons like "untold litigious liability." Seems they wanted nothing to do with the risk of an unknown author telling *THE SIMPLE TRUTH* about a major disaster.

So, I self-published *THE SIMPLE TRUTH* in September 2012. I worked with Amazon to publish paperback and Kindle versions.

To date, sales are nice, comments are positive, and I'm in the black, but it's also important for me to look back to when an industry leader read my book and called me in late 2012. As an executive for a major energy company, he invited me to attend a corporate HES (health, environment, and safety) conference to present the results of my research findings. I accepted and was pleased to make a true contribution to the industry from which I had retired.

And so began my third career . . . as a professional speaker . . . about Macondo.

Variously, as invited guest, panelist, lecturer, and keynote speaker, I made almost fifty presentations about BP's Macondo blowout across the U.S. and international to energy companies, professional societies, technical conferences, petroleum engineering universities, environmentalists, and civic groups. Then my own professional society (SPE—the Society of Petroleum Engineers) named me to be a Distinguished Lecturer (DL), wherein they would pay my way to make my Macondo presentation to SPE sections around the world.

My SPE-DL talk carried the name: "Assessing and Applying Petroleum Engineering Data from the 2010 Macondo Blowout." In that role, I made another thirty presentations to SPE members across the U.S., and in Canada, the United Arab Emirates, and Bahrain, and in England, Scotland, Spain, Australia, and New Zealand.

My last presentation, my 75th, was in Brisbane, Australia, on 19 May 2016. With that presentation, I declared an end to my 73-month, passion-driven, self-imposed Macondo mission.

Yet, it won't be a clean break, because at virtually every technical presentation somebody asked for a copy of my slides. I always apologized before I turned them down . . . because I had an obligation to make my slides available to SPE, wherein SPE would publish the slides on their website. I have fulfilled that obligation, so SPE members can now go to the SPE-DL site and see the slides.

BUT . . . those slides contain not one word of the text included herein; hence, this document—slides plus text plus Q&A—which I choose to call: *FROM THE PODIUM: BP's Macondo Blowout*, is the only complete resource.

PRESENTATION FORMAT

This publication is not just slides. I call it *FROM THE PODIUM: BP's Macondo Blowout.* It includes my slides as well as a complete written *composite* text from my 75 presentations, from late 2012 through my 2015-16 SPE-DL road trip.

The text for my PRESENTATION mimics my words as I made my way from one location to the next. Suffice it to say, because I made each presentation without notes, a given audience scheduled to listen for only 45 minutes likely got only two-thirds of what follows. Less time, lower percentage. Audience members available for an hour and who participated in extensive Q&A, often got very close to hearing the full story, as told here. Some Q&A sessions garnered a question or two; others, an hour or two. Accordingly, I have included herein a shortcut path to Q&A by answering typical questions about key slides as I recall them.

All the above means that this written text is more comprehensive than any single audience had time for, yet there are a number of topics in *THE SIMPLE TRUTH* that are not covered here. In general, if the topic was not *germane* to understanding the physical CAUSE of the blowout (this presentation), I've left it for others to debate. You will find a short list of such topics in **Q&A-5**.

In writing this text, I realize just how many words can be saved in front of an audience with the judicial use of a brilliant-red laser pointer. No pointer, more words. Hence, some of the text you'll see is just choreography to get you to look at the right slide or arrow.

My slides and their format evolved over time, with the core group plucked directly from *THE SIMPLE TRUTH*. But after four dozen presentations, SPE named me to be a Distinguished Lecturer (DL) and invited me to modify my slide format to match the SPE-DL criteria. For convenience, I've kept the SPE-DL slide format (seen in Slides 1 and 2) for this written presentation, which follows.

As stated early on, this document is intended for those in the O&G industry (including all members of SPE) who want and need to know about the CAUSE of BP's 2010 Macondo blowout in the Gulf of Mexico. Nevertheless, and for the record, the following is not an SPE presentation, nor is it presented here as an SPE document.

SPEAKER INTRODUCTION

For my presentations, I've had succinct, professional introductions, as well as the worst of the worst: "I'll let Mr. Turley introduce himself."

A proper introduction is intended to establish speaker credibility for the audience, and, in this case, for those reading this paper.

Hence, the following is a typical engineering-audience introduction.

* * *

John Turley taught petroleum engineering at Marietta College in the U.S. before joining Marathon Oil Company, where he served as Gulf Coast drilling manager, U.K. operations manager, manager of worldwide drilling, and vice president engineering & technology. He holds a professional degree in petroleum engineering from Colorado School of Mines, a Master of Science degree in ocean engineering from University of Miami, and an executive management degree from Harvard.

After he retired, John independently researched the 2010 Macondo blowout and published *THE SIMPLE TRUTH*—a facts-based book in which he examines the engineering causes of BP's Macondo blowout aboard the *Deepwater Horizon*. He has spoken on the topic to numerous technical, academic, and industry audiences across the U.S. and Canada, and in Europe and the Middle East.

As you may know, Mr. Turley is also a 2015-16 SPE Distinguished Lecturer, with 30 presentations around the world. He tells me that with today's presentation here in Brisbane, Australia, he will have completed his Distinguished Lecturer responsibilities. After which he says he's going to retire . . . again.

It is my pleasure to introduce . . .

* * *

After such an introduction, I shake hands with the emcee, go to the podium, and pick up the mic. I use no notes. Slide 1 is already on the screen.

My Presentation follows.

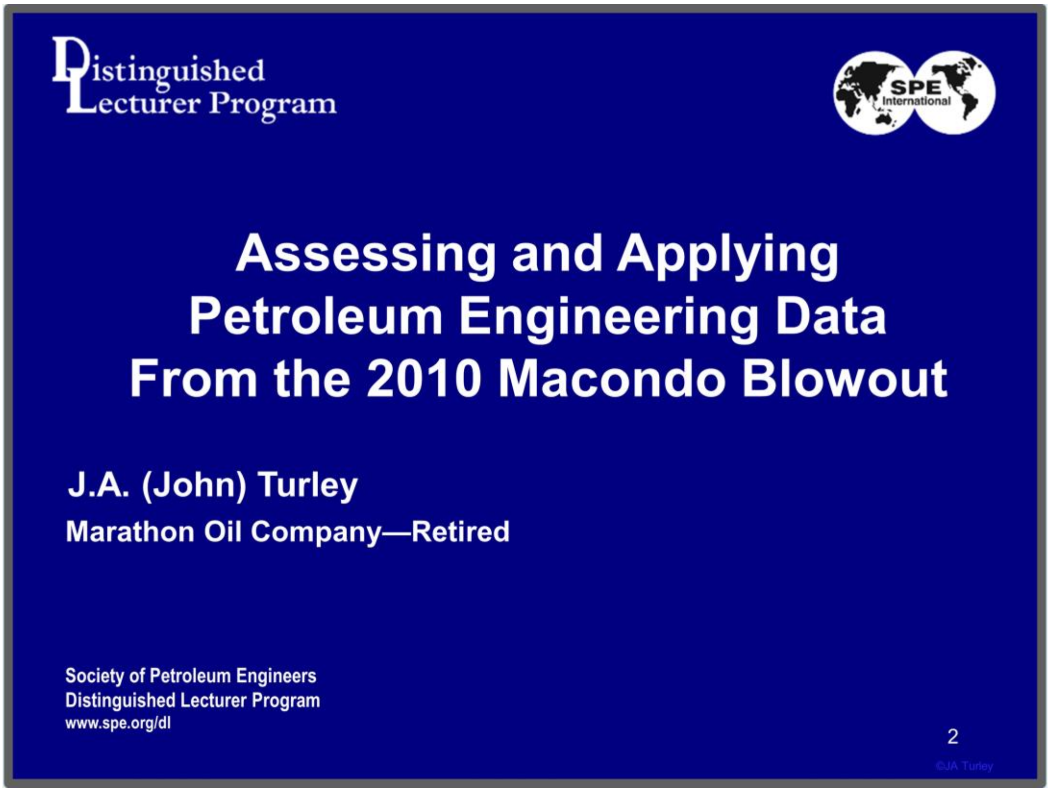
Slide 1

PRESENTATION

Please allow me to start with a word from our sponsor. The SPE Distinguished Lecturer (DL) Program is funded by energy-industry and society donors. Those funds and the DL program pay my travel expenses to take me around the world. And I'm here today because your SPE section voted to put me on your DL program, and for that I thank you.

If you are here today based on your job, your company, your education, your interests (which I fully applaud), but you are not a member of SPE, please check the website (**http://www.spe.org/join/**) for eligibility requirements and join if possible. I've been a member for more than fifty years (allowing me to be a member of SPE's "Legion of Honor"), and the organization has been my go-to source for technology and people issues throughout my career. I'm confident that if you join, SPE will be a positive boost to you and your career.

(I push a button . . . next slide)



Slide 2

Assessing and *Applying* are key words in my presentation.

Our goal will be to trace and understand the failure mechanisms that led to and caused the Macondo blowout, so we can apply what we learn to future wells. We're going to do this by looking at data, all data, from a petroleum engineering perspective.

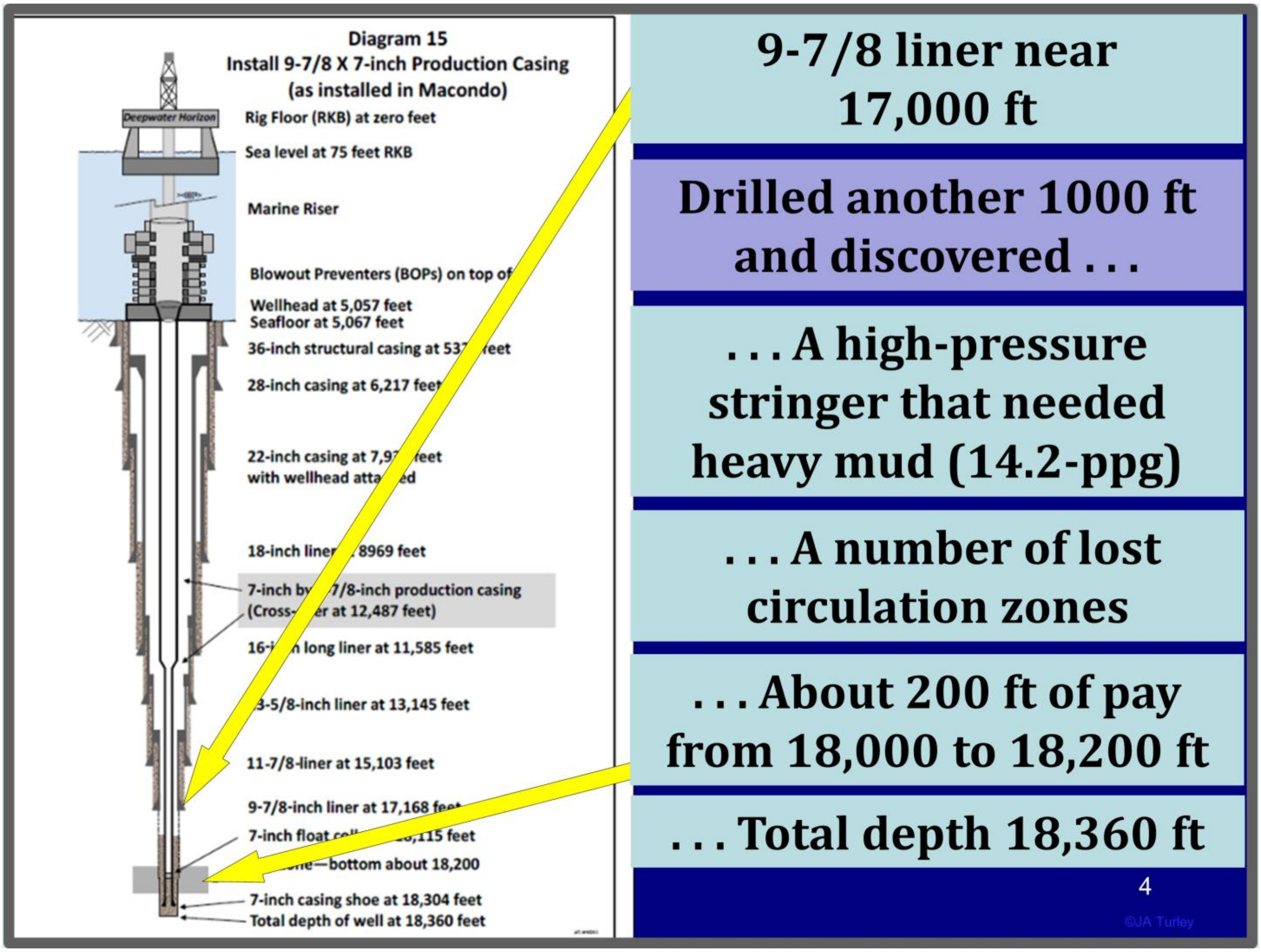
Let's begin by looking at the Macondo well prior to the blowout.

Slide 3

In late 2009, the operator spudded its 20,000-foot exploration well in a mile of water, utilizing an anchored rig named Marianas. That rig was ultimately damaged by a hurricane and replaced by the *Deepwater Horizon* in 2010.

The geologic target was a deep structure (nicknamed *Macondo)* below about 17,000 feet. The nickname allowed for private discussions in public places, without identifying the well. But it also meant the well became the *Macondo* well, and the ultimate disaster became the *Macondo* blowout.

So . . . let's jump deep into the well, to about 17,000 feet.



Slide 4

Note: During my slide-show presentations, I tell audiences that the tiny words in the diagrams (on the left, above, noted as Diagram 15,) are from *THE SIMPLE TRUTH* and are not important to the message. But . . . the big words on the right side do matter. Readers are invited to review all diagrams from *THE SIMPLE TRUTH* at the end of this work (including a full-size copy of Diagram 15 on Page 93).

* * *

Slide 4 shows the floating rig (*Deepwater Horizon*) and the well. The rig, using GPS and thrusters to stay on location, is considered a *vessel underway*; hence, it has a captain and is regulated by the U.S. Coast Guard (USCG). And that's why the USCG led the original post-blowout depositions of survivors and personnel related to the Macondo well and the blowout.

A side note of interest. Since the *Deepwater Horizon* was a powered vessel, like a ship, its name, in print, is always in italics. Conversely, the Marianas, an anchored rig, is not considered a powered vessel at sea, therefore its name is not italicized.

Now, back to **Slide 4**.

The floating rig is connected to the Macondo well by a 21-inch-diameter drilling riser (capacity about 1600 barrels). The riser is connected to the blowout preventers (BOPs), which are firmly connected to the wellhead, and in turn to the structural casing strings that penetrate the seafloor.

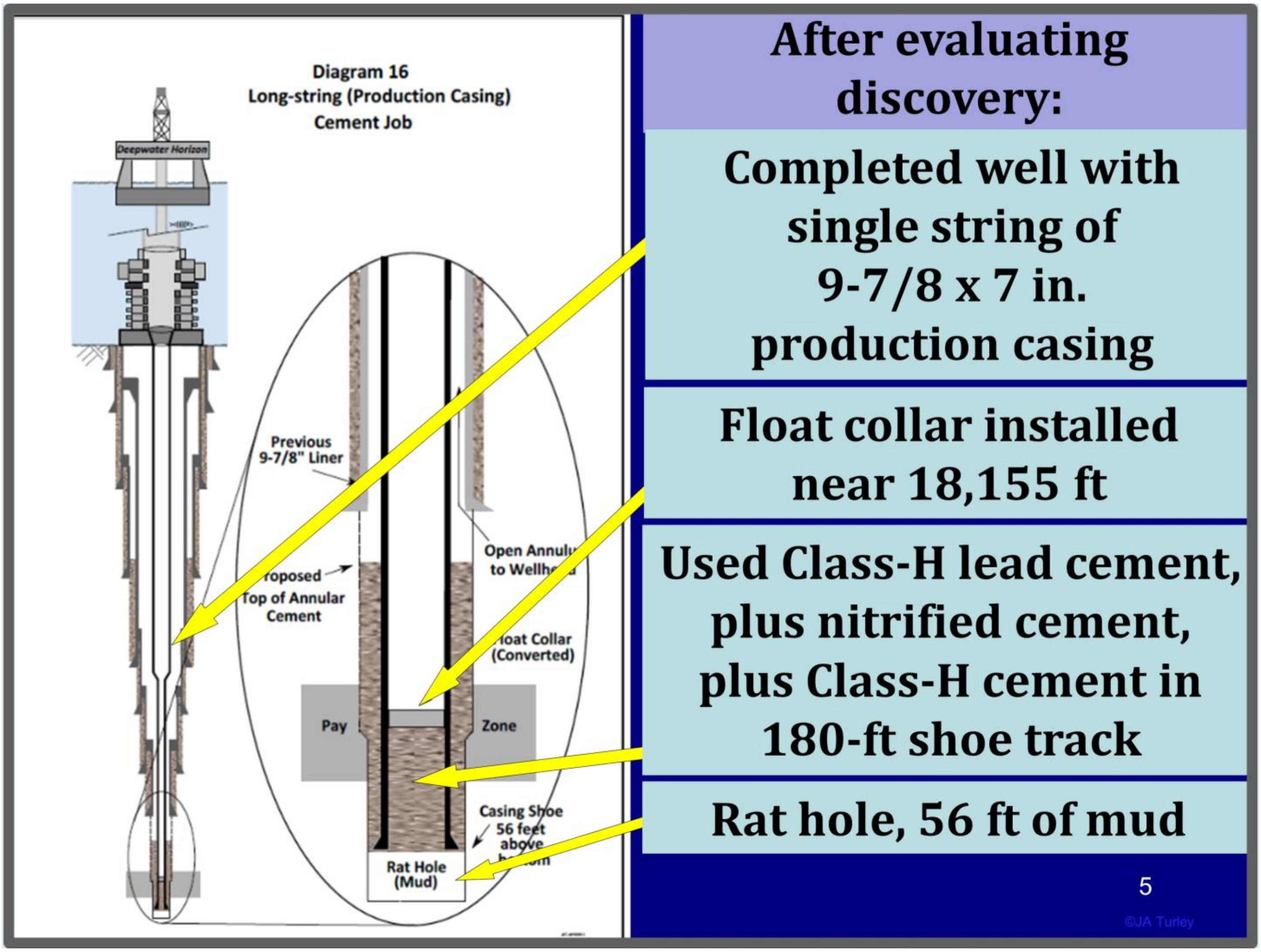
The 15,000-psi BOP stack, solidly fixed to the wellhead, is topped by two 10,000-psi annular BOPs (though one was de-rated to 5,000 psi to accommodate stripping 6-5/8-inch drillpipe). Below the annular BOPs are three VBRs (variable-bore rams), a blind-shear ram, and a casing shear ram. The lower VBR was inverted to act as a test ram.

As drilling progressed, using synthetic-oil-base mud, multiple strings of casing were run to just below 17,000 feet (see **Slide 4**, the upper big yellow arrow). After drilling out and testing the 9-7/8-inch shoe to 16.0 ppg (pounds per gallon), the operator then took a few days to drill the next thousand feet of wellbore, with several interesting findings.

Early on, a ten-foot stringer required 14.2-ppg mud. The operator would have liked the drill-ahead mud weight to be a bit heavier, but persistent lost-circulation zones below the stringer were sensitive to increased mud weights and required massive doses of lost-circulation material (LCM) for ultimate control.

And then good news: a 200-foot-thick oil-and-gas discovery zone (see **Slide 4**, the lower yellow arrow), which proved to be 1,000 psi underbalanced compared to the 14.2-ppg mud column.

With the 10-foot zone under control, the lost circulation zones plugged, and the pay zone dead, the operator drilled an additional 160 feet of wellbore below the pay to look for additional hydrocarbons, and to ensure adequate footage of wellbore below the pay for well-logging and casing operations.



Slide 5

After extensive well-logging and formation-testing activities, the operator made a bit trip to bottom and then ran a single string of 9-7/8 X 7-inch production casing (see top arrow in **Slide 5**). The operator used a 5,000-foot-long workstring to get the top of casing down to the wellhead, where the casing was hung with a casing hanger. (For scaled-up version of Diagram 16, from *THE SIMPLE TRUTH*, see Page 94)

The casing was landed 56 feet off bottom, for good reason. Specifically, in deep-water operations, the casing hanger, located on top of the casing, must reach and seat inside the casing head, at the seafloor, *before* the bottom of the casing reaches the bottom of the well. The opposite would be disastrous . . . requiring the too-long casing string to be pulled from the well and sent back to town for the connections to be redressed. For a million-dollar-a-day operation, that not a good scenario.

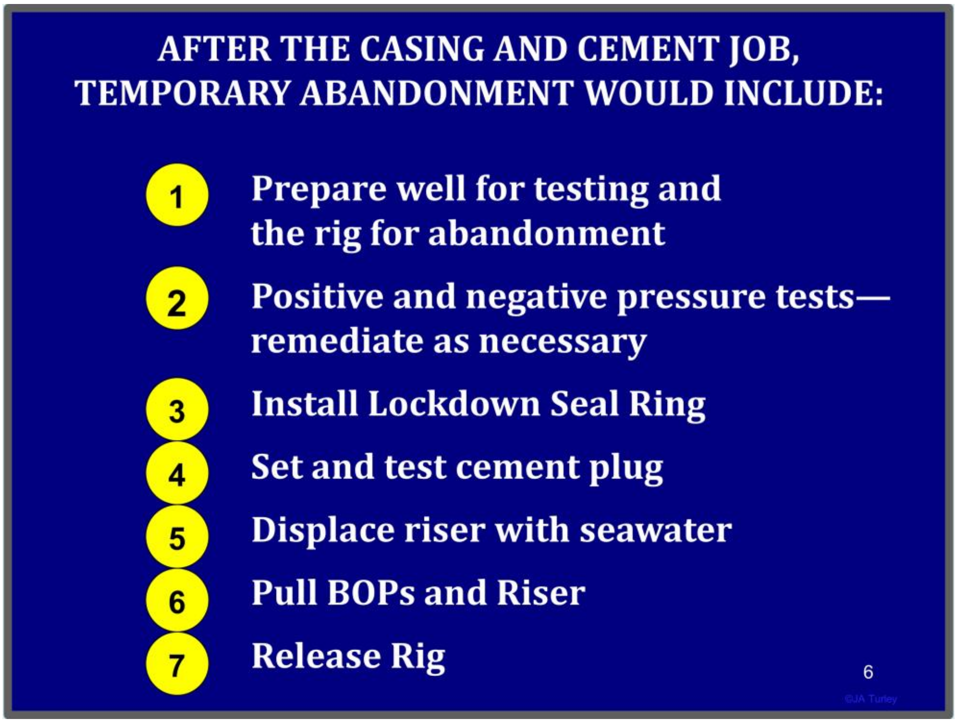
The 56 feet of non-cased wellbore below the casing (see lowermost arrow) is called *rat hole* and will be important to the rest of this discussion.

A twin-flapper Float Collar (see second yellow arrow) had been installed in the Macondo production casing string, just below the middle of the pay zone. The flappers in the float collar for would act as one-way check valves. Once they were closed, flow *up the casing* would not have been possible.

But there's a catch. The casing is run with the flappers blocked open, so that, as the casing is lowered into the wellbore, mud fills the casing from the bottom up. Then, when ready, i.e., while circulating bottoms up or while displacing the cement, the open flappers are "converted" into high-pressure check valves. We initiate *conversion*, by increasing the fluid flow through the float collar to a predetermined rate (barrels of mud per minute). The flappers must be *converted* to turn them into check valves.

Two kinds of cement were used for the production casing. The lead slurry was 16.7-ppg Class H, which was followed by lightweight nitrified cement, and finally by additional 16.7-ppg Class H as the tail slurry. The combined slurries in the annulus were designed to ensure the cement column did not exceed 14.2 ppg, because of the lost-circulation zones. The Class-H tail slurry filled the lowermost annulus and the bottom 180 feet of casing, called the shoe track. This section of casing is between the float collar and the guide shoe (see third yellow arrow).

So . . . we've made and evaluated a discovery, cased and cemented the wellbore, and we're ready for what's next . . . *temporary abandonment*.



Slide 6

Wait! What's this about *temporary abandonment*?

Here I tell audiences . . . Producing hydrocarbons from a deep-offshore well is radically different than producing from shallow-water and onshore wells, either of which can be produced in weeks or months after drilling is complete. Conversely, in deep water, where developments demand huge investments and careful planning, we have a lot of work to do after the discovery.

We'd start by drilling delineation wells to better define reservoir geometry and the size of its reserves. Then we'd turn over all the data to a subsea development team to design the seafloor production facilities, pipelines, and receiving stations necessary to accommodate production of crude oil and natural gas. Hence, years go by from the time a deep-water exploration discovery is made, until the field produces hydrocarbons.

Which means, as noted in **Slide 6**, we need to secure the cased-and-cemented Macondo well, so we can release the rig—scheduled for *tomorrow*—and send it to its next contracted location.

The next location for the *Deepwater Horizon* was to be a previously drilled well that required water-based mud. Macondo's mud was synthetic-oil-based mud. Therefore, a planned activity for *preparing the rig for temporary abandonment* included getting rid of several thousand barrels of oil-base mud from the pits and from the riser, and pumping it to a workboat for onshore disposal. That exercise also included getting rid of several hundred barrels of leftover, 16-ppg, water-base, lost-circulation materials (LCM). Getting rid of the mud and LCM was done simultaneous to other Macondo temporary-abandonment operations.

Two important pressure tests were designed to ensure, prior to releasing the rig, there were no leaks in the wellbore. A 2,700-psi *positive-pressure test* (from the BOPs down to the top of the float collar) successfully proved there was no leak from inside the casing to outside the casing.

Then, a *negative-pressure test* successfully showed that, with reduced hydrostatic pressure in the wellbore, there was no leak from outside the casing to inside the casing.

The Lockdown Seal Ring (LDSR) is a device designed in conjunction with the casing hanger and casing head. The LDSR would be attached to a 5,000-foot-long drillpipe workstring, and lowered through the riser to the casing hanger, below which the casing was attached. The LDSR locks and seals the casing hanger in place, forever preventing uplift and leaks.

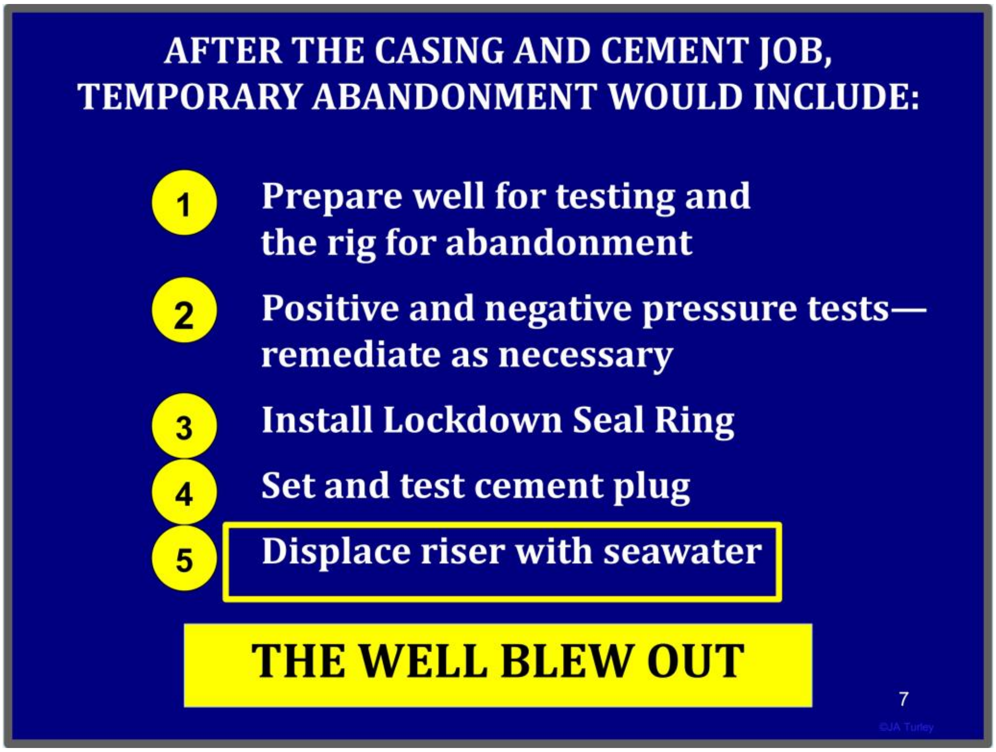
Given that the well is cased with steel pipe, and surrounded by annular cement, with another 180 feet in cement in the shoe track, and that the float collar contains two high-pressure one-way check valves . . . *that's still not enough security*. So, the operator installs one last cement plug in the casing, below the seafloor. This plug is typically 300 feet long, is allowed to set-up and harden, and is tested with a drill bit to ensure its integrity. No fluids would ever be able to get past such a high-integrity cement plug.

With the well secure, it was then planned to displace the drilling riser with seawater, to capture and recover its contents—about 1,600 barrels of oil-base mud—which could not be dumped into the sea.

Given that the riser is displaced (and is now full of seawater) and that the well is otherwise pressure tested and secure, the last steps were strictly mechanical—pull the riser and BOPs, and then release the rig.

* * *

UNFORTUNATELY . . .



Slide 7

. . . DURING THE PROCESS OF DISPLACING THE RISER WITH SEAWATER, THE WELL BLEW OUT.

* * *

What? How can this be? We followed the above steps, ran good casing, got a good cement job, obtained good pressure tests inside and out, and left high-integrity flow barriers in the wellbore.

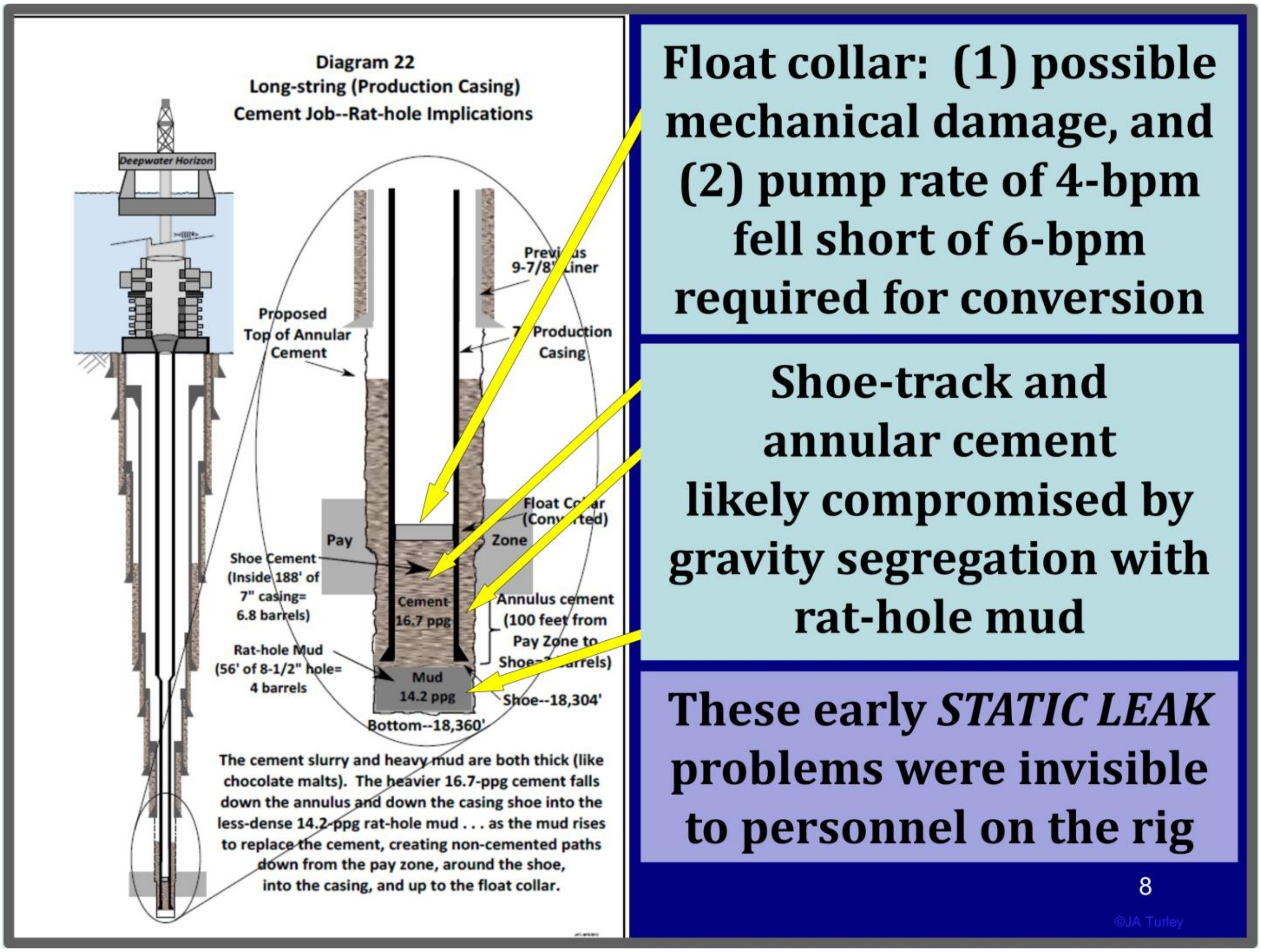
But the fact is, as shown in **Slide 7**, the well did blowout. Therefore, we need to go back and examine the above list. Every step. Because something happened as we worked our way down the list that turned our temporary abandonment procedure into a tragically lethal disaster. And that should not have happened. So . . . what do we look at?

I elected early on (during the USCG hearings) to ignore finger pointing, and he-said-she-said, and politics, and deep pockets, and companies, and people.

My non-committee, no-deadline, no-vested-interest solo focus was therefore on assessing rig data to define the CAUSE of the Macondo blowout. Therefore, it's time to look at data.

And we'll start at the top of the list (**Slide 6 and Slide 7**) and work our way down the page, because we obviously missed data and other hard evidence that had to be critical to the entire operation.

Let's start with the casing and cement job.



Slide 8

Recall the float collar (the top big arrow in **Slide 8**), which needed to be "converted" to function its dual high-pressure check valves. The manufacturer had performed (pre-blowout) laboratory tests using Macondo's 14.2-ppg oil-base mud, and determined a 6-bpm (barrel-per-minute) minimum pump rate was required to produce the pressure drop inside the float collar necessary for conversion. (Note: Diagram 22, from *THE SIMPLE TRUTH*, is on Page 96)

Yet, records show that after the casing was installed, the pump rate into the casing, while circulating mud and displacing cement, never went above 4.1 bpm. Which means the float collar was never converted, and the open flappers never acted as high-pressure check valves.

There was contention, even in court, that cuttings may have plugged the guide shoe and/or float collar, requiring more than 3,000 psi to break circulation. Further arguments claimed that such high pressure may have even breached (i.e., made a hole in) the casing just below the float collar. These are good points for our later Q&A, but the data confirm one thing: the well ultimately flowed *upwards* through the float collar, so the flappers had to be open . . . therefore, not converted.

The separation of oil and vinegar is a common occurrence, given that the less-dense fluid (oil) floats on top of the heavier fluid (vinegar). The same thing happens is wells with rat holes, especially if the mud in the rat hole is less dense than the cement slurry above it (i.e., in the shoe track and annulus). For Macondo, the 14.2-ppg mud in the rat hole was significantly less dense than the 16.7-ppg Class-H cement slurry in the lower annulus and inside the 180-foot-long shoe track.

This is not a surprise phenomenon —API RP (Recommended Practice) 67 Section 7.5 specifically identifies the problem, and recommends that a heavy "pill" of mud be spotted in the rat hole prior to running the casing, so gravity segregation will not occur. This was not done on Macondo (this topic is covered in **Q&A-3**, to follow).

Such gravity segregation allowed lighter-weight (14.2-ppg) oil-base mud to percolate upwards from the rat hole through the 16.7-ppg cement into the annulus (only a hundred feet to the bottom of the pay), as well as up the casing and into the 180 feet of 16.7-ppg shoe-track cement.

Bad news: There are now two potential sources of a static leak path between the annulus and the wellbore: (1) the unconverted (open) float collar, and (2) the oil-base-mud contaminated cement in the lower annulus and in the shoe track.

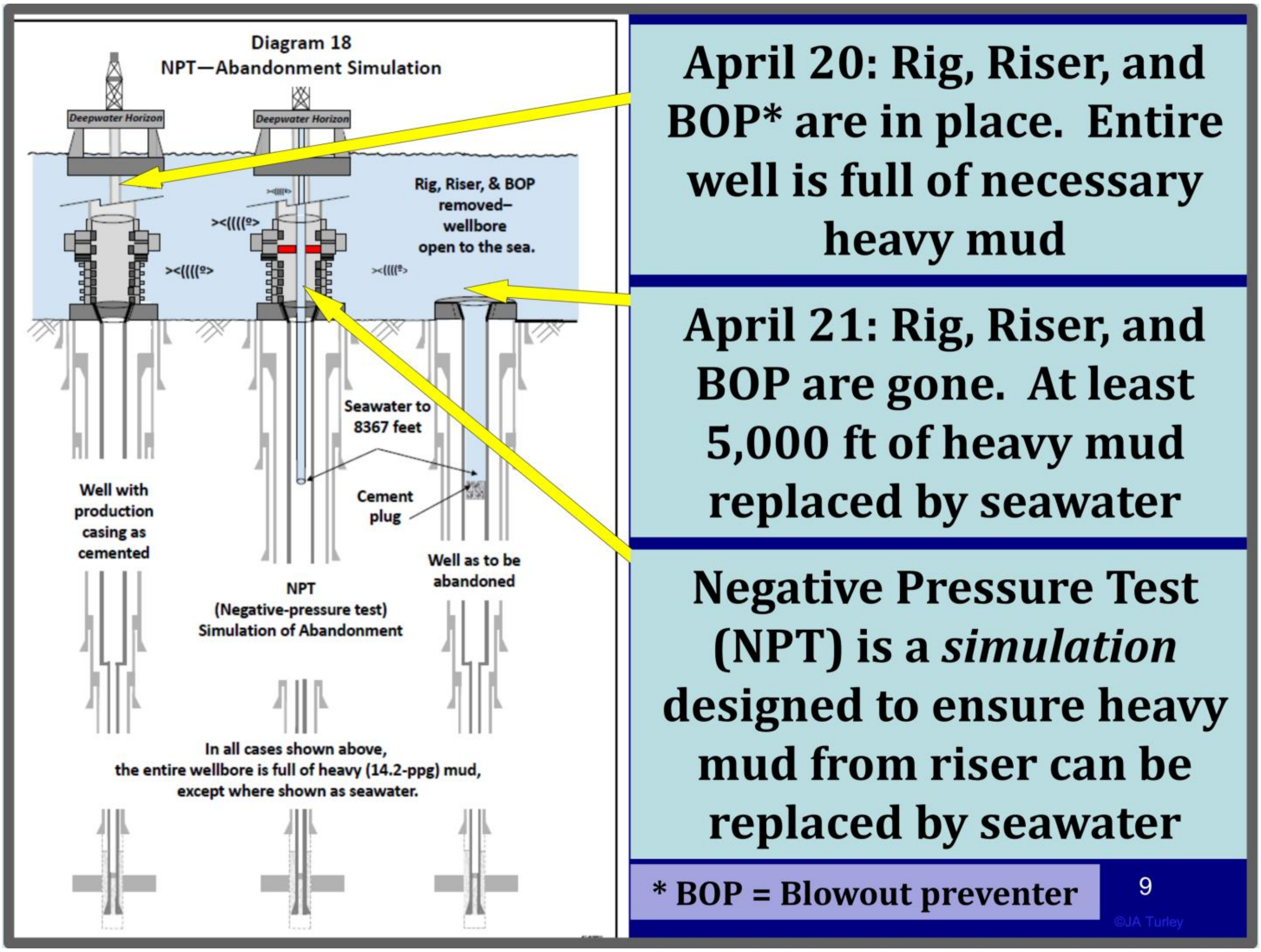
Good news: The leaks are *static* because the wellbore is still full of 14.2-ppg mud, and the well is dead (1,000-psi overbalanced). Even better news is that we're about to *test for leaks* as part of the temporary-abandonment procedure, and we should therefore find any leak, and repair it as necessary.

* * *

So, let's look in detail at the two pressure tests—a high-pressure test and a negative-pressure test.

The 2,700-psi (high-pressure) positive-pressure test was accomplished by closing the blind-shear rams (BSR) and using the cement-unit pumps to raise the pressure on the wellbore. Such pressure would extend from under the BSR down to the top cement wiper plug, which is on top of the float collar. The cement plug has a solid-core, so the wellbore pressure above the plug cannot get past (below) the float collar. The test was done in two steps—low pressure first, then the high-pressure 30-minute test. All data indicate the positive-pressure test successfully proved there was no leak from the inside out.

So, it's time to get ready for the negative-pressure test (NPT) . . . not to be confused with the same acronym when used for non-productive time.



Slide 9

Look at the **Slide 9**, the schematic on the far left. The 18,000-foot wellbore is full of 14.2-ppg mud. The well is dead—1000-psi overbalanced. Nothing is leaking (in spite of the *potential* static leaks).

(Note: Diagram 18, from *THE SIMPLE TRUTH*, is on Page 97)

But look at **Slide 9**, where the schematic on the far right depicts the Macondo well as early as "tomorrow." There is no rig, no riser, no BOP . . . and the well will have lost 5,000 feet of 14.2-ppg mud and replaced it with 5,000 feet of 8.6-ppg seawater. We need to know if the associated loss of hydrostatic pressure (about 1,500 psi) will cause a leak (anywhere in the wellbore) and allow external fluids to enter the wellbore.

We could test for leaks by disconnecting and lifting the BOPs . . . but that is not a good idea.

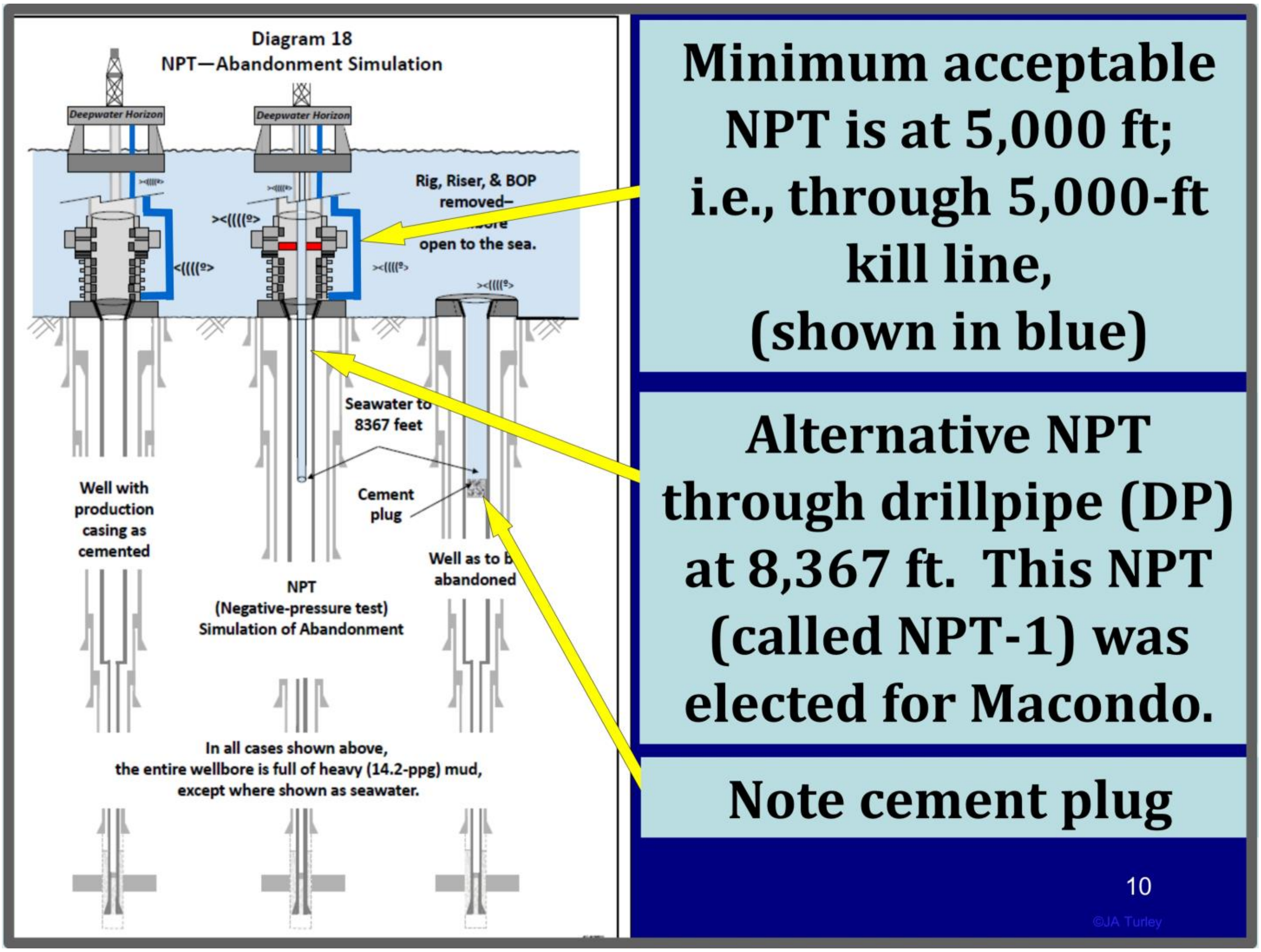
Better yet, we will *simulate* the loss of head with a *negative pressure test* (NPT), by making the wellbore think the top 5,000 feet is full of seawater.

Even before we take the first step, there are two possible results from the successfully implemented negative-pressure test (NPT):

(1) **Good news**: If during the NPT simulation (with the wellbore pressure reduced), the wellbore shows no leak . . . then the casing is pressure secure, and we can proceed with the temporary-abandonment process; or

(2) **Also good news**: If the NPT reveals there is an active leak anywhere into the low-pressure wellbore, then we know we must delay the temporary-abandonment process because we have work to do. It's good news, not because there's a leak, but because *identifying and remediating* any such leak is mandatory . . . and is exactly why we run the negative-pressure test.

So, let's run our negative-pressure test . . . NPT.



Slide 10

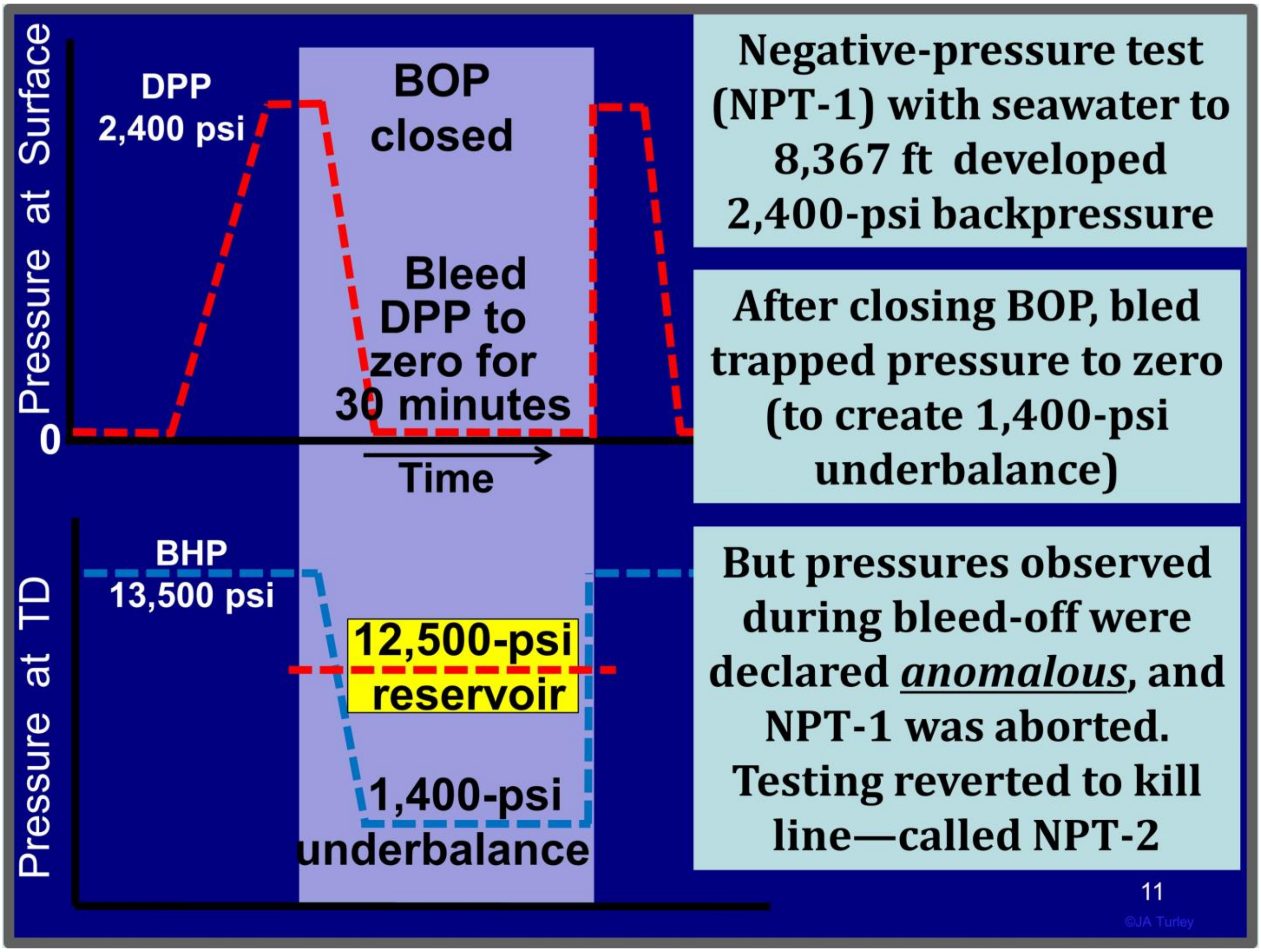
The drilling riser has a number of external, built-in, high-pressure lines, one of which is the kill line. As shown in **Slide 10**, the 3-1/16-inch, 15,000-psi kill line (the heavy blue line) reaches from the rig floor to the BOP—about 5,000 feet. By filling the kill line with seawater and then closing the BOP, the 18,000-foot-deep wellbore sees 5,000 feet of seawater on top of 13,000 of heavy mud. This mixed-fluid column *simulates* what the wellbore (from the sea floor down to the float collar) would see if the BOPs were lifted in the 5,000-foot-deep Gulf. Such a test (using a 5,000-foot-kill-line NPT) would meet the approved regulatory requirements for Macondo.

Yet, data indicates the operator elected to run an even-more-rigorous NPT, using 8,367 feet of drillpipe, rather than 5,000 feet of kill line. The stated purpose of the deeper NPT was to accommodate the installation of the LDSR (lockdown seal ring).

The LDSR (which locks and seals on top of the casing hanger inside the casing head) must be either pushed down, or pulled down, with 100,000 pounds of load. The operator elected to use about 3,000 feet of heavyweight drillpipe below the wellhead to pull down on the LDSR, which required 3000 feet of room below the casing head.

The final cement plug was therefore planned to be installed and tested below that depth (near 8,300 feet) to provide the necessary clearance for the LDSR installation.

All that planning meant the negative pressure test (NPT) would utilize the 8,367-foot-long drillpipe workstring. For convenience, we call the 8,367-foot negative-pressure test *NPT-1*.



Slide 11

Slide 11 is a graphic pictorial of NPT-1 (using 8,367 feet of drillpipe).

The upper (red) graph generalizes the pressure gauge readings at the top of the drillpipe (actually located at the cement unit), and the lower graph (blue) generalizes a *hypothetical* pressure gauge down at the top of the float collar.

In the lower graph, note the bottom-hole pressure (BHP), with a full wellbore of 14.2-ppg mud, is about 13,500 psi. Also, note that the main reservoir pressure is about 12,500 psi (recall the 1000-psi of overbalance mentioned earlier).

In the upper red graph, the observed drillpipe pressure increases from zero to 2,400 psi as the 8,367-foot workstring is filled with seawater. This trapped pressure is "backpressure"—a measure of the u-tube effect of the heavy mud column outside the drillpipe and the lighter-weight seawater on the inside.

Note that the bottom-hole pressure (BHP) at the float collar (blue lower graph) does not change as the drillpipe is filled with seawater.

But then we close an annular BOP. This isolates 5,000 feet of heavy mud in the drilling riser from the rest of the wellbore, and creates a single fluid-filled system. The closed system is comprised of 2,400 psi of trapped fluid pressure, above 8,367 feet of seawater, on top of the remaining column of 14.2-ppg mud (for a BHP at the float collar near 13,500 psi). Note the pressure at the float collar does not change when we close the BOP.

Now . . . since it's a closed, fluid-filled system, if we decrease the 2,400 psi of trapped pressure (at the cement unit) by, for example, 100 psi, every pressure in the wellbore drops by 100 psi (shown on both graphs). We do this by opening a valve at the cement unit and allowing a small volume of seawater to escape the drillpipe, with a corresponding reduction in trapped pressure (and throughout the wellbore).

When we back-flow more seawater and drop the trapped pressure by a total of 1,000 psi, the wellbore pressure at the float collar is now balanced with the reservoir pressure (though they are separated by casing and cement).

We continue dropping the drillpipe pressure by back-flowing additional small volumes of seawater, step-by-step (barrels out, pressure down), until we reach our goal of zero psi. At zero psi on the cement-unit surface gage, the wellbore pressure at the float collar would be 1,400-psi underbalanced compared to the reservoir.

The regulatory requirement for Macondo's NPT called for dropping the pressure to zero and observing it for 30 minutes (where zero increase in pressure would indicate no leak).

But there was a problem.

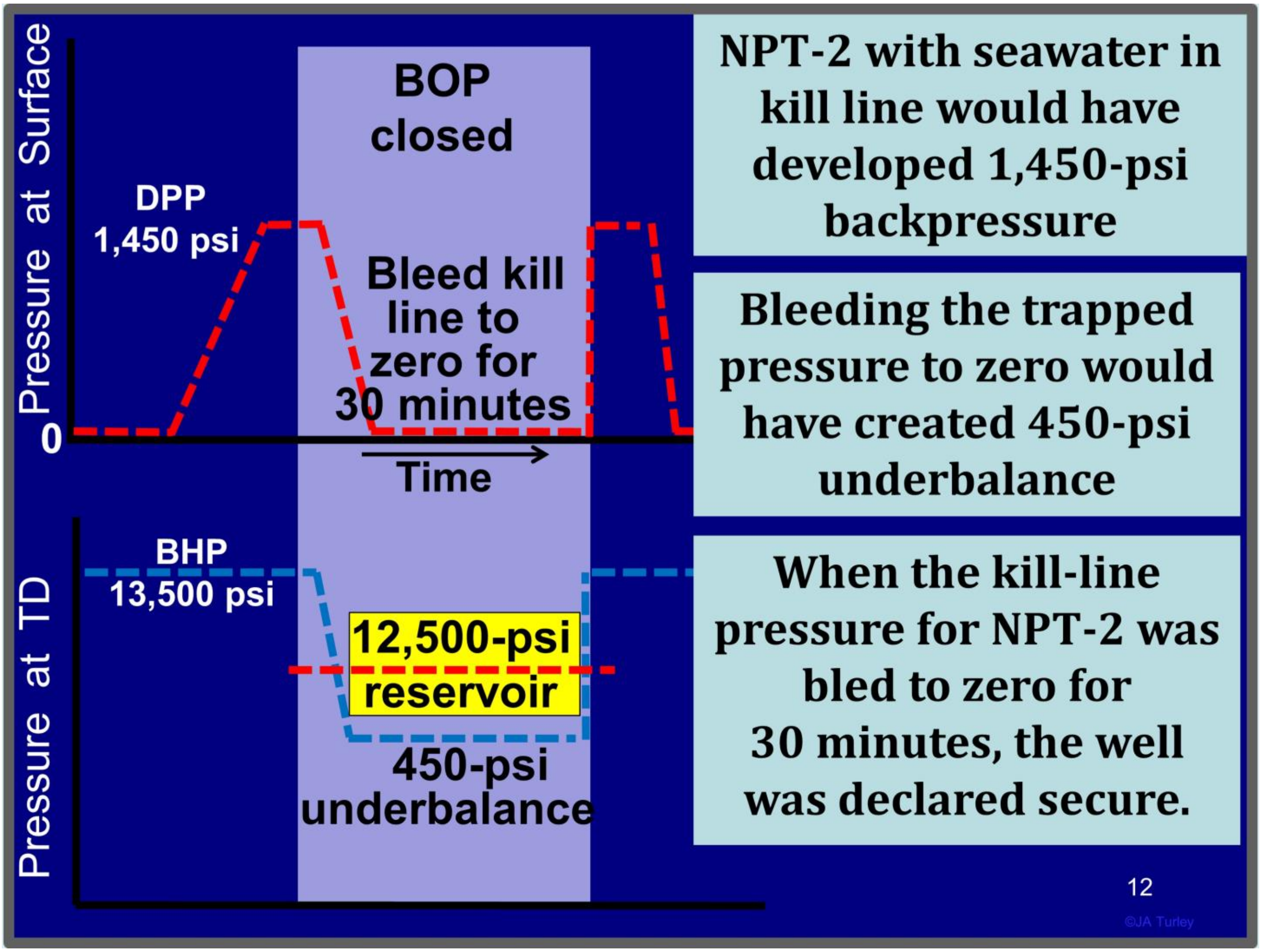
Once the trapped backpressure was dropped from 2,400 psi to about 200 psi, it would not decrease further. Even after opening the cement-unit valve and allowing as much as 15 barrels of seawater to flow from the drillpipe to the cement unit, the drillpipe pressure would not stay at zero.

Because the drillpipe pressure would not bleed to zero even when the drillpipe was opened, and because 15 barrels of seawater had flowed back to the cement unit during the five-minute period ending at 6:00 p.m., the valve at the cement unit was closed (at 6:00 p.m.) and not reopened.

These phenomena were declared (on the rig, and in USCG depositions) to be the result of "the bladder effect" (see **Q&A-1**)

NPT-1 was therefore considered *anomalous* and was *aborted*.

The Macondo negative-pressure-test procedure was therefore switched from the 8,367-foot drillpipe test (NPT-1), to the 5,000-foot kill-line test (deemed *NPT-2)*.



Slide 12

If NPT-2 had been run using the NPT-1 procedure, then **Slide 12** (top of diagram, in red) would represent the kill-line pressure at the rig floor. The bottom diagram, in blue, shows the pressure at the float collar for NPT-2, using the 5,000-foot kill line.

The 5,000-foot kill line, when filled with seawater, would generate 1,450-psi of trapped u-tube pressure.

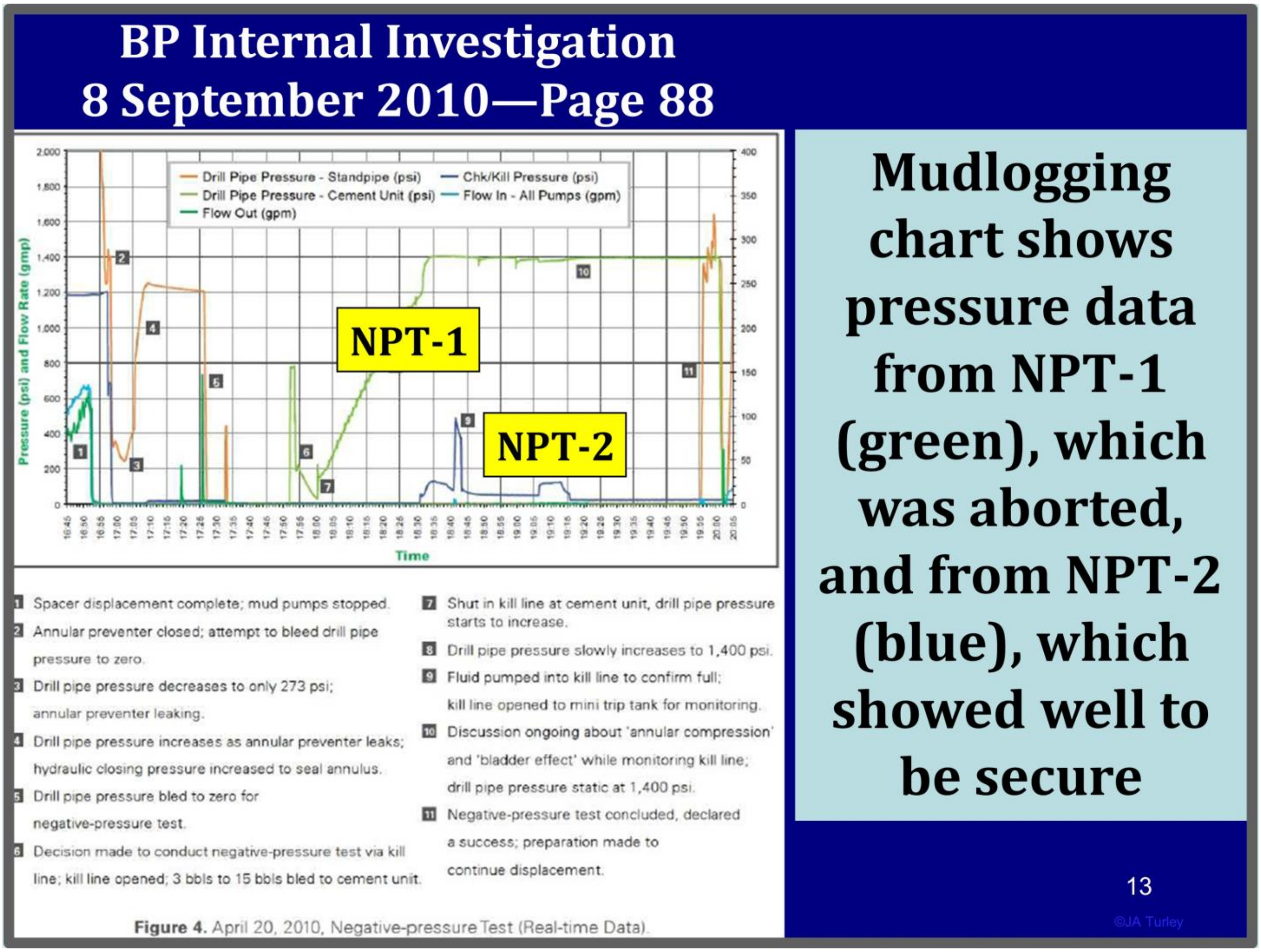
Then, with the BOP closed, bleeding the 1,450 psi to zero psi would generate 450 psi of underbalance.

Good news: The kill-line pressure was successfully dropped to zero, where it held for the required 30 minutes, after which the well was deemed secure, ready for the rest of the temporary-abandonment procedure, including displacing the riser with seawater.

Bad news: We know the well was not secure (because it blew out), therefore something must be wrong with our negative-pressure-test procedures, and results, and conclusions.

Which means we need to go back and look deeper at all aspects of NPT-1 and NPT-2.

To do this, we'll look at actual pressure charts from the mud-logging unit. These charts were generated on the rig and sent wirelessly to onshore computers. The operator made the charts available to the courts and through its own internal investigations after the blowout (referenced on the next page, top of **Slide 13**).



Slide 13

The time/pressure mud-logging chart (**Slide 13)**, shows measured surface pressures, with NPT-1 drillpipe pressures in green, and NPT-2 kill-line pressures in blue. Each horizontal pressure line is 200 psi, and the time labels are five minutes apart.

(A full-scale version of the mudlogging chart is on Page 98)

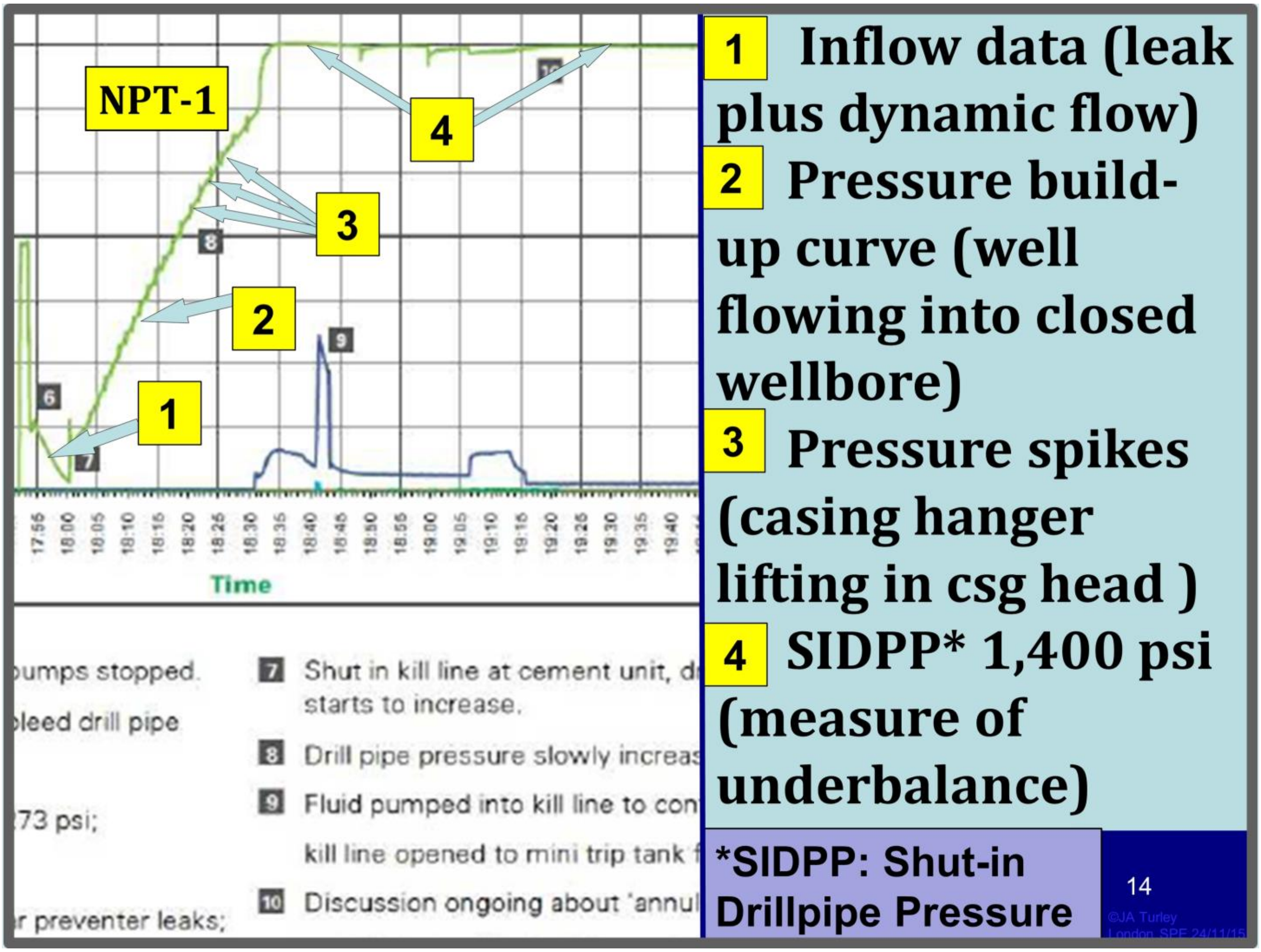
For NPT-1, a key area of interest is the short diagonal green line between 5:55-6:00 p.m. This is the recording of that last 200 psi that would not bleed-off for NPT-1. More on this later.

But the data to the left (prior to 5:55 p.m.) is also of interest because it appears to have set the stage for an important decision yet to be made. In short, when the annular BOP was first closed around the drillpipe for NPT-1, and the pressure *under* the annular BOP was severely reduced (as per the NPT procedure), fluid from the riser leaked past the rubber sealing element (bladder) of the annular BOP, and pushed seawater back up the drillpipe. And yes, the fluid level in the riser had dropped.

No big deal—standard operating procedure—the driller increased the closing pressure on the annular. Then it happened again. Same leak, same result.

When the annular-BOP closing-pressure was ultimately increased enough to withstand the 2,400-psi pressure reduction required for NPT-1, no additional fluid leaked past the BOP (and the riser stayed full). We will refer to this later, when we talk about "the bladder effect" (and in **Q&A-1**).

Now, back to the short diagonal green line at 5:55 p.m. In the next Slide, we'll look at the same data, on an increased scale.



Slide 14

The Yellow #1 arrow in **Slide 14** (short diagonal green line from 5:55-6:00 p.m.) is the drillpipe pressure recording when Macondo first began to flow at 5:55 p.m. During the following five-minute period, with the drillpipe open, the well flowed 15 barrels of seawater from the drillpipe to the cement unit, and the pressure refused to go to zero.

That was not supposed to happen.

The 15 barrels of fluid (the source) that displaced the seawater had to come from somewhere. Fifteen barrels in five minutes is 4,000 barrels a day. The well is flowing at 4,000 BPD.

The likely source is the reservoir (to be confirmed), yet there are statements in published Macondo investigative reports that "there was no definitive indication (during NPT-1) of communication between the wellbore and the reservoir."

I say quite the opposite is true, as follows.

* * *

At 6:00 p.m., the *vertical* green line indicates the valve at the cement unit was closed (no more flow to the cement unit).

But the reservoir (unaware a valve had been closed 3-1/2 miles away) continued to flow into the under-pressured wellbore, increasing the wellbore pressure. The recorded ever-increasing wellbore pressure (Yellow #2) is a *pressure buildup curve*, which can be interpreted to quantify flow characteristics of the reservoir.

As flow continued into the wellbore, and the wellbore pressure increased, both the drawdown on the reservoir and the flow rate decreased. Finally, when the reservoir had fully charged the wellbore and flow stopped, the pressure at the surface (1,400 psi) was a measure of the original underbalance between the fluid column in the wellbore and the discovery reservoir. This is noted as Yellow #4.

If we took a kick while drilling a well, closed the BOP, and observed 1,400-psi on the drillpipe, we would note the pressure as our SIDPP (shut-in drillpipe pressure). The SIDPP would be a measure of how underbalanced we were when we drilled into the kicking formation.

The 1,400-psi stabilized pressure observed during NPT-1 is the SIDPP for the in-progress Macondo kick. The 8,367 feet of seawater on top of 10,000 feet of heavy mud is 1,400 psi underbalanced to the formation, which is in open communication with the wellbore. And the reservoir began its flow into the wellbore at near 4,000 BPD.

These data confirm the source of flow is the 200-foot-thick discovery reservoir.

Further, there are a number of interesting pressure spikes (Yellow #3) on the pressure-buildup curve. The data indicate that the radical reduction of pressure (2,400 psi) above the casing hanger (and under the closed annular BOP), unseated the casing hanger in short bursts, as if belching. Each "belch" was recorded as a spike on the pressure-buildup curve.

Importantly, this unseating of the casing hanger means the LDSR (lockdown seal ring) had not yet been installed. This situation does not contribute to the blowout yet to come, but it will play a role in delaying the kill procedure after the blowout.

Now, as stated earlier, without *data* to back it up, there was discussion on the rig (shortly after 6:00 p.m.) that the data generated by NPT-1 was "*anomalous*." Given that the data considered anomalous was in fact solid evidence of communication, flow, kick . . . this author cannot condone such claim. But I will at least state my thoughts.

The argument, in part, was that "the bladder effect" (leaking annular BOP bladder) caused the flow-back of 15 barrels, and negated the worthiness of NPT-1, which led to NPT-1 being aborted.

To complicate matters, there are serious world-class petroleum engineers who pontificate an unrelated form of the "bladder effect" and its associated rising gas bubbles, gas trapped under the annular preventer, temperature expansion criteria, etc. But that level of engineering sophistication was (my opinion) beyond the basis of the "bladder-effect argument" on Macondo.

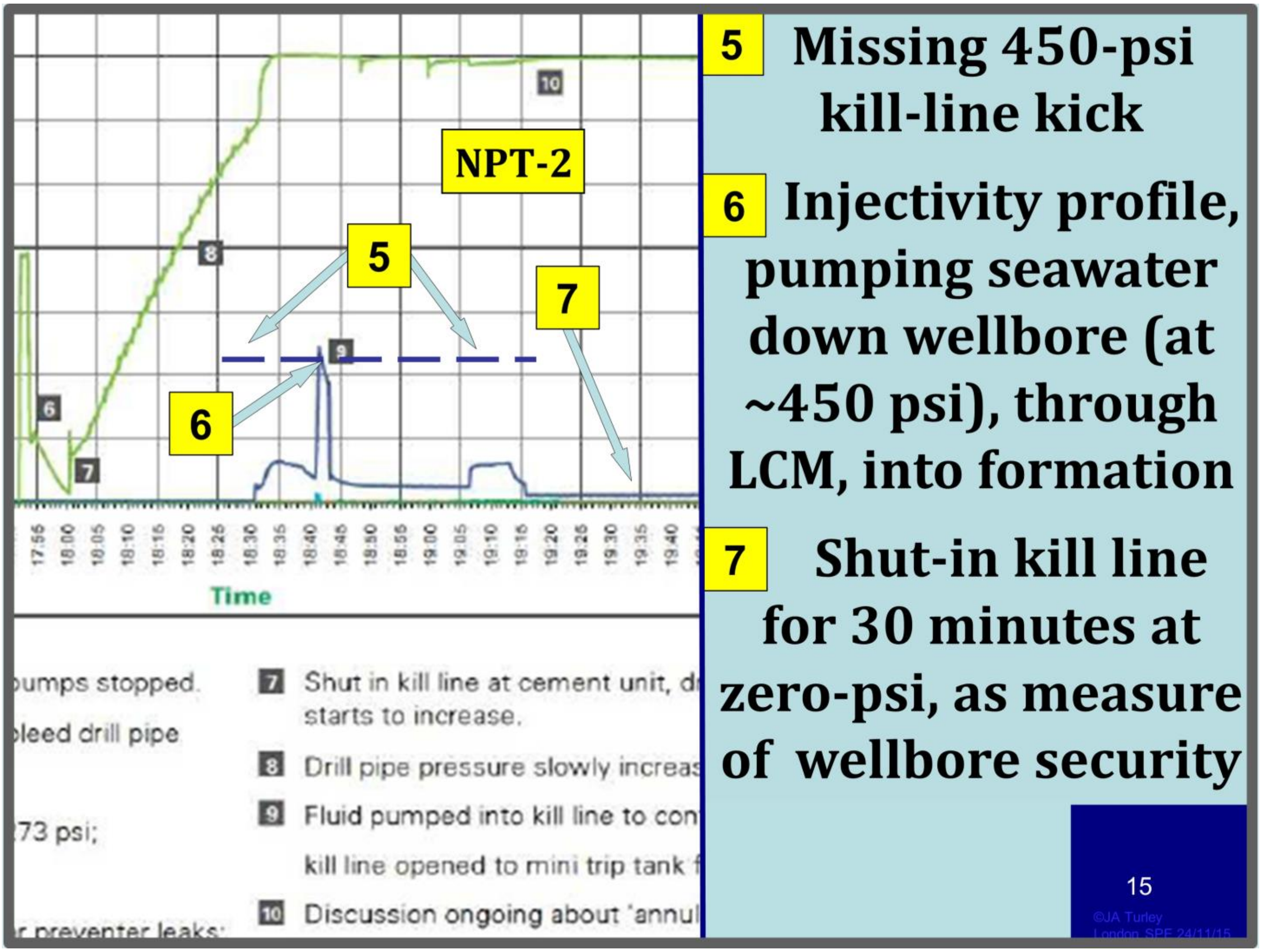
Instead, the term was used loosely on the rig referring to the hours prior to 5:55 p.m. (refer to **Slide 13**) when the closing pressure on the annular was insufficient, more than once, and mud from the riser leaked past the annular bladder and expelled seawater from the drillpipe . . . unrelated to the flow-induced 15 barrels expelled from 5:55-6:00 p.m.

Three criteria dispel the leaking-BOP argument: (1) the riser remained full of mud, (2) the pressure buildup curve was a measure of the rate of flow from the reservoir, and (3) the 1,400-psi SIDPP could have been generated only be the reservoir that was 1,400 psi underbalanced to the wellbore.

More on the "bladder effect" in **Q&A-1**.

Nevertheless, based on the argument, a key outcome prevailed: NPT-1 was aborted and NPT-2 was commenced using the kill line.

So, let's look at the data from NPT-2.



Slide 15

NPT-2 utilized the kill line, which was full of seawater. As noted in **Slide 15**, the data show two anomalies, though neither (apparently) got enough attention to shut down the test.

First, NPT-2 is missing the 450-psi kick (Yellow #5), which is the kill-line equivalent of the 1,400-psi NPT-1 kick up the drillpipe.

So, the question must be: How could a very real kick through the wide-open 8,367 feet of drillpipe not manifest as a kick through the wide-open 5,000 feet of kill line? Or maybe the kill line wasn't open. Perhaps a valve was closed on the lower end of the kill line.

No, it wasn't closed, as we'll see below.

But something did block the kill line, preventing the kick from being seen at the surface. Here, we will refer back to **Slide 6**: "Preparing the rig for Temporary Abandonment." Recall we mentioned getting rid of the oil-base mud as well as several hundred barrels of water-base lost-circulation materials (LCM). Records show the LCM was pumped down the drillpipe and up into the lower riser, where it would act as a spacer between the heavy mud to be eventually displaced from the riser, and the seawater that would do the lifting.

But there was a problem.

Recall that prior to 5:55 p.m., there were a couple of occasions (at the start of NPT-1) when the closing pressure on the annular was inadequate, and mud bypassed the annular and displaced seawater from the drillpipe. The closing-pressure problem was fixed, but the occasions of fluid bypassing the annular meant the LCM moved deeper into the riser and ended up *in the BOPs* rather than *above the BOPs*.

And LCM is designed to plug holes. Holes like the small inside diameter of the 3-1/16-inch, 15,000-psi kill line. With the bottom end of the kill line plugged by LCM, the 450-psi "push" of the kick could not manifest at the surface.

So how do we know the bottom kill-line valve was open? This leads us to the second NPT-2 anomaly, which occurred when seawater was pumped into the kill line to ensure it was full of seawater.

Note: pumping into the kill line should not have been possible, as the fluid-filled, closed wellbore (with the top cement wiper plug on top of the float collar) had passed the 2,700-psi positive pressure test.

Nevertheless, during the act of pumping seawater into the kill line (see Yellow #6), the pressure increased rapidly (as expected), but "broke back" at about 500 psi before the pump was turned off. The "break-back" appears equivalent to the break-back pressure one might see during a cement squeeze job. So, even though the kill line should not have been able to take fluid, it did. Which means we had to be pumping the fluid somewhere, like into the kicking formation.

But that begs two questions:

(1) What happened to the LCM that blocked the kill-line kick? and,

(2) how can you pump into the formation given the successful results of the 2,700-psi positive pressure test?

First, the 450-psi driving pressure of the kick likely was not enough to pump LCM *up the kill line*, but 500 psi from the top was able to push LCM *away from the kill line* and transmit pressure into the wellbore.

Second, had the top cement wiper plug remained in place on top of the float collar, it would not have been possible to pump past it. But the top plug did not remain in place, as it had been lifted away from the float collar by the 15 barrels of back flow during NPT-1. This means that when the kill-line pressure exceeded about 450 psi and transmitted its pressure to the wellbore, the pressurized fluid found an exit point . . . back into the formation . . . where we have now turned the Macondo well into an injection well.

The data says that with the missing 450-psi kill-line kick, and confirmation of "injection-well" communication with the annulus, and with there still being a 1,400-psi kick in progress on the drillpipe . . . the entirety of *NPT-2 was invalid*.

Nevertheless, the kill line was opened at 7:16 p.m. (see **Slide 15**) and showed zero pressure at the surface (with the help of the LCM) for more than the requisite 30 minutes; hence, the test was declared to have successfully shown no leak into the casing; i.e., *NPT-2 was declared valid and the well was declared secure*.

Which meant it was time to get on with the Temporary Abandonment Procedure. Recall in **Slide 6** that the remaining steps to be taken include: install the LDSR, set a cement plug in casing, then displace the riser with seawater, pull the BOPs and riser, and release the rig.

The first two steps were not taken.

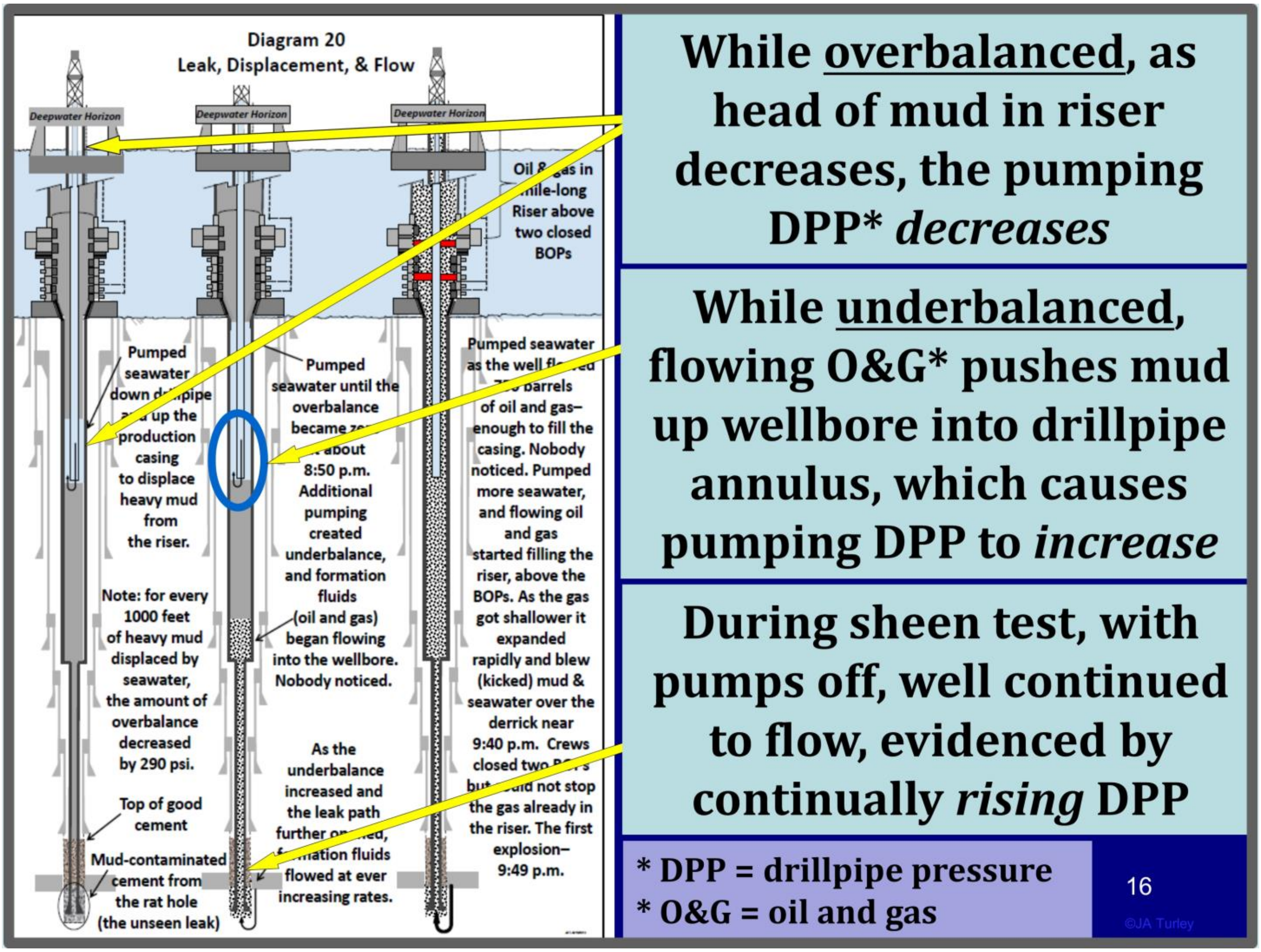
Instead, a review of rig data confirms the next activity included two key steps: (1) open the BOPs, and (2) commence displacing the riser with seawater.

This means the LDSR had not been set (recall spikes on pressure buildup curve—**Slide 14**, Yellow #3). It also means the 8,300-foot-deep cement plug (see **Slide 9**, middle of right-hand schematic) had not been set, which was designed to further isolate the deep wellbore from the seafloor.

Opening the (annular) BOP immediately killed the well, since all the heavy mud in the riser once again became a key part of the 18,000-foot column of wellbore fluid. In fact, the kicking formation, even though still open to the wellbore, was immediately 1,000-psi overbalanced by the total mud column.

The Macondo well was dead.

The simple act of opening the BOP, which killed the well, is the upside of the negative-pressure test *simulating* the replacement of the upper wellbore with seawater.



Slide 16

But now we start pumping seawater into the drillpipe (left-hand schematic, **Slide 16**). As we do, seawater exiting the drillpipe displaces heavy mud from the riser (the drillpipe annulus). As mud was displaced from the riser and replaced by seawater, the circulating pressure on the drillpipe (caused by annular back pressure) decreased with the reduced footage of mud; hence, the drillpipe pressure dropped by the minute.

(A full-size Diagram 20, from *THE SIMPLE TRUTH*, is on Page 100)

Also decreasing was the total hydrostatic head of heavy mud at the bottom of the well. In fact, with each barrel of seawater pumped, with each minute that passed, the total hydrostatic overbalance on the reservoir decreased.

Until it got to zero. And we were still pumping seawater.

And that's when the well commenced to flow (middle schematic, above).

As the formation flowed, a column of hydrocarbons moved up the wellbore, lifting the mud above it. The uplifted mud rose up and around the outside of the drillpipe, increasing the backpressure on the drillpipe. Data show the drillpipe pressure stopped falling, and started rising—the demarcation between overbalanced and underbalanced—when flow from the reservoir commenced, about 8:55 p.m.

We (apparently) don't see this change and keep pumping seawater.

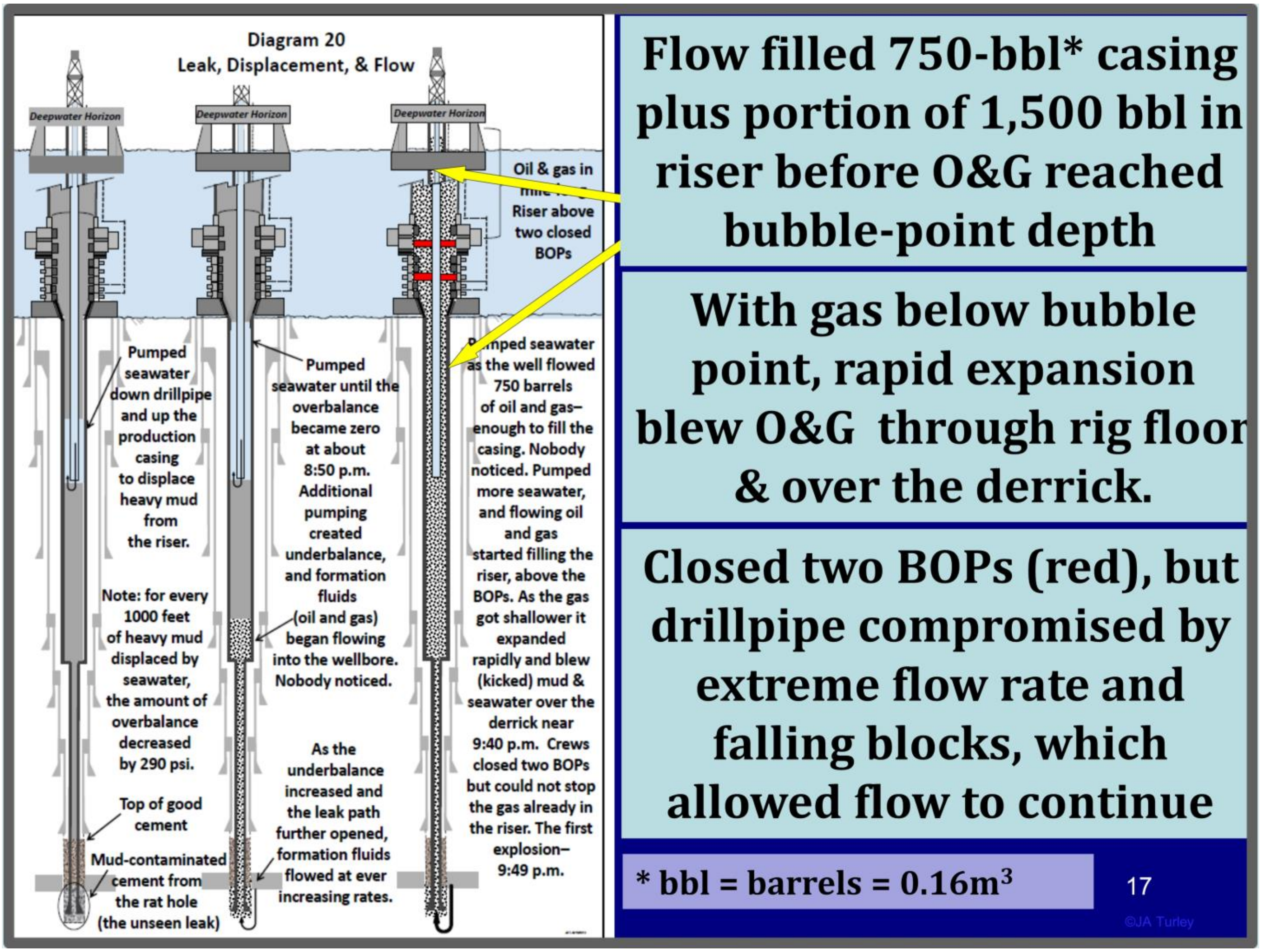
We pump seawater until the LCM reaches the top of the riser, then turn off the seawater pump. The LCM is water base, and since all the oil-base mud was above the LCM, there should be no more oil-base mud in the riser. We instigate a "sheen test" to ensure there is no more oil-base mud, and get a positive result (no sheen). Accordingly, crews rig up to allow future returns from the riser to go overboard (since there's no more oil-base mud).

But there's a problem.

During the sheen test, while the seawater pump was off, the well should have been dead. Instead, additional mudlogging charts show the drillpipe pressure continued to rise . . . *because the well was still flowing*.

But after the successful sheen test, with the well flowing, we went back to pumping seawater.

The schematic on the far right deserves its own slide.



Slide 17

The well continued to flow hydrocarbons (right-hand schematic, **Slide 17**), eventually filling the entire 750-bbl casing string, then filling the BOPs, and started filling the 1,500-bbl riser.

Note: The BOPs are still open, and we are still pumping seawater, exacerbating the flow from the reservoir.

Somewhere along that rapidly accelerating path up the wellbore and riser, the shallowest gas—normally under high pressure and in solution—reached the *bubble point*. Which means the dissolved gas finally experienced a pressure so low (due to less hydrostatic head) that it evolved from the oil to form free gas, in the form of tiny bubbles.

And as any given bubble flowed (and was pumped) to a shallower depth (lower pressure), the bubble expanded. Perhaps slowly for a few seconds, then explosively fast, the collective mass expansion displacing the shallowest fluids from the riser, and further reducing the pressure on top of the already expanding gas.

The first non-analog evidence the well was flowing took the form of an eruption of fluids through the rig floor and over the derrick.

Rig crews closed an annular BOP and a variable bore ram (VBR)—see red closed BOPs in **Slide 17**.

And herein lies the major difference between deep-water wells and all others, whether offshore or onshore.

When the deep-water Macondo annular BOP was first closed, it worked exactly as designed and expected. It sealed the annulus outside the drillpipe. It prevented the reservoir from additional flow (other than pressuring up the wellbore—another pressure-buildup curve—below the BOP).

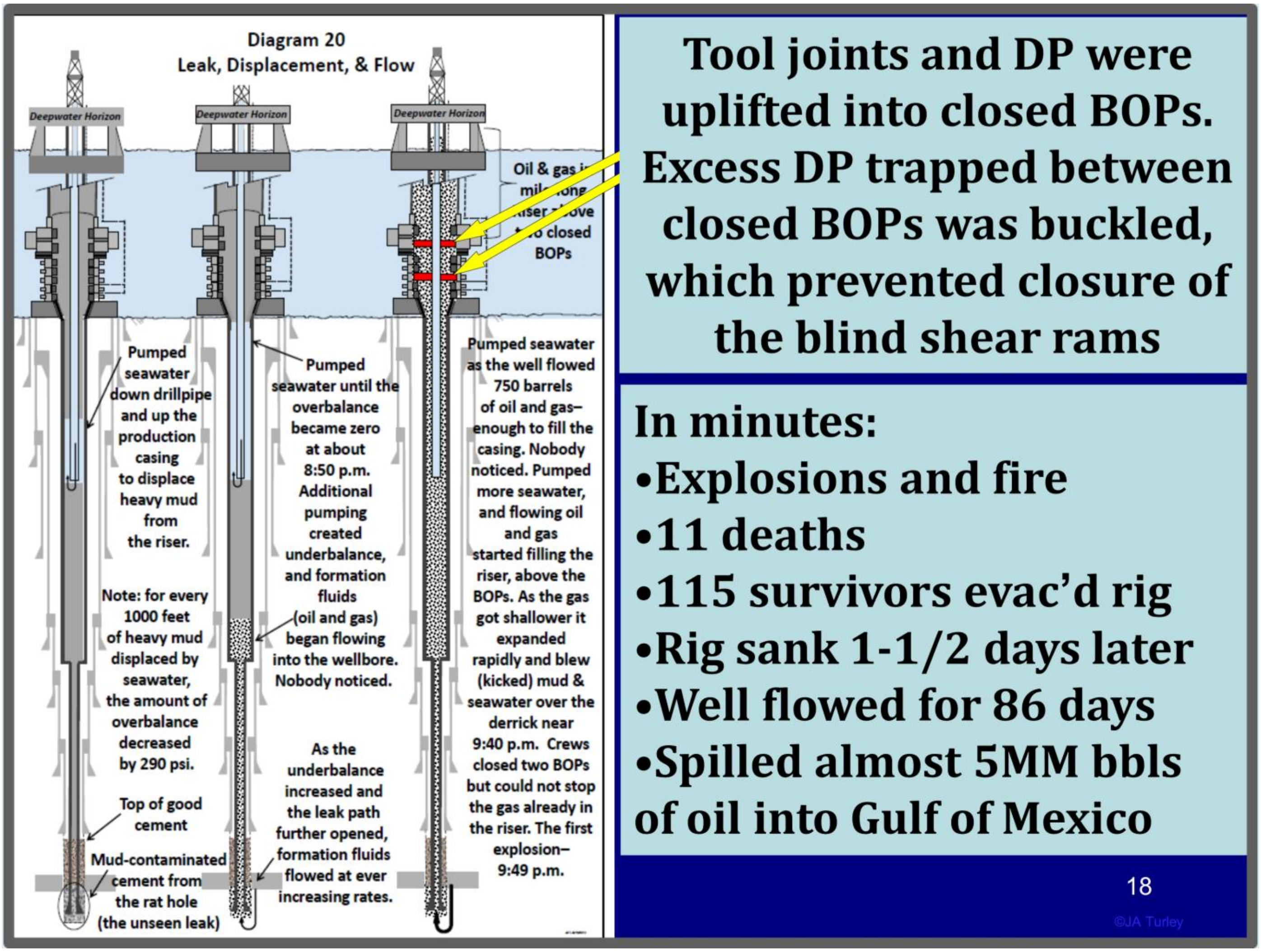
But because the BOPs were a mile below the rig, all the crude oil and natural gas in the 1,500-bbl riser continued to accelerate up the riser driven by the sub-bubble-point gas, which continued to expand violently.

The exiting oil and gas (from above the closed BOP) engulfed the rig floor and derrick and blew laterally under the rig floor throughout the moon pool.

In minutes, engine-room suction fans inhaled a mix of gas and atomized oil, which fueled the diesel engines driving the power generators. Within seconds, the room exploded (about 9:49 p.m.), shutting down power throughout the rig. Perhaps ten seconds later, the oil and gas under the rig floor exploded, taking out the moon-pool walls and entering the hallways, quarters, galley. The entire rig, from substructure to the top of the derrick was engulfed in flame.

Good news: As bad as that was, no new flow could enter the riser past the closed annular and VBR BOPs, or enter the drillpipe, which was still tied to the seawater pumps.

Bad news: But that changed when the conflagration on the rig floor (fed by burning oil and gas from the riser) eventually brought down the blocks, which landed on top of the drillpipe. That event opened a large conduit, up the drillpipe, through the closed BOPs, and instantly allowed new formation fluids to enter the wellbore and riser, through the ruptured drillpipe, further feeding the inferno on the rig. Some argue that the blocks didn't fall, and that the powerless rig drifted off station, which parted the drillpipe (locked high in the blocks and low in the BOPs). Kind of academic without data, but in any case, the NOW open drillpipe became the open conduit right up through the closed BOPs.



Slide 18

The two closed BOPs (**Slide 18**), in concert with the violent uplift of the flowing well, created a problem with unusual mechanical consequences, which significantly impacted the kill of the well. Specifically—though successfully used earlier for the positive pressure test—the blind shear ram (BSR), located between the two closed BOPs (with open drillpipe between them) would not close, and could not be forced to close, for weeks and months to follow . . . and the well continued to flow through the open drillpipe.

Explanation: In short, when the BOP was recovered from the seafloor in September 2010 and subjected to a forensic examination by Det Norske Veritas (DNV), more drillpipe was found between the closed BOPs than the distance between them. The drillpipe in the gap was deformed (buckled) and off-center, which prevented the BSR from closing. Arguments persist among academics and experts as to whether the violent fluid uplift drove excess pipe into the gap, or if pressure differentials (inside and outside the drillpipe) between the closed BOPs buckled the pipe.

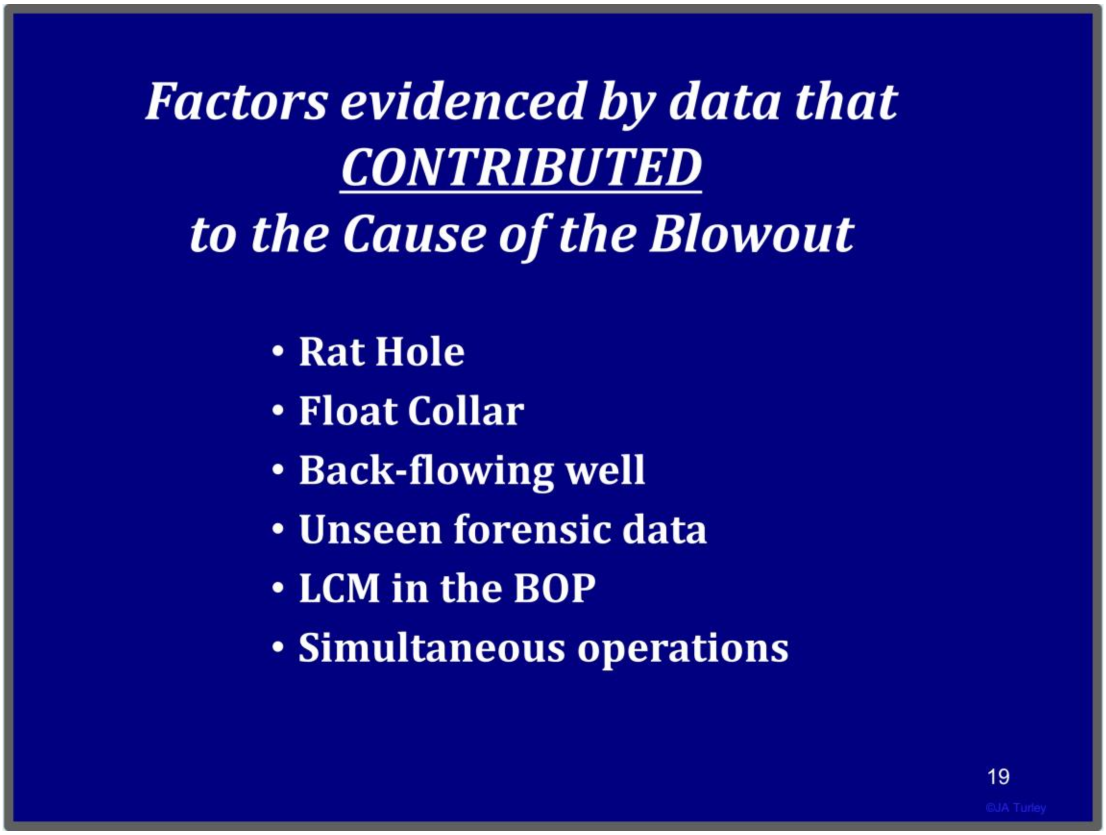
So, my opinion. In spite of the debate, the bottom line is: the BSR would not close, and the entrapped drillpipe was subsequently found to be severely buckled. The deformed, distorted pipe was so far off center the BSR could not function. Also of interest, the drillpipe inside the closed annular BOP was found to be externally fluid eroded, an indication of the violence of the flow even as the annular BOP was first closing.

A second serious impact of the BSR-buckled-drillpipe problem was that the Emergency Riser Disconnect system depended on the BSR closing. Which means the auto-disconnect system at the lower-marine-riser package (LMRP) would not release. The LMRP includes a remote-operated connector just below the upper annular BOP, which, when released, disconnects the LMRP and the riser from the rest of the BOP stack. Therefore, the rig was stuck on location, unable to release from the riser or BOP stack.

* * *

The long-term environmental and financial consequences of the blowout are well documented, but we are left with key statistics that will forever define the tragedy.

Eleven good men died. Survivors totaled 115, though a number sustained serious and permanent injuries. The *Deepwater Horizon* burned and sank a day and a half later. The Macondo well flowed near five million barrels of crude oil and natural gas into the Gulf, before being killed on Day 86. Events during those terrible 86 days are beyond the scope of this work.



Slide 19

With all the above helping us to understand the sequence of events that caused the Macondo blowout, let's look *back* at what we've seen, as well as *forward* to how we can apply what we've learned to future activities.

Slide 19 lists factors that *contributed* to the blowout. Alone, any might seem innocuous. Yet, for Macondo, none was. And had any one of them been recognized and acted on with authority, the tragedy likely would have been averted.

(1) The *rat hole* was necessary as part of the procedure for landing the long string of production casing. Yet, decades ago, industry experts realized less-dense rat-hole mud could gravity segregate *upward* into heavier cement in the casing and in the annulus (see API RP 67 Section 7.5). Such upward migration of mud would contaminate the cement. Mud-contaminated cement does not set, does not harden, does not seal as designed. Preventing this known problem was easily resolvable—with zero rig time and zero risk—during the original design of the well.

Nevertheless, the design program for the well stated: '*Do not need to set 16.5 ppg mud in rat hole* *as volume is only ~4 bbls . . .'* That's like saying: *You don't need more oil in your car because it's only a few quarts low*. Two bad directives . . . though their consequences are tragically different.

* * *

(2) The *float collar* played a role that could have been so different. By design, the float collar contains two high-pressure flappers that act as one-way check valves (preventing flow up the wellbore). The flappers are run in the open position so the casing fills with mud as it is being run. By design, the float collar must be "converted" in order for the flappers to activate as check valves. The manufacturer tested the model being used in the Macondo well to confirm the float collar would convert at a minimum throughput pump rate of 6 BPM. Data from the rig show the maximum pump rate at the float collar was 4.1 BPM. Therefore, the float collar did not convert, and the flappers never got the chance to act as check valves.

* * *

(3) *Back-flowing the well* contributed on several fronts. Specifically, during the last 200-psi of the 2,400-psi NPT-1 drawdown, the contaminated cement in the lower annulus and the 180-foot shoe track finally yielded to the increasing *negative* differential pressure, and the well commenced flowing. The initial flow further cleared the mud-contaminated annulus-to-wellbore path, and the well flowed 15 barrels into the low-pressure wellbore during the next five minutes.

The flow also lifted the top cement plug (which allowed injection into the kill line during NPT-2).

Further, continued flow into the underbalanced wellbore created the pressure-buildup curve (indicative of the reservoir's flow capacity). The buildup-curve pressures climbed for 35 minutes and leveled-off at 1,400 psi, a measure of the underbalance between the flowing reservoir's formation pressure and the NPT-1 mixed fluid column (8,367 feet of seawater on top of 14.2-ppg mud).

Records reveal a significant in-court debate which centered on the possibility of a breach in the casing below the float collar. This topic to be covered in **Q&A-2**.

* * *

(4) *Unseen forensic data* is a big category, which includes all the flow-related data evidenced by the pressure chart for NPT-1 as well as other documented mud-logging flow-and-pressure charts. All this data was unseen, or more fairly, was neither seen nor understood to such extent that a firm decision was made to stop testing and remediate whatever problem had allowed flow from the reservoir into the cemented production casing.

Further, NPT-2 provided two additional key pieces of unseen forensic data. First, a simple two-part drawing showing: (a) the NPT-1 wellbore, with its specific seawater-filled drillpipe and mud column, and its shut-in pressure of 1,400 psi, side-by-side with (b) the NPT-2 wellbore, with its specific seawater-filled kill line and mud column, and its shut-in pressure of . . .

Whoops, a simple calculation says . . . we're missing what should be a 450-psi kill-line kick.

It's the *missing* part that would have been so vivid in a simple drawing of the wellbore with balanced hydrostatic pressures up the drillpipe and up the kill line. Neither seeing nor missing the kill-line kick contributed to our falsely justified comfort with NPT-2.

By the same token, we missed the data that showed injection into the reservoir (i.e., communication with the annulus). Yes, we showed the kill line to be full of seawater, but the data also showed that "something gave" when we pressured up the kill line. Missing the assessment of "what gave," contributed to our comfort level in declaring NPT-2 a good, no-leak test.

* * *

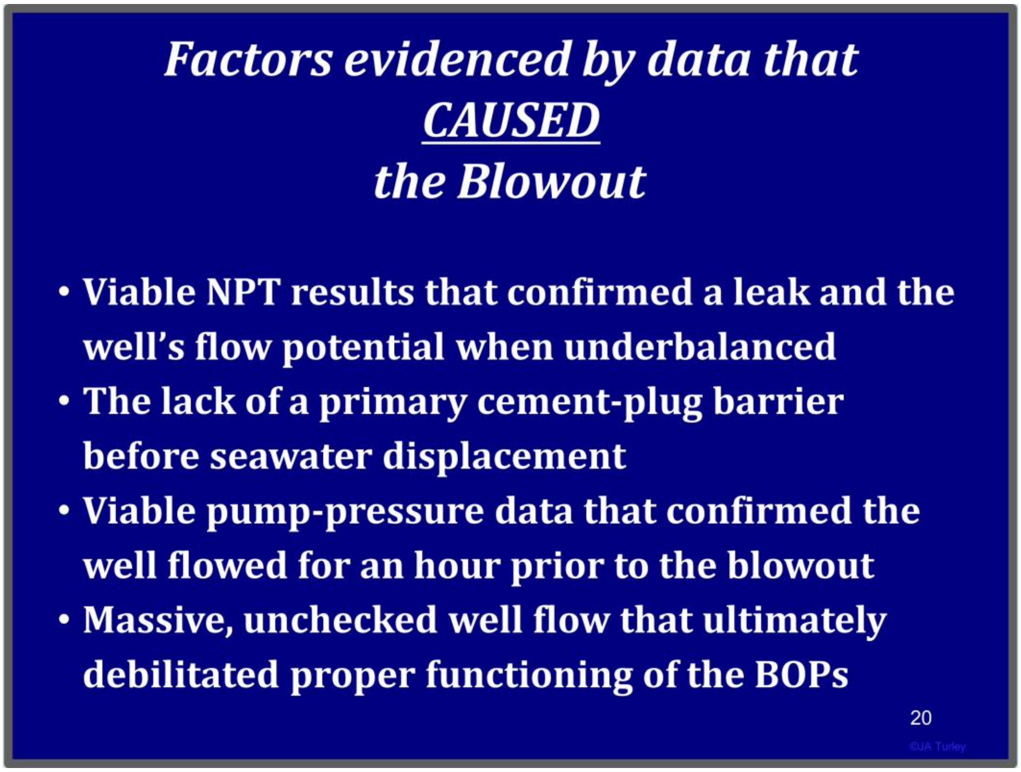
(5) LCM in the BOP did not cause the blowout, but it single-handedly allowed the NPT-2 test pressure to be dropped to zero, which made NPT-2 look good . . . and that was a major contributor to the cause of the blowout.

* * *

(6) *Simultaneous operations* (pumping mud overboard to a workboat, moving mud and cleaning mud pits, and preparing for the next day's operations) also *contributed* by making it difficult to accurately measure *and mandatorily balance* barrels of seawater being pumped into the well with the barrels of mud, LCM, and seawater exiting the riser. To the extent possible with such incomplete data, post-blowout analysis and cross-correlation of charted data (beyond the simplicity of pit-volume totalizers and differential barrel counters with pre-set alarms) showed the well to be flowing (more barrels out of the well than being pumped in) before 8:55 p.m., but this data was either not seen or not acted on to such extent as to recognize the flow, stop the work, and initiate well-control procedures.

* * *

Though each of the above items/actions *contributed* to the blowout, several factors were more directly linked to the *cause*.



Slide 20

The items listed in **Slide 20** are strongly linked to the *CAUSE* of the blowout:

(1) NPT-1 data showed that the Macondo wellbore was in communication with the annulus, and that the well flowed when exposed to a pressure reduction of about 2,400 psi (1,400-psi underbalance). Such confirmation gave the Macondo leaders no viable recourse other than to stop the temporary-abandonment procedure, investigate and identify the location of the leak, and remediate as necessary. Every action on the rig after the well was shut-in at 6:00 p.m. and after the leak/flow data was declared anomalous and further ignored—and every unseen intervention opportunity along the way, including data from NPT-2—drove the operation closer to the cataclysm that would follow.

* * *

(2) A critical barrier for any temporarily abandoned wellbore (i.e., as for a hurricane) is the 300-foot-long cement plug normally set a few hundred feet below the seafloor. It is designed with a single purpose in mind—plug the wellbore so NOTHING can get through the plug. Had the plug been set *after* (invalid) NPT-2 showed the bottom of the well to be secure and *before* the riser was displaced with seawater, the story would have ended quite differently.

Based on data that showed what had and had not been done prior to the blowout, a plan-changing decision had been made to set the cement plug *after* the riser was displaced, ostensibly so the plug would be set in seawater rather than in oil-base mud. As part of the same decision, this would have delayed the setting of the lock-down seal ring (LDSR), but would allow it, too, to have been set in seawater rather than in mud.

On both counts, this meant the riser was displaced and the well blew out prior to setting the cement plug and the LDSR.

* * *

(3) Pump-pressure data while displacing the riser with seawater provided *extensive* incontrovertible evidence the well commenced flowing just prior to 9:00 p.m. Had the evidence been recognized early on, immediate action would have allowed rig crews to shut-in the well and kill a *low-volume*, *low-pressure kick* . . . prior to remediating the casing/cement-leak problem.

* * *

(4) The Macondo blowout preventers (BOPs) have taken a lot of heat since the blowout. As in: the *blowout preventers* did not prevent the blowout. Point taken, but the topic is an important part of this presentation.

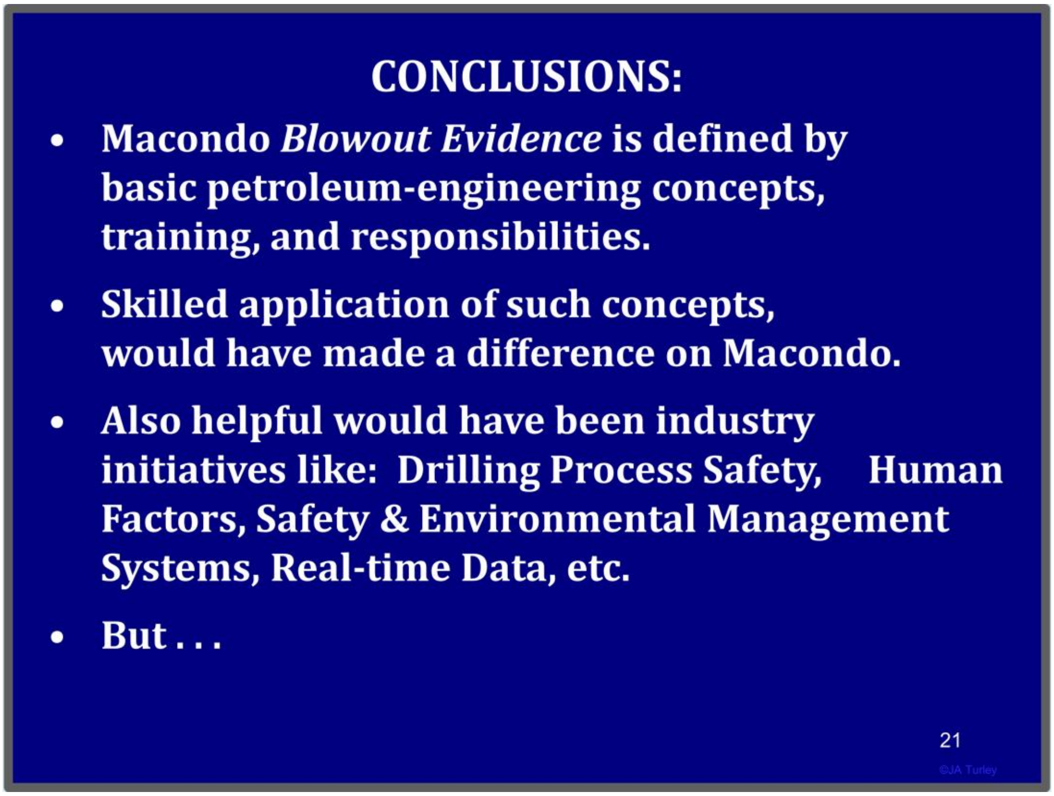
The normal well-control function of a BOP is well known (as taught in petroleum-engineering universities, and on the job, and through mandatory, professional, well-control schools around the world). Specifically, operators have a critical incentive to *minimize* the volume of formations fluids that ever enters the wellbore. Accordingly, they are skilled at recognizing *early* symptoms of kicks (i.e., via pit-volume totalizer, differential-flow meters, etc.). After the *very first symptom* of a possible kick, the prudent operator takes immediate necessary steps to allow closing the BOP as soon as possible. The immediate closing of the BOP prevents further influx and allows rig crews to gather necessary information to quantify the kick and kill the well.

Not so with Macondo. As shown herein, the steps that contributed to and caused the blowout took place *hours* before the BOPs were called into action. The well first kicked during the pressure drop associated with the NPT-1 simulation and was shut-in near 6:00 p.m.

Later, with open BOPs and the help of seawater pumps, the well lost its overbalance (about 8:55 p.m.) and kicked and flowed for almost an hour. The flowing well filled the casing and most of the riser with near 2,000 barrels of crude oil and natural gas, and blew (about 9:45 p.m.) with violent gas-driven energy through the rig floor and over the crown of the rig . . . before the first BOP (annular) was closed. A variable-bore ram was also closed.

The first explosion occurred near 9:49 p.m.

As described above (following **Slide 18**), the combination of the extreme long-duration kick and accelerating voluminous flow contributed to lifting and buckling the drillpipe inside the BOP stack, specifically in the gap between the closed annular and the closed VBR. Note: though the blind shear ram (BSR) had been used earlier in the day for the 2,700-psi positive-pressure test, the buckled drillpipe prevented the BSR from closing. Had the debilitated BSR been able to close and seal, the duration of the *in-progress* blowout would have been measured in hours and days rather than weeks and months.



Slide 21

Worldwide, degree programs most often referred to as *petroleum engineering* and *petroleum technology* are the only academic programs dedicated to teaching the engineering concepts necessary for drilling wells, controlling the complexity of fluids and pressures, completing wells for production, producing hydrocarbons, and managing the vast underground geologic complexes in which oil and gas are found. After graduation, petroleum engineers (and other engineers, for sure) further mature through on-the-job training, specialized course work, and years of experience to ensure a deep understanding of the concepts required for a career in the energy business.

For Macondo, as noted in **Slide 21**, the engineering concepts that define the cause and manifestation of the Macondo blowout are best defined as Drilling 101. No differential equations. No massive spreadsheets. No sophisticated software packages. Conversely, with a clear understanding of hydrostatics, and mud weights, and fluid pressures, and cement, and wellbore mechanics, and well-control requirements, and formation flow criteria—basic Drilling 101—no petroleum engineer reading this document should be overwhelmed by any aspect of the Macondo blowout data.

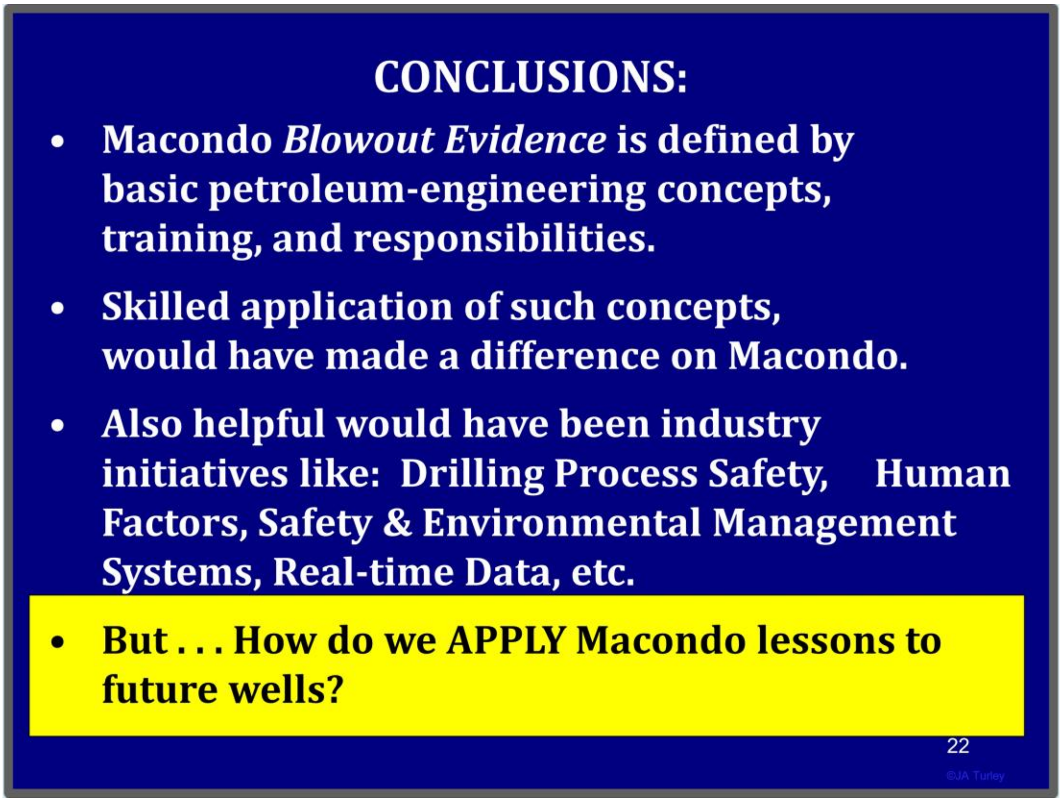
Yet, knowing and understanding basic concepts is different than applying such knowledge to managing wells, every well, any well . . . as should have been done on Macondo, without question, without fail.

While I continue to focus ONLY on the *Macondo data* that define the blowout, others—individuals, engineering study groups, academics, journalists, corporations, consultants, legal entities, environmental groups—tirelessly investigate and pontificate the topics I (reluctantly) forced myself to avoid—human factors, group think, finger pointing, company culture, training requirements, politics, metrics analysis, liability assessment, completion procedures, regulations, real-time data, process safety, root & latent cause analysis, operator & service-company relationships, shallow Macondo well-control problems, toxic dispersants, product-service-resource initiatives, riser-gas detection, disaster management, non-Macondo historical catastrophes, equipment redesign, drilling reliability, drilling process safety, risk management, and other "could've, would've, should've" topics without limit. Entire books have been written on these topics and more.

Are such studies and related findings good? Oh, yes! I call them *umbrella* issues, because they pertain to Macondo and our entire industry. Each is a critical issue, being examined by the best of the best, all for a good cause: to help minimize the chance of ever repeating a Macondo-type disaster.

But the above slide ends with the word *BUT.*

BUT what?

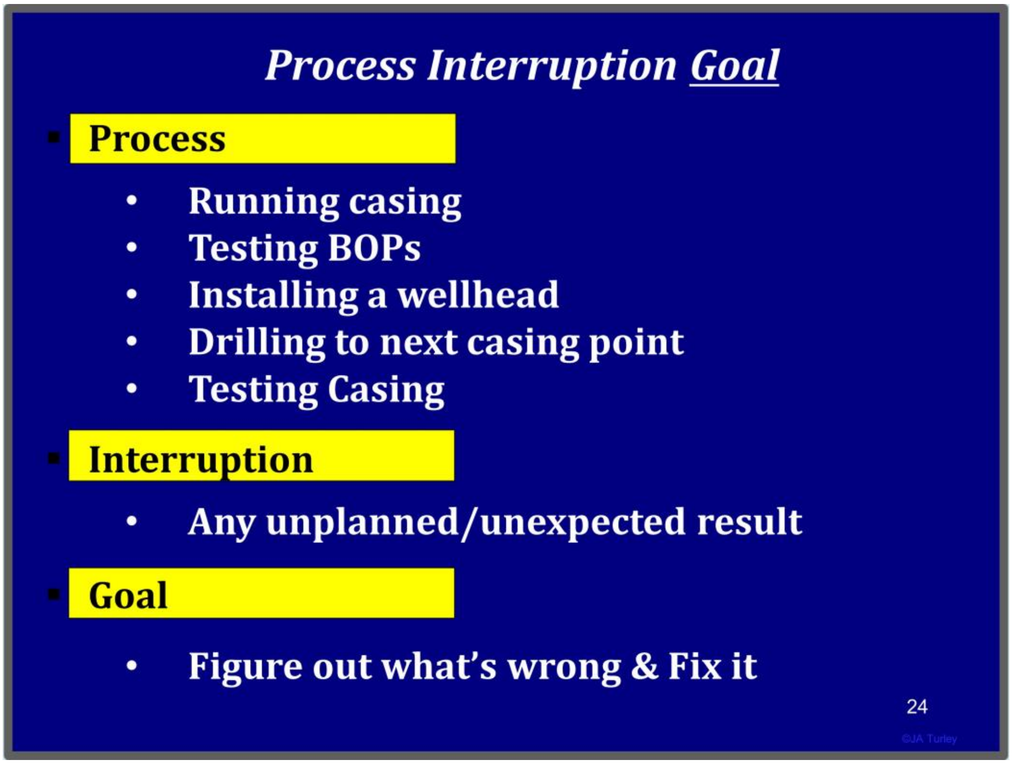


Slide 22

BUT . . . though involved experts continually strive for closure and applicability of the complex, seemingly open-issue "umbrella" topics, we must ask ourselves, as in **Slide 22** . . . *How do we apply what we've learned from Macondo data to future wells?*

To do this, let's look at a proven concept used by NASA and by the commercial aviation industry, which I'll paraphrase as "process interruption."

(And, yes, I skipped Slide 23 on purpose, as I cover its contents with the following.)



Slide 24

So how do we go from flying a space shuttle or an airplane to drilling a well?

Certainly, our commercial flight to Dallas takes off, climbs, cruises, navigates, approaches, and lands. For a passenger to be able to say, "That was a good flight," every step must have worked, in the right order, even if there were problems, prior to disembarkation.

Similarly, a well (**Slide 24**), from rig-up to rig-down, or from mob to de-mob, can be defined as a continuous sequence of processes that must be completed before we can say, "That was a good well." Here, though, a single process might be a *casing job*, followed by a process called *cementing*, followed by a process called *drilling to the next casing point*.

As with flying, every process in the scheduled well must be completed before the next step can be taken, and each step must be completed with success, even if there are problems along the way.

And that means, if any step in any process is interrupted by an unplanned or unexpected result (equivalent to engine failure, or loss of hydraulic power, or stuck landing gear, or an Apollo 13 audible alarm), then something is wrong . . . and the problem must be fixed.

Let's look at a familiar drilling example.

Slide 25

I have often said there are few things worse than the doghouse coffee on an offshore rig.

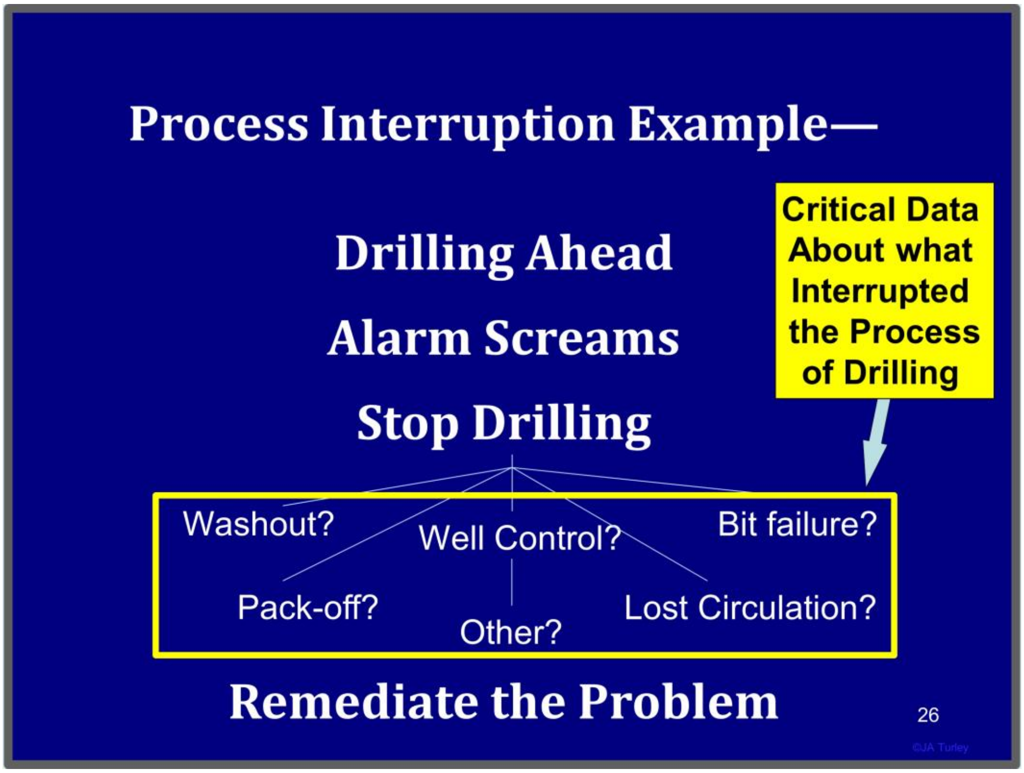
But a screaming alarm (**Slide 25**) on the rig floor can instantly overshadow vile coffee and cause the driller to stop drilling, shut down the mud pumps, pick-up off bottom, and close the annular BOP.

Well Control for a full-fledged kick is perhaps akin to a pilot realizing he's just lost power. In both cases, it's time for immediate response and deliberate actions, because the penalty for failure can be high. And on a rig, that's exactly what we do.

But . . . we need to agree there's something wrong with the rig-floor alarm, stop-drilling, well-control example.

It's much too simple.

And that's because a rig-floor alarm while drilling at 15,000-feet below sea level requires the same in-depth scrutiny as does an alarm in the cockpit while flying at 15,000 feet above sea level.



Slide 26

And the problem is this . . . a number of things, in addition to a kick (**Slide 26**), can interrupt the process of drilling. Many are alarmed, but some are not, and even these need rapid response.

For example, an immediate drop in standpipe pressure may indicate a washed-out tool joint, where a few-seconds delay by the driller in picking-up off bottom and shutting-down the mud pumps may be the difference between a bit trip and a fishing job.

Less mud being returned, or a drop in total pit volume, may be lost circulation—just the opposite of a kick.

Every drilling parameter, on the rig floor and at the bit—torque, drag, pump pressure, rate of penetration, mud weight, gas in returns, weight on bit, pit volume, mud properties, pick-up & slack-off, etc.—is measured and monitored for a reason. A change in a single parameter could mean nothing, or could be something that demands immediate attention.

Hence, it's critical to all parties (and practiced throughout the industry) that whenever the drilling process is interrupted by an alarm—or by any spurious signal, or event, or unexplained happening—the first step is to *stop drilling*. Only then can we take the time to look at critical data and determine the source of the interruption so we know what problem to solve.

Hah! No big deal. That's what we do on every rig around the world while we're drilling.

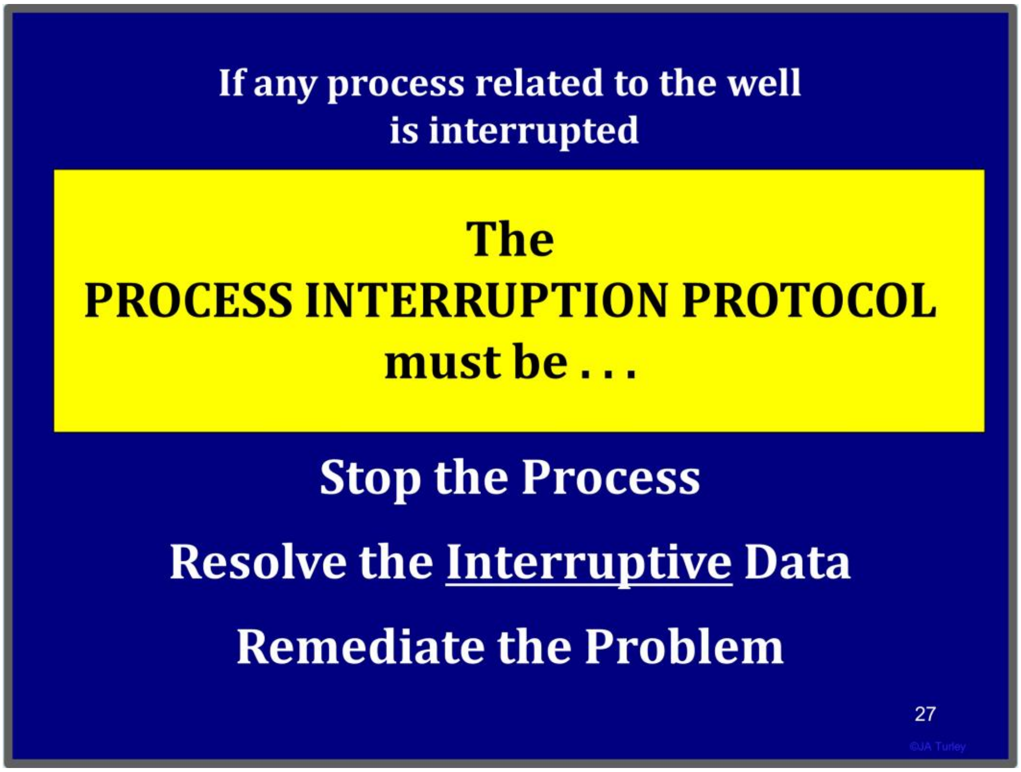
But we seem to do it only for drilling (and not always then).

So, let's apply our drilling-interruption example to what we know about the Macondo well, where the catastrophe happened *not while drilling*, but during what should have been a straight-forward, end-of-well, temporary-abandonment procedure.

Hence, we need to define a procedure that applies to every process throughout the entire well, during drilling of course, but *not just during drilling*.

And we will call the procedure our ***Process Interruption Protocol***.

It's the protocol (the procedure) we will use if any aspect of any process gets interrupted.



Slide 27

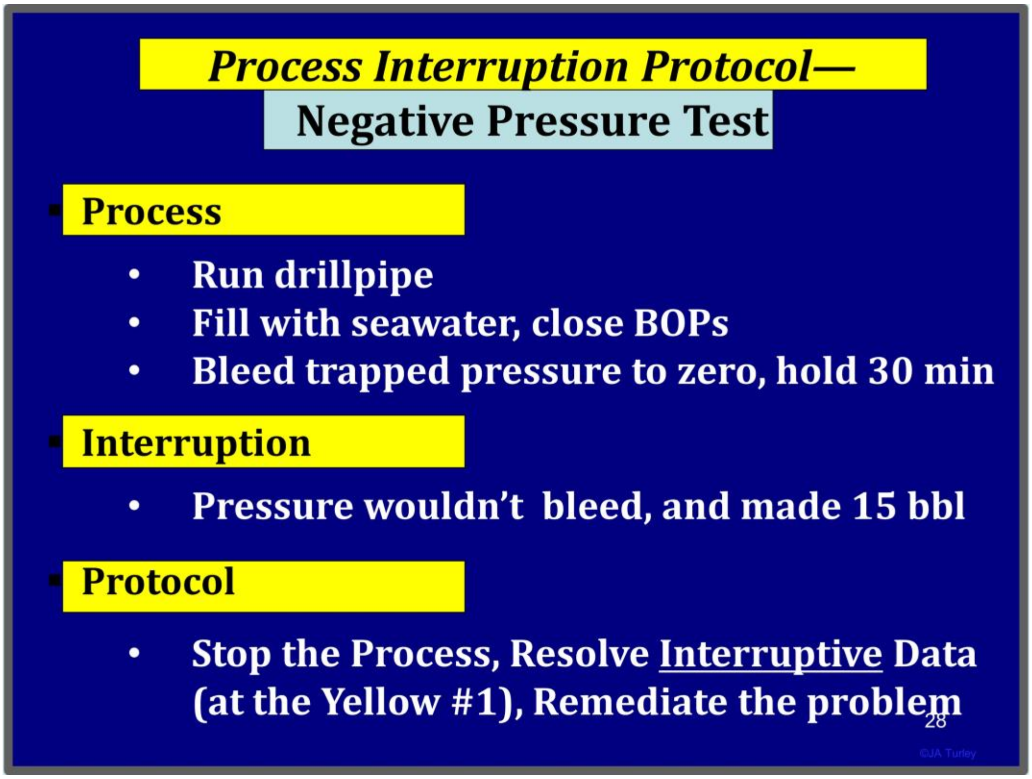
Here, as shown in **Slide 27**, the same procedure that works for the process of drilling (drilling gets interrupted . . . so we stop drilling, resolve the data, and remediate the problem) needs to be applied to every process throughout the well.

If we are running casing (the process of running casing), and any step in the process gets interrupted (i.e., by stuck pipe, or mud drops in the annulus, or the well kicks), then the ***Process Interruption Protocol*** says:

(1) Stop running the casing.

(2) Assess the data that accompanied the interruption.

(3) Remediate the problem.



Slide 28

What if, as per **Slide 28**, the ***Process Interruption Protocol*** had been applied to the *Macondo negative-pressure test*?

The Macondo NPT process was straightforward.

1. Run the drillpipe . . .
2. fill it with seawater . . .
3. observe the amount (2,400 psi) of trapped back-pressure . . .
4. close the annular BOP . . .
5. bleed small amounts of seawater from the drillpipe to incrementally reduce the trapped pressure . . .
6. continue bleeding seawater and reducing the trapped back-pressure until gets to zero . . .
7. hold the pressure at zero for 30 minutes . . .
8. Then, if no increase, declare the well secure.
9. Conversely, if the NPT shows there is a leak, fix the problem.

But something happened (*the interruption*) during the Macondo negative-pressure test (NPT-1). The trapped pressure bled as per the procedure down to about 200 psi. Nevertheless, while further manually bleeding seawater from the drillpipe to reduce the pressure from 200 psi to zero:

(1) the drillpipe returned about 15 more barrels of seawater than expected, and

(2) the drillpipe pressure would not bleed to zero.

Here, because the NPT was interrupted, the ***Process Interruption Protocol*** says:

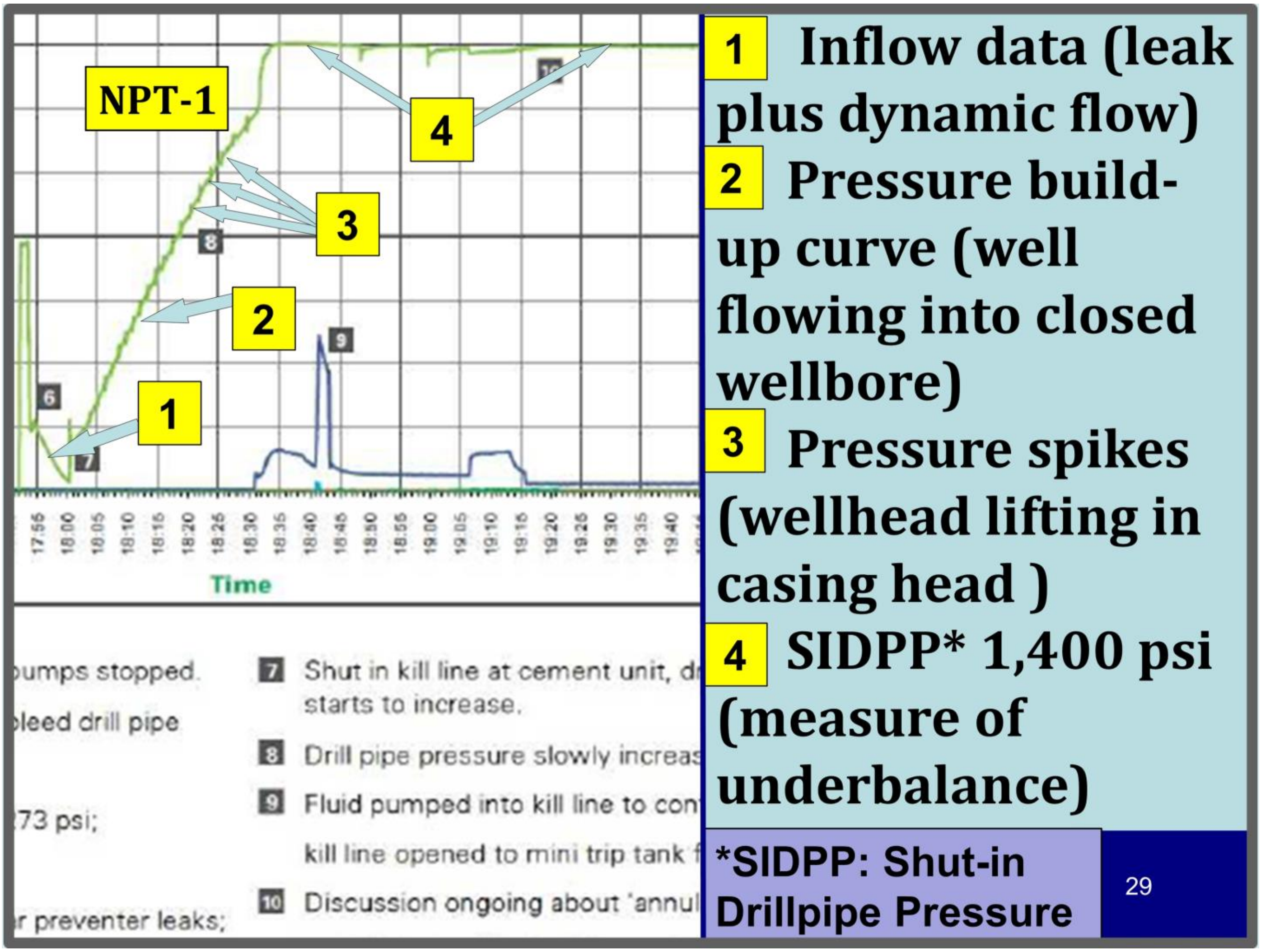
(1) Stop the NPT

(2) Resolve the interruptive data

(3) Remediate the problem

* * *

So, let's look back at the mud-logging chart that showed NPT-1 data.



Slide 29

For the 8,367-foot deep NPT-1, as shown in **Slide 29**, the *Interruptive Data* presented itself from 5:55-6:00 p.m. (the Yellow #1)

The ***Process Interruption Protocol*** says that when faced with *Interruptive Data* that was not part of the plan, *Stop the process*, which means *Stop NPT-1*. No more negative-pressure testing. No NPT-2. Now is the time to put our entire focus on the NPT-1 *Interruptive Data*.

A thorough examination of the *Interruptive Data* at the end of NPT-1 reveals, without ambiguity, that there are only two likely sources of the extra 15 barrels of seawater from the drillpipe: (1) through a leaking annular BOP, or (2) from the deep wellbore and annulus.

In looking at the *Interruptive Data*, we would have asked if the annular BOP closing pressure was again insufficient, and if mud from the riser had bled past the annular and forced 15 barrels of seawater up the drillpipe. For Macondo, the data show otherwise. The riser was checked (after 15 barrels flowed back) and was found to be full of drilling mud. Therefore, no mud leaked from the riser past the annular to lift seawater up the drillpipe.

See more in Q&A on this topic (**Q&A-1**).

As we continue to look at the NPT-1 6:00 p.m. *Interruptive Data*, the other alternative is that the reduced wellbore pressure—severely under-balanced by NPT-1—somehow invited flow from the annulus into the wellbore. And since we ran the negative-pressure test to look for leaks—perhaps we've found one. This supposition would have matched the data, as such flow down the annulus and up the casing would lift seawater from the drillpipe, and the same flow would disallow us to bleed the drillpipe pressure to zero. For these reasons, along with the immediately subsequent pressure-build-up curve and the 1,400-psi shut-in drillpipe pressure, the data show without ambiguity that the flow was from the deep reservoir, down the annulus, and up into the underbalanced (low-pressure) wellbore.

Alternatively, as later argued in court, if the casing had been breached (i.e., just below the float collar), the flow path would have been directly into the side of the casing, rather than down the annulus and up the shoe track. This topic is discussed in **Q&A-2**.

Hence, had the ***Process Interruption Protocol*** been followed for Macondo, NPT-1 would have been officially stopped shortly after 6:00 p.m., and the *Interruptive Data* (bolstered by the build-up data that immediately followed) would have led to the right assessment. Namely, that the *Interruptive Data* generated by the significantly reduced NPT-1 wellbore pressure: (1) *proved communication with the annulus* and (2) *invited the formation to flow* into the underbalanced wellbore.

As a direct result of applying the ***Process Interruption Protocol***, the simple conclusion would have been:

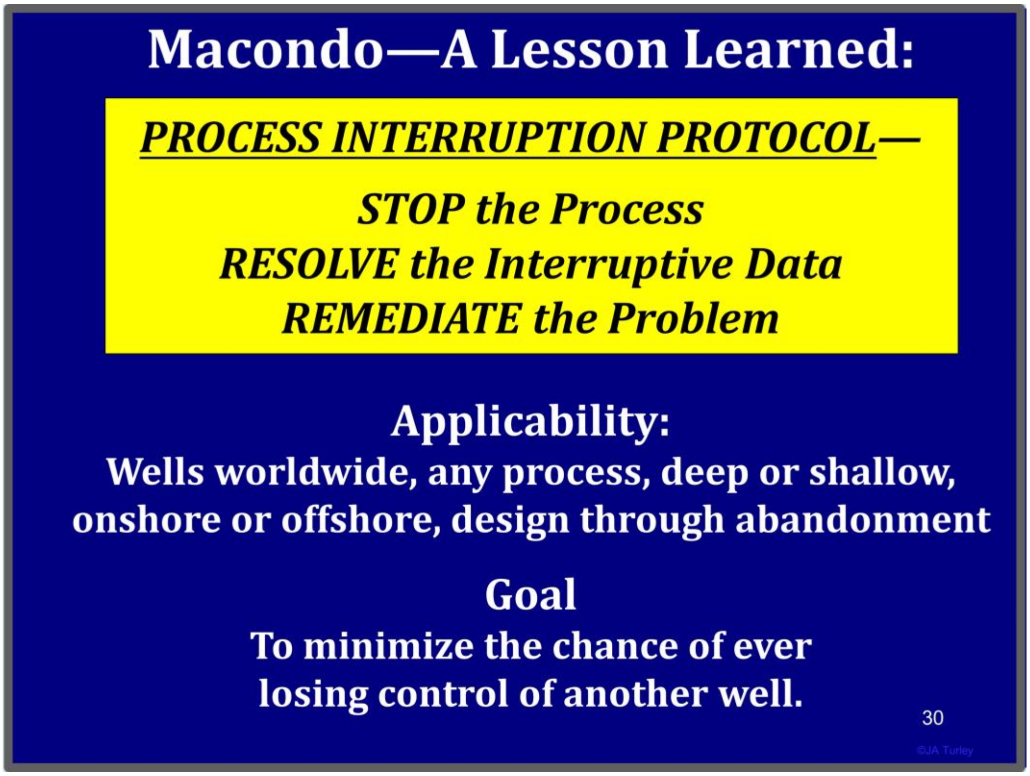
(1) There is a leak between the wellbore and the annulus.

(2) The problem must be investigated and remediated before we continue with the temporary-abandonment procedure.

In hindsight, and with weeks and months to look at data, we were able to discover float-collar and rat-hole problems that caused the silent leak. But on the rig, in real time, those conclusions were not so obvious.

But . . .

This clear-cut, unambiguous assessment of annular communication would have led the operator to mandatorily change the temporary-abandonment plan, and commence identification and remediation of the leak.



Slide 30

As summarized in **Slide 30**, the purpose of this presentation is to show that an engineering *Assessment* of Macondo data justifies *Application* of a simple, proven, problem-solving methodology (***Process Interruption Protocol***) that not only would have been applicable—and lifesaving—on Macondo, but that will also be applicable to other wells.

By identifying incremental processes throughout the drilling of any well, the lessons learned from Macondo—the ***Process Interruption Protocol***— allows us to apply the technique and minimize the chance of ever losing control of another well.

QUESTIONS AND ANSWERS

(Q&A)

Throughout this written presentation, I've endeavored to recall a litany of Q&A sessions, wherein questions came from every direction—young engineers, service company experts, corporate executives, litigators, petroleum engineering faculty, world-class offshore drilling engineers, and, of course, a diverse cross-section of other petroleum engineers from around the world. And from those questions, I've bolstered and salted my generic presentation with answers, as appropriate, throughout.

But there are other Q&A topics, raised in technical sessions around the world, that I'll address here.

Q & A Topics

Q&A-1)—*The Bladder Effect:*

This term—phenomena—was apparently first tabled and debated on the rig just after 6:00 p.m., as the causal reason the well produced 15 barrels and the drillpipe pressure would not bleed to zero. The argument was devoid of any kind of engineering assessment.

Regardless of the *basis* of the argument (fluid leakage through the annular, or the annular rubber being pushed deeper into the BOP by heavy mud in the riser, or a bubble of gas under the annular BOP, or whatever, whether real or imaginary), the *result* of the argument being won was devastating . . . causing NPT-1 to be aborted and NPT-2 to be commenced.

Here, in the spirit on the ***Process Interruption Protocol***, let us allow the hypothetical *bladder effect* to become a part of the *Interruptive Data*. That means the *bladder effect*, as related to the annular BOP, needs to be resolved . . . from an engineering perspective.

And such resolution would have been simple. To do so, recall the NPT is a simulation. The well is kicking *only* because the annular BOP is closed around the seawater-filled drillpipe. So, to get rid of the BOP-related bladder effect, let's take the annular BOP out of the process.

A three-step procedure to take the annular BOP out of the NPT equation will give us quick resolution: (1) Open the annular BOP, and note the well is immediately dead (1,000 psi overbalanced), and then (2) close the VBR (variable-bore ram), which contains no "bladder," and then (3) repeat the NPT pressure-reduction process through the drillpipe.

With the annular BOP bladder taken out of the equation, the repeated NPT through the drillpipe (using the closed VBR) would once again expose the deepest casing and annulus to the extreme drawdown. But with the path down the annulus and into the wellbore already flushed by the original 15 barrels of flow from the formation, the well would have kicked sooner and harder (with higher flow rates), and would have more rapidly settled at the SIDPP of 1,400 psi. All of which would have led to the same conclusion—repeated here for clarity:

(1) There is a leak between the wellbore and the annulus.

(2) The problem must be investigated and fixed before we continue with the temporary-abandonment procedure.

* * *

Q&A-2)—*Casing breach below the float collar*:

This point was argued in court by expert technical witnesses with high incentive to win the breach/no-breach debate on behalf of their opposing respective clients. I have no vested interest in caring which witnesses wore red, blue, or green ties.

Specifically, a claim was made (and disputed) that there was a likelihood (without proof) the casing had been breached (i.e., a wide-open hole in the casing) just below the float collar. The claim was based on two technical reasons: (1) during the casing running procedure, the casing took load and had to be worked through the original under-reaming ledge at 18,130 feet (pictured in **Slide 5**); and (2) immediately after the casing was run (prior to cementing), it took more than 3,000 psi to finally break circulation . . . which was argued as evidence of the breach being formed.

The counter argument was that it took 3,000 psi to clear cuttings from the plugged guide shoe.

The crux of the argument was that given such a breach, there would have been no annular or shoe-track cement below the breach, leaving almost half of the pay zone un-cemented and exposed to the open wellbore (though the wide-open breach and the open float collar).

There was no hard data *presented* to counter either argument, so I will let the data we've already seen speak for itself. Specifically, we saw Macondo flow 15 barrels in five minutes, before the well was shut-in. Afterwards, the continued flow into the low-pressure wellbore was so slow that it took 35 minutes (recall the pressure-buildup curve) to pressure the wellbore to the equilibrium SIDPP of 1,400 psi.

That being said, had the flow been through an open breach in the middle of the pay zone, as claimed, with more than 1,000 psi of underbalance (an inch from the proven-high-capacity *un-cemented* Macondo reservoir), the resulting kick would have manifested explosively fast, measured in seconds.

That did not happen.

Conversely, the actual flow path was so arduous it took 35 minutes for the produced fluid to pressure-up the casing to 1,400 psi. *Arduous*, as in: hydrocarbons flowing down through 100 feet of mud-contaminated-cement in the three-quarter-inch-wide annulus, and then up through the mud-contaminated cement in the 180-foot shoe track, before flowing through the open (not-converted) float collar and into the wide-open wellbore.

Bottom line: the slow-flow-rate kick data seen in the pressure-buildup curve confirm there was no breach in the casing below the float collar.

* * *

Q&A-3)—*Spotting high-density mud in the rat hole*:

This would have been a zero-time, zero-dollar action. To wit: while circulating bottoms-up after logging, just before pulling the bit for the casing job, the driller calls the mudroom to make a small but heavy (i.e., 17-ppg) mud pill. When ready, the driller flips a switch, picks up the i.e., 10-barrel pill, and counts strokes to place it on bottom before pulling the bit and leaving the pill behind. With that simple procedure, the rat-hole gravity-segregation problem goes way. This was not done on the Macondo well.

It's important to say here that any deep, hot, high-pressure cement job can experience problems. The Macondo production-casing cement job, as designed, had its own share of built-in *potential* problems—cement quality and set time, small cement volume, slow displacement rate, pressure-sensitive annulus, multiple workstring and casing sizes, and tight-fitting casing (7-inch inside 8-1/2-inch hole). With so many *potential* problems that might affect final cement quality, one such almost-guaranteed (as opposed to *potential*) problem had an easy solution—prevention of cement contamination by spotting a heavy-mud pill in the rat hole. Without the pill, the resulting gravity-segregation began the moment the cement job was complete—long before the heavy cement had even the slightest chance of curing while setting above the lighter-weight oil-base mud in the rat hole.

* * *

Q&A-4)—*Use of dispersant after the Macondo blowout*.

Though my talk targets the *cause* of the blowout, months of public and media pressure about environmental impact increased public and industry concern across the nation and worldwide. I was asked about the Macondo dispersant during presentations at several locations, including the Evangeline (Lafayette, Louisiana) Sierra Club; Melbourne, Australia; and St. John's, Newfoundland (to name a few), which opened the door for the following answer.

BP's Macondo well flowed for 86 days and spilled 5 million barrels of crude oil. The spilled oil was "dispersed" with Corexit®, as preauthorized by the U.S. EPA for oil spills in navigable waters. Environmental experts (including, for example, marine biologists and environmentalists from my alma mater, the University of Miami) speak ***with vigor*** against toxic, slow-acting, inefficient Corexit®, and they recommend non-toxic, faster-acting, more-efficient, enzyme-based bioremediation agents. There may be many brands, but one is OSE-II. Such products, proven around the world, don't disperse the oil; they work by causing indigenous bacteria to get very hungry for oil.

The U.S. EPA misclassifies such products as bacteria-based (though there are no bacteria in the products) and has declared them unsuitable for oil spills in U.S. navigable waters.

Post-Macondo hydrocarbon spills (i.e., Santa Barbara County, in 2015) have used and will continue to use the same ineffective Corexit® dispersant unless the EPA can be convinced otherwise. For more technology-based information on this hotly debated topic, see: **www.ProtectMarineLifeNow.org**

* * *

Q&A-5)—*Macondo topics not covered herein.*

My view while studying Macondo was as if I were watching an autopsy by coat-and-tie attorneys who were pretending to be pathologists trying to determine not why the patient had died during a physical exam but how to allocate liability for the patient's death. And I didn't like what I saw. And I'd like to never see it again. So, I kept my assessment of Macondo simple.

Accordingly, my focus for this presentation has been on: (1) assessing data that define the definitive mechanical and operating steps and decisions that contributed to and caused the blowout, and (2) applying lessons learned from Macondo to future work.

Further, the following *additional* topics were not (could not be) included during my short verbal presentations, but are of interest to a wide audience. Each is addressed in *THE TRUTH,* but I list them here for others to debate:

(1) drilling the Macondo pay interval below the lost-circulation zones (note: I address geologic hazard drilling, specifically transition-zone drilling, in *THE TRUTH*, as per my 1976 (not a typo!) SPE paper: "A Risk Analysis of Transition Zone Drilling";

(2) not circulating prudent/recommended volumes of mud to clear the wellbore before running casing;

(3) running a long string of production casing versus a liner with or without a tie-back;

(4) using nitrified cement;

(5) fluid losses during the cement job

(6) running fewer-than-recommended casing centralizers;

(7) not running a CBL (cement bond log); and

(8) other credible topics way beyond the scope of my one-hour presentation.

Additional Macondo-blowout topics not in my presentation continue to be covered in-depth by others, including: (1) the entire list of highly credible "Umbrella topics" that I listed in the text for **Slide 21**, and (2) all *post-blowout* decisions and activities that occurred aboard the *Deepwater Horizon* the night of 20 April 2010 and during the subsequent months-long killing of the Macondo well.

In the world of could've, would've, should've, and because I was limited to about an hour of presentation time, my apologies (though without remorse) if I left out anybody's hot-button topic(s).

* * *

Q&A-6)—*Post-Macondo blowouts*

Though my goal for Macondo was specific relative to CAUSE, I was also convinced the assessment of the data and application of results would ultimately help the industry's entire well-management community to minimize the chance of ever losing control of another well.

Maybe that has happened. It's not improbable that somebody read my book or heard my presentation and made a related decision that kept a well safe. But there's no way to ever know . . . because a well *NOT LOSING CONTROL* is the norm.

Yet, in the years since BP's Macondo blowout there have been other significant blowouts around the world. I have not researched for even a minute any of these events, which I will leave to others.

I can only hope a plethora of my young engineering colleagues will: (1) use every academic, intellectual, common-sense, and on-the-job-training tool they have so they can manage and take responsibility for every well they're ever involved with, and (2) look in depth at each failure—by assessing and applying—and perhaps add to the Macondo story, always with the same goal—to minimize the chance of ever losing control of another well.

IN CLOSING

A number of good people recently asked me why I wrote the book, and why, ultimately, I made all those presentations. My answer, in a couple dozen words, is:

Only if we understand and care about

the cause of BP's Macondo blowout,

will we know why it should not have happened

and why it should never happen again.

Or, more succinctly:

Passion

For your part, I invite you to do three things:

(1) apply the lessons learned herein throughout the rest of your career, to every well, onshore, offshore, around the world;

(2) PLEASE encourage each of your colleagues and connections, without limit, to go to my website (**JohnTurleyWriter.com**) and download his or her own free copy of this presentation, and remind them to encourage others to do the same; and

(3) read the facts-based book, *THE SIMPLE TRUTH: BP's Macondo Blowout*, whether you borrow it from a colleague, or get it from your library, or purchase it through Amazon.

After you've absorbed this document, and after you've read the book and shared it with a friend, and perhaps after you've seen the movie *Deepwater Horizon* (the debut was 30 September 2016), I look forward to hearing from you.

I welcome edits, suggestions, and comments to:

John Turley at:
jatmessages@gmail.com
or to: J.A. (John) Turley on LinkedIn
Website: JohnTurleyWriter.com

ADDENDUM ONE

Documents extracted from

THE SIMPLE TRUTH:
BP's Macondo Blowout

DIAGRAMS (1-22)

The following photos and full-scale schematics are from *THE SIMPLE TRUTH: BP's Macondo Blowout*. Many of the *Diagrams* were used (as noted) as the base drawings for *Slides* in this presentation.

Diagram 7—(Photo) *Deepwater Horizon*—pre-blowout (permission on file)

Diagram 8—Install 18-inch Liner

Diagram 9—Well Kicks below 18-inch Liner

Diagram 10—Install 16-inch Long Liner

Diagram 11—Install 13-5/8" & 11-7/8" & 9-7/8" Liners

Diagram 12—Production Liner Option

Diagram 13—Liner Tie-back Option

Diagram 14—Conversion of Float Collar

Diagram 15—Install 9-7/8" X 7" Production Casing

Used in presentation Slide 4

Diagram 16—Production Casing Cement Job

Used in presentation Slide 5

Diagram 17—Wellhead, Hanger, & Lockdown Seal Ring

Diagram 22—Production Casing—Rat-hole Implications

Used in presentation Slide 8

Diagram 18—Abandonment Simulation

Used in presentation Slides 9 and 10

Mudlogging Chart—BP's Internal Investigation—Page 88

Used in presentation Slides 13, 14, 15, 29

This document was discussed in, but was not presented in, *THE SIMPLE TRUTH*

Diagram 19—Negative Pressure Tests

Diagram 20—Leak, Displacement, and Flow

Used in presentation Slides 16, 17, 18

Diagram 21—(Photo) Transocean *Deepwater Horizon*—post blowout

* * *

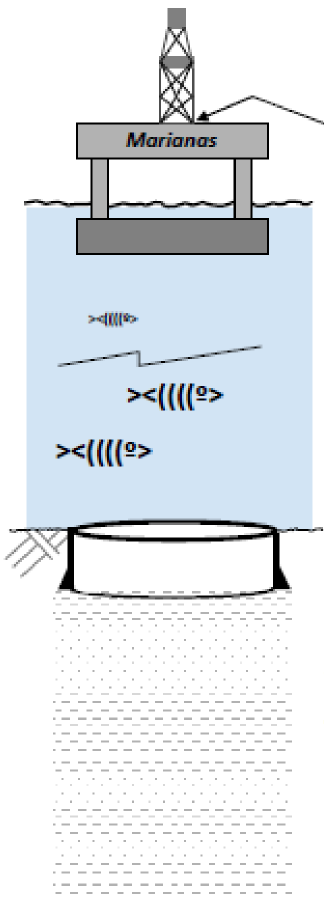
NOTE: I have not included my 160+ *Footnotes* or *References* from *THE SIMPLE TRUTH*, as they have not been referenced in any of my presentations, and they are integral to the data-driven book's story and its 50-page Epilogue.

Diagram 1 (Photo)
Transocean's
Transocean Marianas

Source & Permission
on file

Diagram 2

Mississippi Canyon Block 252 #1—Macondo—*Transocean Marianas*
Install 36-inch structural casing



Rig Floor (RKB) at zero feet

Sea level at 75 feet RKB

Gulf of Mexico is 4,992 feet deep at location of Macondo well

Seafloor at 5067 feet RKB

36-inch structural casing at 5,321 feet RKB

While the 36-inch casing was being jetted to its target depth, the "drilled cuttings" (sand and shale) spilled onto the seafloor

Note: Casing, after installation below the seafloor, is as shown above. For reader orientation, the drilled part of the well may be better visualized as follows:

Hole drilled | **Cutaway view** | **Casing installed**

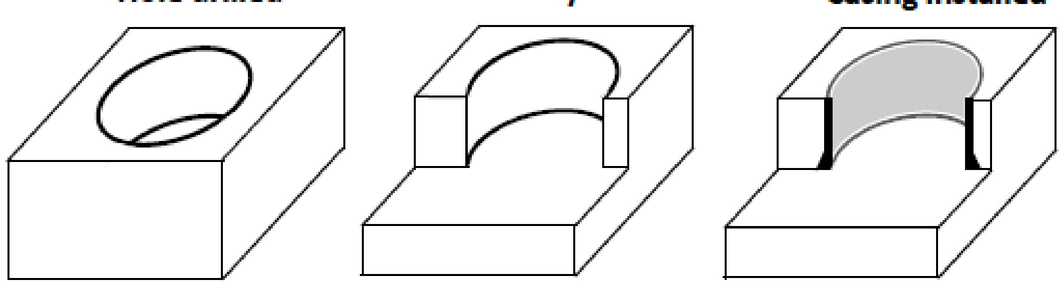
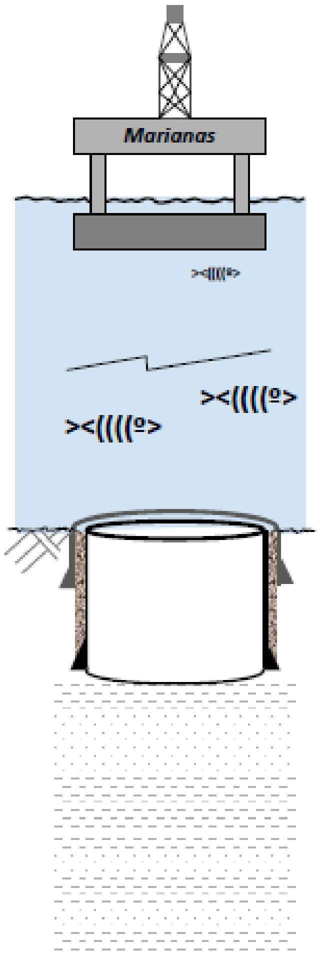


Diagram 3
Install 28-inch casing



Rig Floor (RKB) at zero feet

Sea level at 75 feet RKB

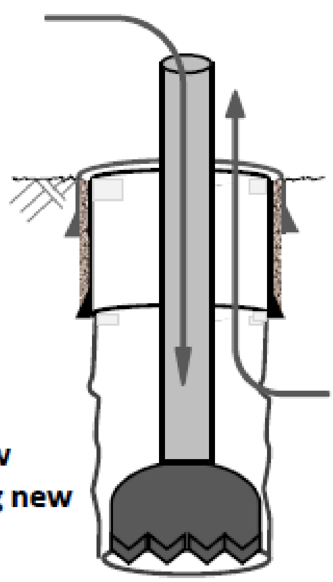
Seafloor at 5067 feet

36-inch structural casing at 5,321 feet

28-inch casing at 6,217 feet

While drilling below the 36-inch casing, the drilled cuttings spilled onto the seafloor. After running the 28-inch casing, crews filled the annulus outside the casing with cement from the shoe (bottom of the casing) to the seafloor. To drill deeper, see below.

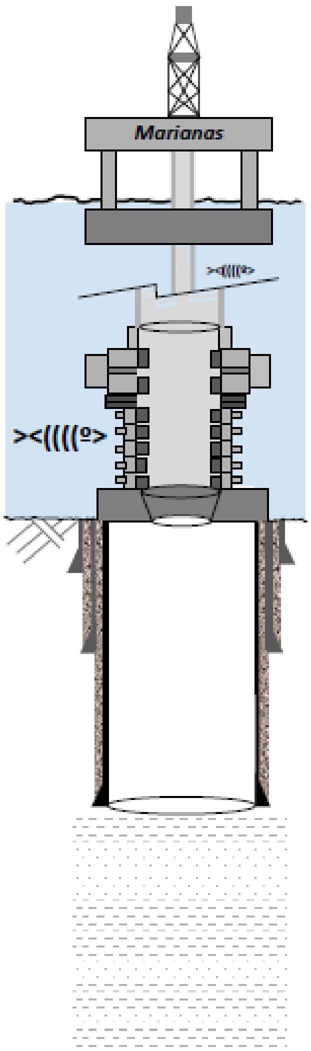
Drilling fluid (mud or seawater) pumped from the rig, down the drill string, and through the drill bit, where it mixes with drilled cuttings.



Drilling fluid and cuttings leave the bit and are pumped up the annulus, then spill onto the seafloor.

Drill bit drilling below 28" casing, preparing new hole for 22" casing

Diagram 4
Install 22-inch casing with Wellhead



Rig Floor (RKB) at zero feet

Sea level at 75 feet RKB

Marine Riser (connects rig to blowout preventer and wellhead)

Blowout Preventers (BOPs) on top of Wellhead at 5,057 feet

Seafloor at 5,067 feet

36-inch structural casing at 5,321 feet

28-inch casing at 6,217 feet

22-inch casing at 7,937 feet, with wellhead permanently attached at 5,057 feet

While drilling below the 28" casing, the cuttings went to the seafloor. After running the 22" casing and the wellhead, the 22" casing's annulus was filled with cement from the casing shoe to the seafloor.

This critical step allowed the BOPs (18-3/4" inside diameter) to be installed on top of the wellhead, and the riser (21" outside diameter) to be installed on top of the BOPs. Note: scale of drawings is exaggerated

New drilled cuttings from below the 22" casing will be circulated up the drillpipe annulus (through rock, casing, BOP, and riser) to the rig

Diagram 5

Cameron--18-3/4-inch, 15,000-psi Blowout Preventer

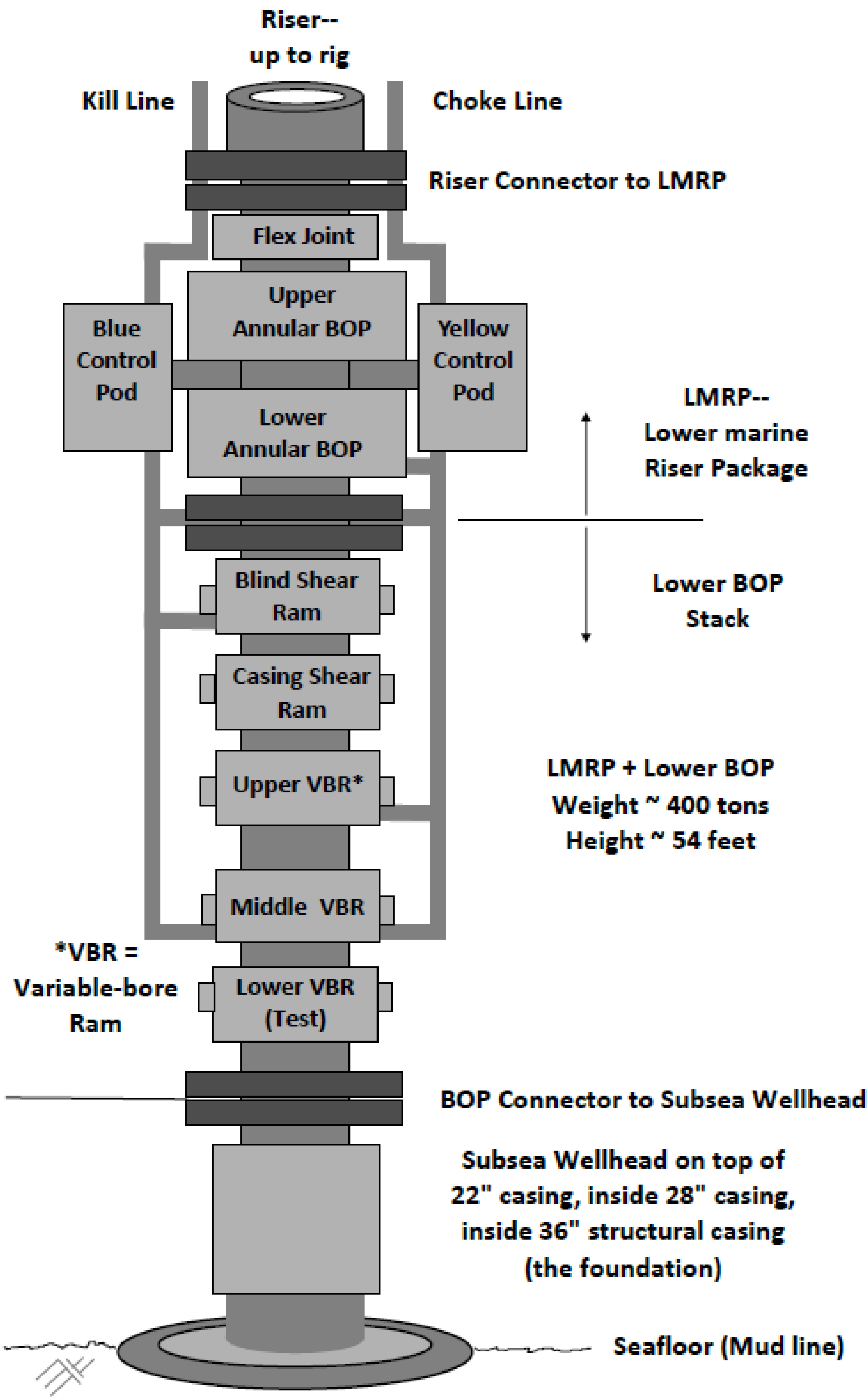
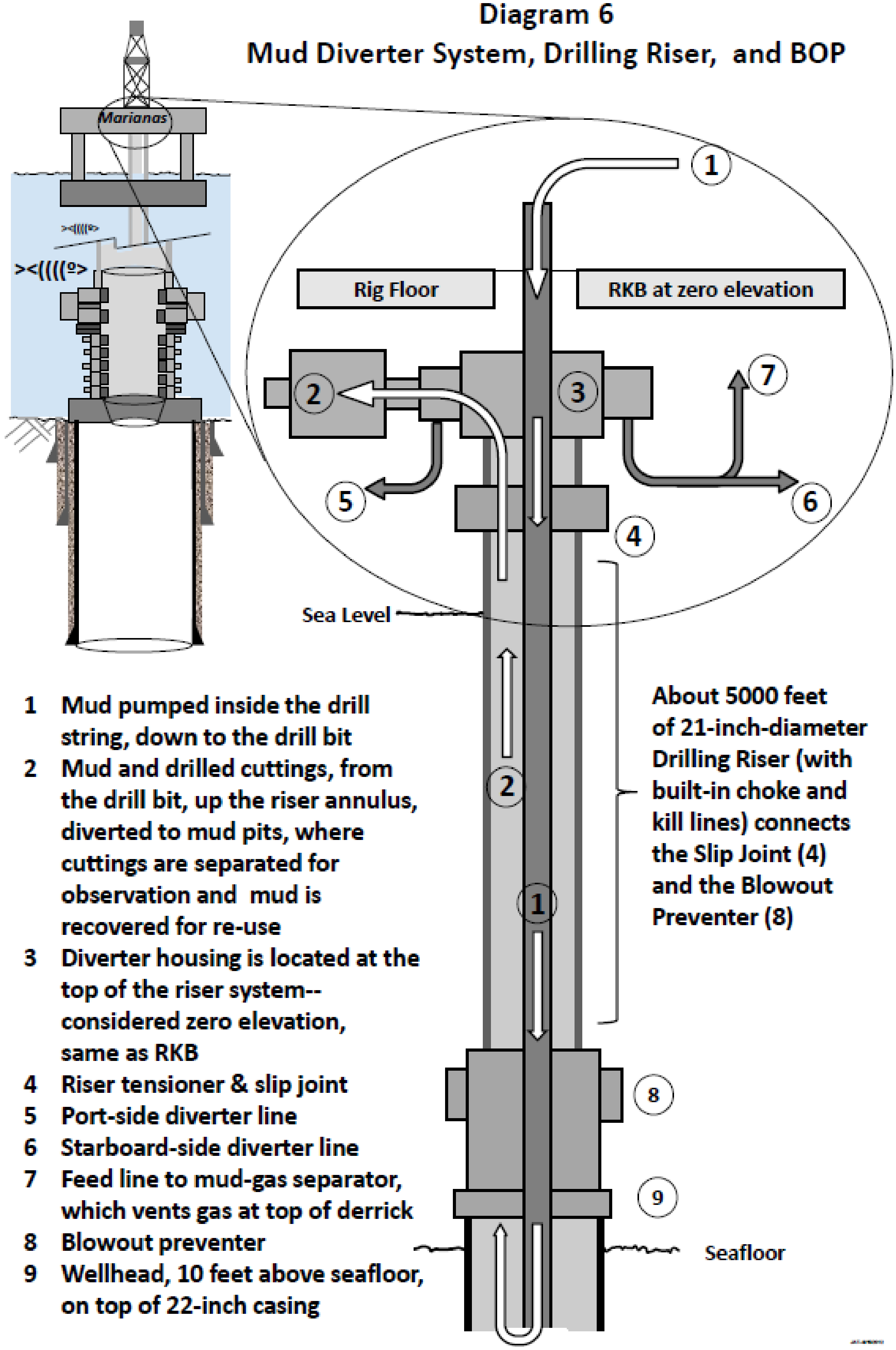


Diagram 6
Mud Diverter System, Drilling Riser, and BOP



1 Mud pumped inside the drill string, down to the drill bit
2 Mud and drilled cuttings, from the drill bit, up the riser annulus, diverted to mud pits, where cuttings are separated for observation and mud is recovered for re-use
3 Diverter housing is located at the top of the riser system--considered zero elevation, same as RKB
4 Riser tensioner & slip joint
5 Port-side diverter line
6 Starboard-side diverter line
7 Feed line to mud-gas separator, which vents gas at top of derrick
8 Blowout preventer
9 Wellhead, 10 feet above seafloor, on top of 22-inch casing

Diagram 7 (Photo)

Transocean *Deepwater Horizon*

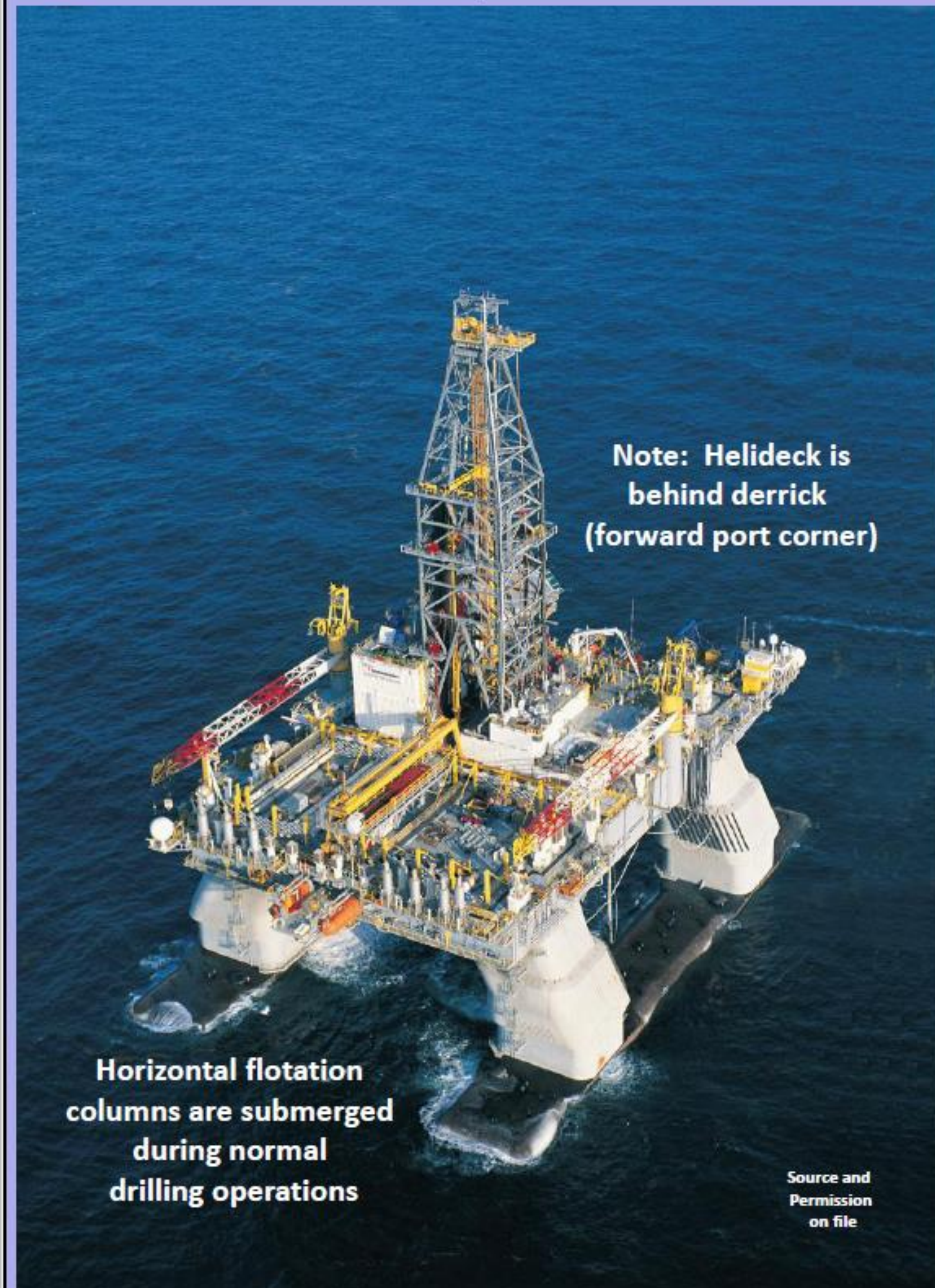
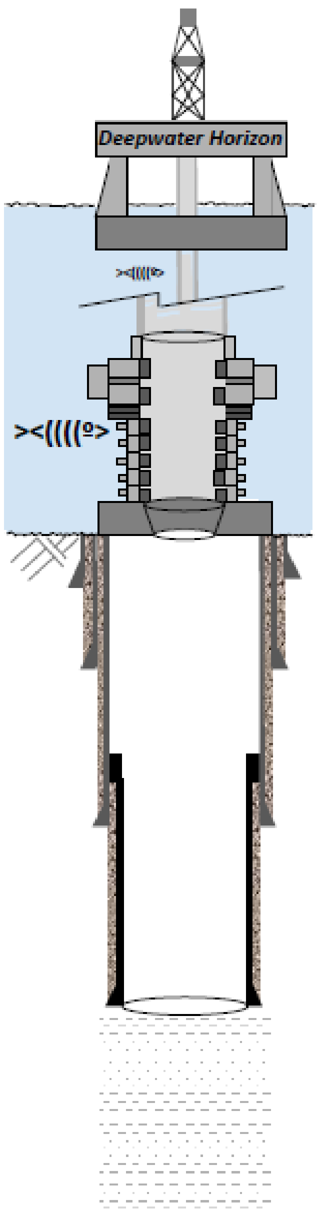


Diagram 8
Install 18-inch liner



Rig Floor (RKB) at zero feet

Sea level at 75 feet RKB

Marine Riser

Blowout Preventers (BOPs) on top of Wellhead at 5,057 feet

Seafloor at 5,067 feet

36-inch structural casing at 5,321 feet

28-inch casing at 6,217 feet

22-inch casing at 7,937 feet with Wellhead attached

18-inch liner at 8,969 feet (top of liner at 7,489 feet)

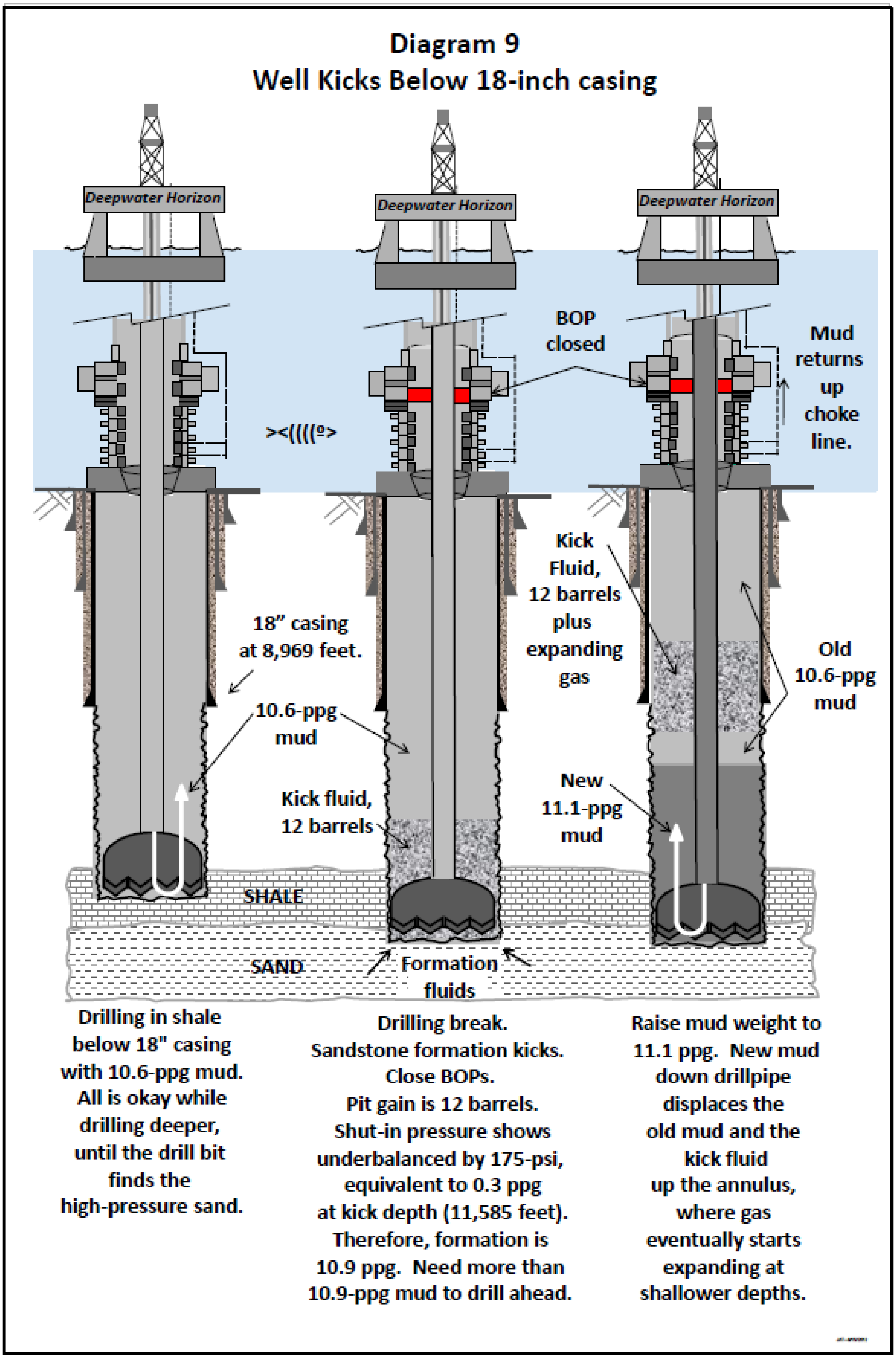


Diagram 9
Well Kicks Below 18-inch casing
Deepwater Horizon
Deepwater Horizon
Deepwater Horizon
BOP closed
Mud returns up choke line.
><((((º>
Kick Fluid, 12 barrels plus expanding gas
18" casing at 8,969 feet.
10.6-ppg mud
Old 10.6-ppg mud
Kick fluid, 12 barrels
New 11.1-ppg mud
SHALE
SAND
Formation fluids
Drilling in shale below 18" casing with 10.6-ppg mud. All is okay while drilling deeper, until the drill bit finds the high-pressure sand.
Drilling break. Sandstone formation kicks. Close BOPs. Pit gain is 12 barrels. Shut-in pressure shows underbalanced by 175-psi, equivalent to 0.3 ppg at kick depth (11,585 feet). Therefore, formation is 10.9 ppg. Need more than 10.9-ppg mud to drill ahead.
Raise mud weight to 11.1 ppg. New mud down drillpipe displaces the old mud and the kick fluid up the annulus, where gas eventually starts expanding at shallower depths.

Diagram 10
Install 16-inch long liner

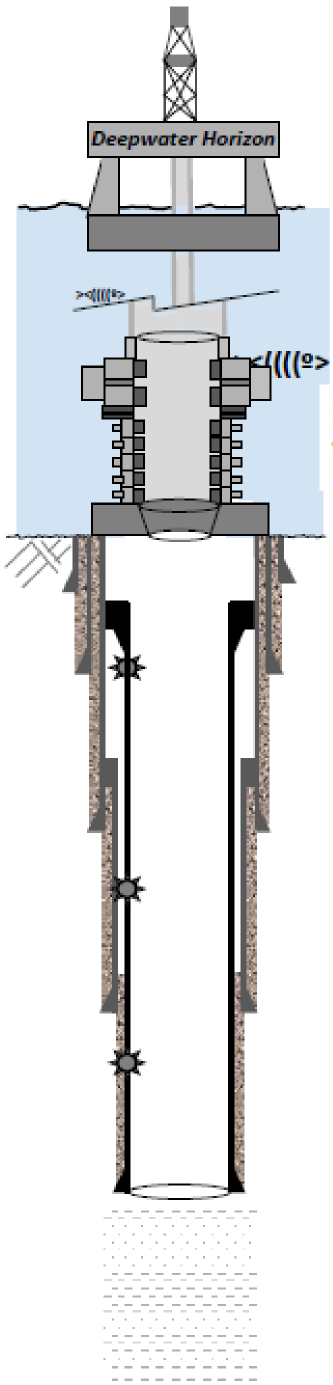


Diagram 11
Install three liners—13-5/8 and 11-7/8 and 9-7/8
(Several days between liners)

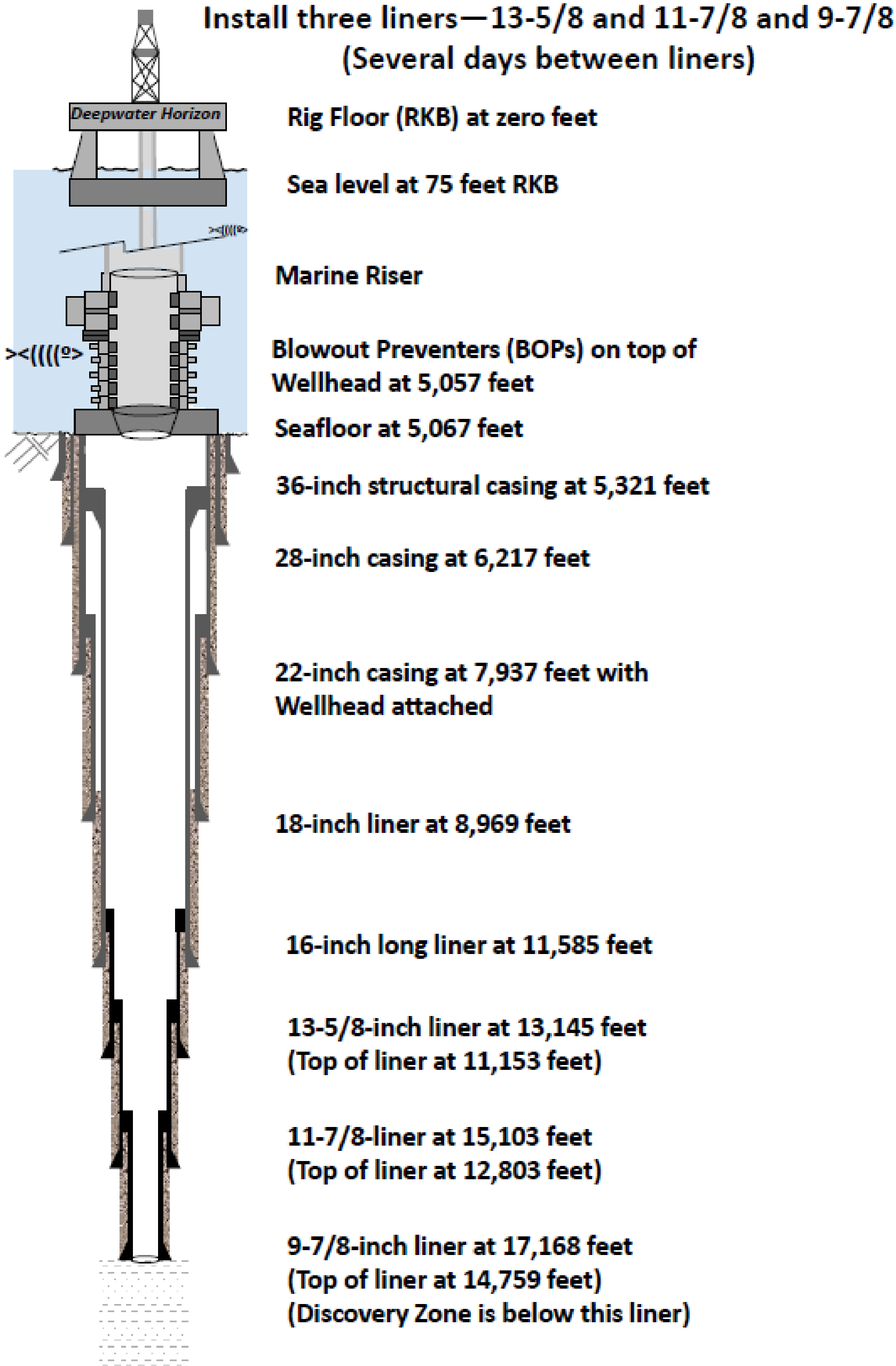
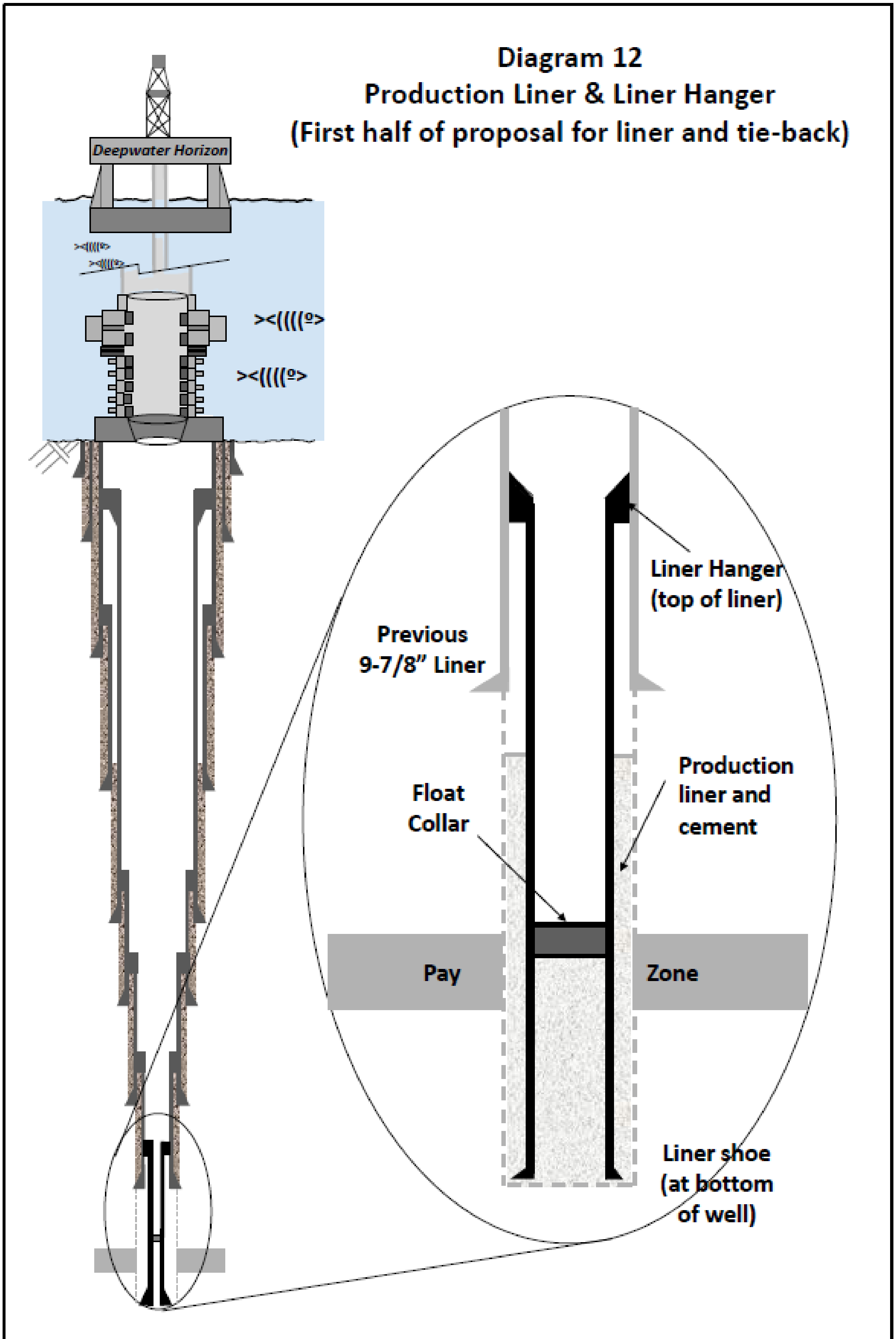


Diagram 12
Production Liner & Liner Hanger
(First half of proposal for liner and tie-back)



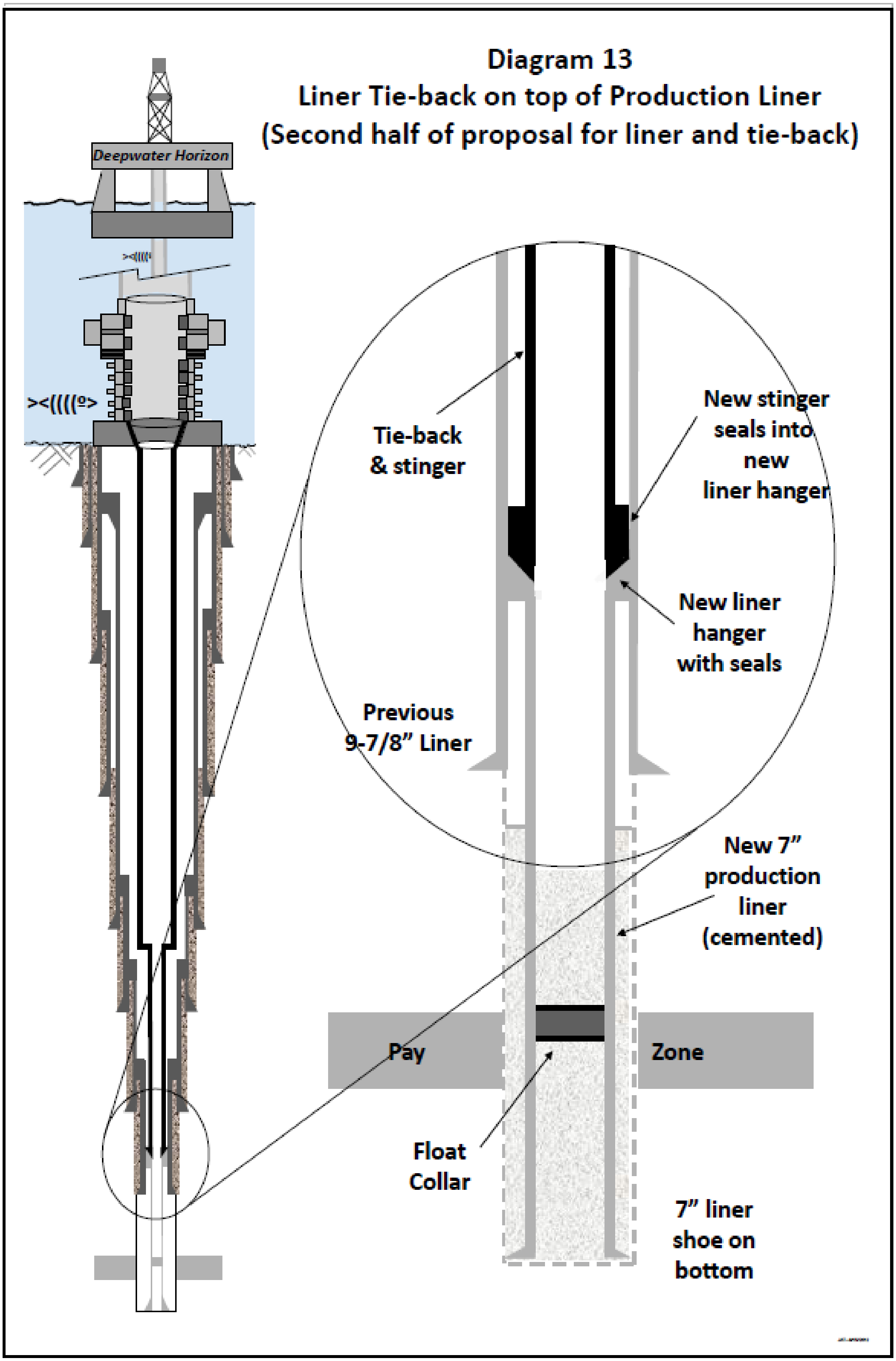


Diagram 13
Liner Tie-back on top of Production Liner
(Second half of proposal for liner and tie-back)
Deepwater Horizon
><((((º>
Tie-back
& stinger
New stinger
seals into
new
liner hanger
New liner
hanger
with seals
Previous
9-7/8" Liner
New 7"
production
liner
(cemented)
Pay
Zone
Float
Collar
7" liner
shoe on
bottom

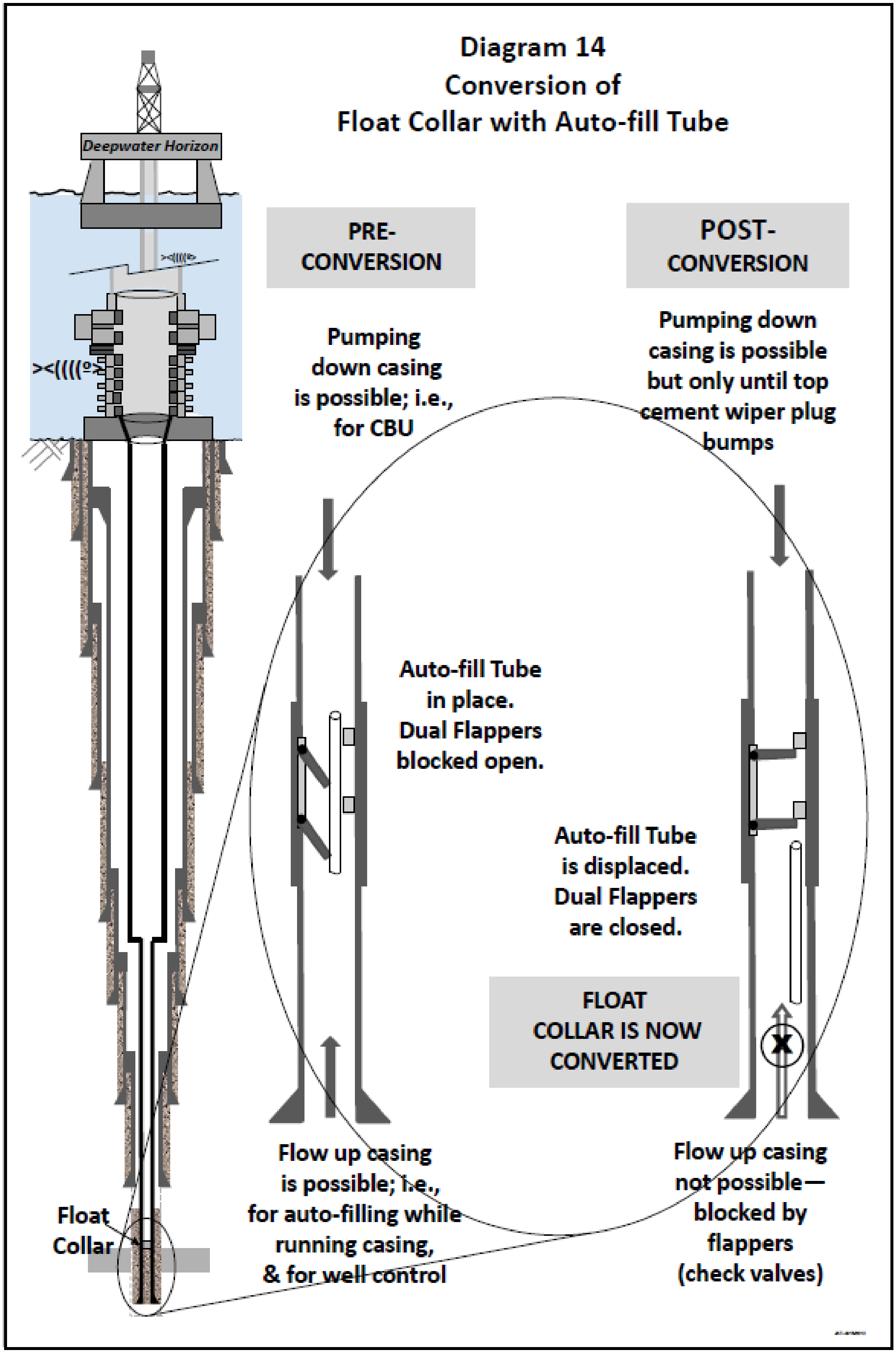


Diagram 14
Conversion of
Float Collar with Auto-fill Tube
Deepwater Horizon
PRE-
CONVERSION
POST-
CONVERSION
Pumping
down casing
is possible; i.e.,
for CBU
Pumping down
casing is possible
but only until top
cement wiper plug
bumps
Auto-fill Tube
in place.
Dual Flappers
blocked open.
Auto-fill Tube
is displaced.
Dual Flappers
are closed.
FLOAT
COLLAR IS NOW
CONVERTED
Float
Collar
Flow up casing
is possible; i.e.,
for auto-filling while
running casing,
& for well control
Flow up casing
not possible—
blocked by
flappers
(check valves)

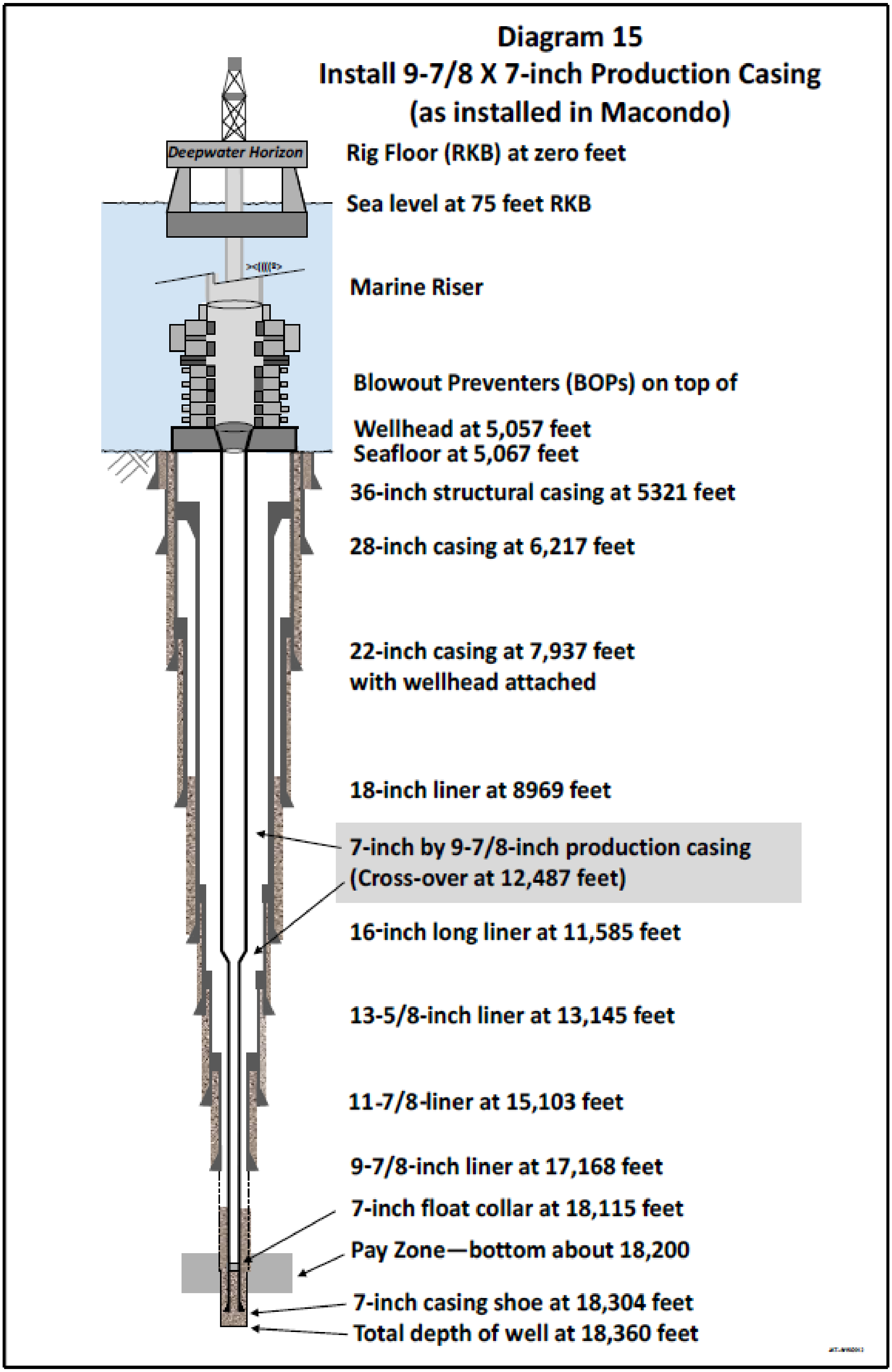


Diagram 15
Install 9-7/8 X 7-inch Production Casing
(as installed in Macondo)
Deepwater Horizon
Rig Floor (RKB) at zero feet
Sea level at 75 feet RKB
Marine Riser
Blowout Preventers (BOPs) on top of
Wellhead at 5,057 feet
Seafloor at 5,067 feet
36-inch structural casing at 5321 feet
28-inch casing at 6,217 feet
22-inch casing at 7,937 feet
with wellhead attached
18-inch liner at 8969 feet
7-inch by 9-7/8-inch production casing
(Cross-over at 12,487 feet)
16-inch long liner at 11,585 feet
13-5/8-inch liner at 13,145 feet
11-7/8-liner at 15,103 feet
9-7/8-inch liner at 17,168 feet
7-inch float collar at 18,115 feet
Pay Zone—bottom about 18,200
7-inch casing shoe at 18,304 feet
Total depth of well at 18,360 feet

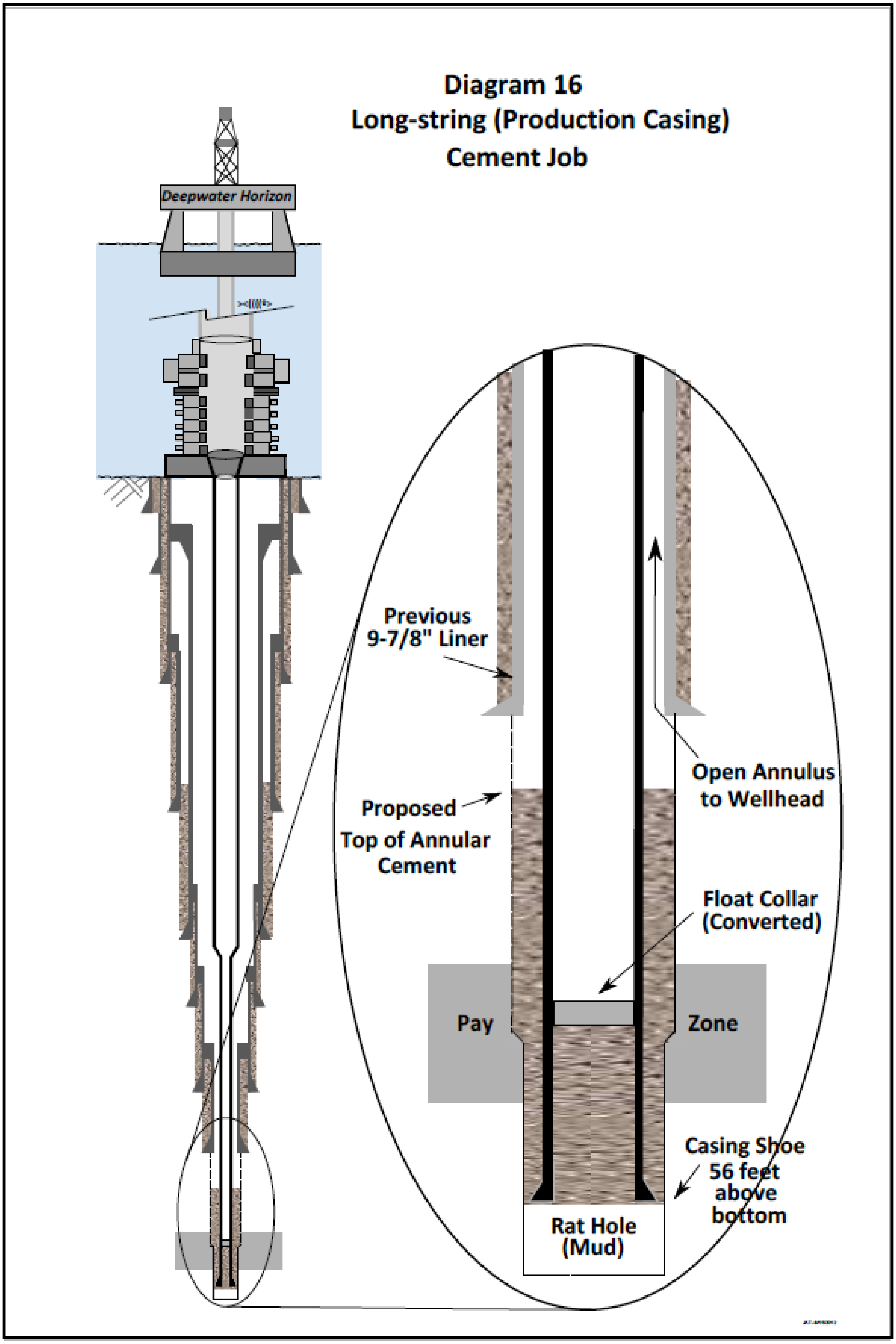


Diagram 16
Long-string (Production Casing)
Cement Job
Deepwater Horizon
Previous
9-7/8" Liner
Open Annulus
to Wellhead
Proposed
Top of Annular
Cement
Float Collar
(Converted)
Pay
Zone
Casing Shoe
56 feet
above
bottom
Rat Hole
(Mud)

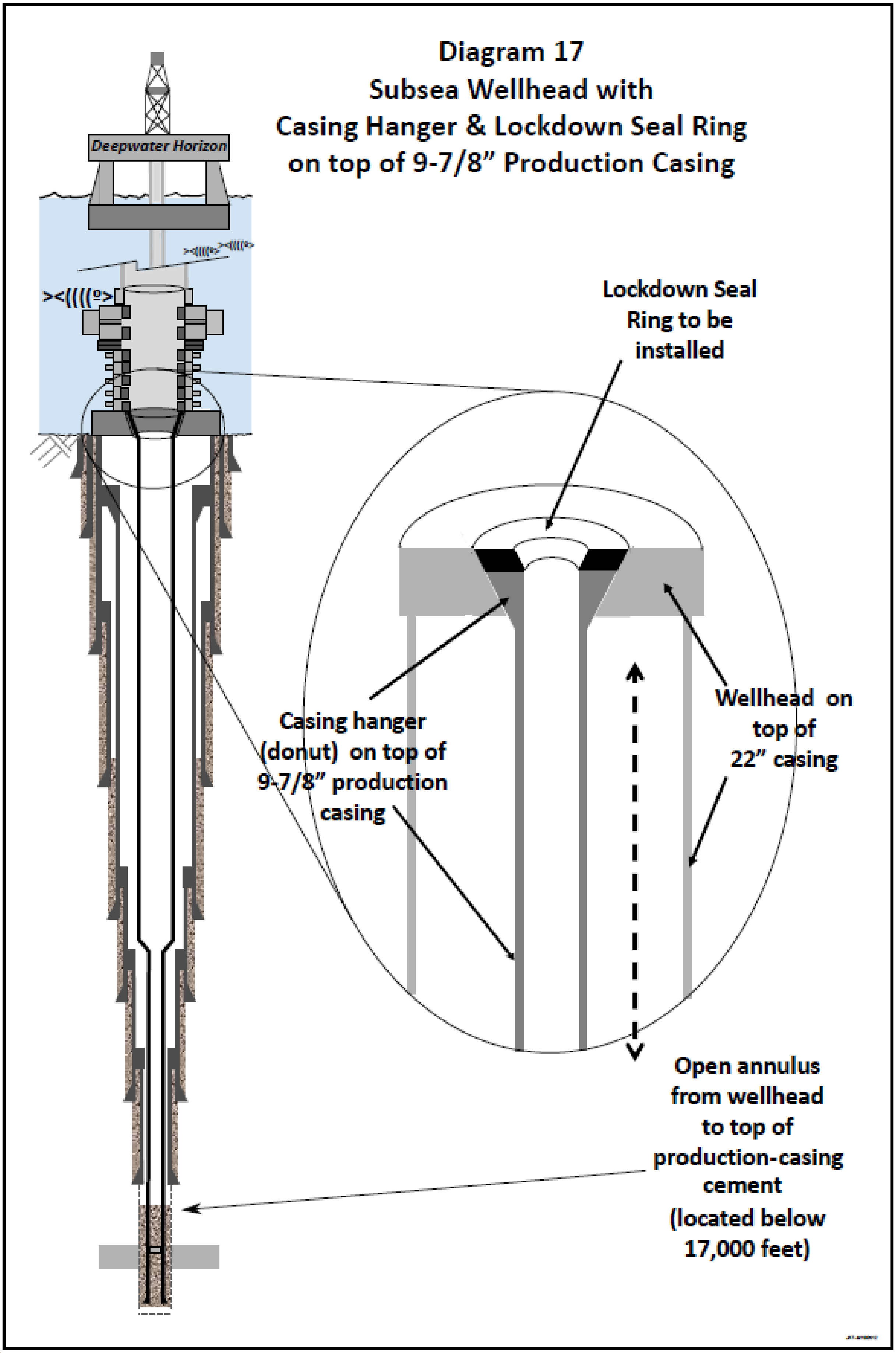
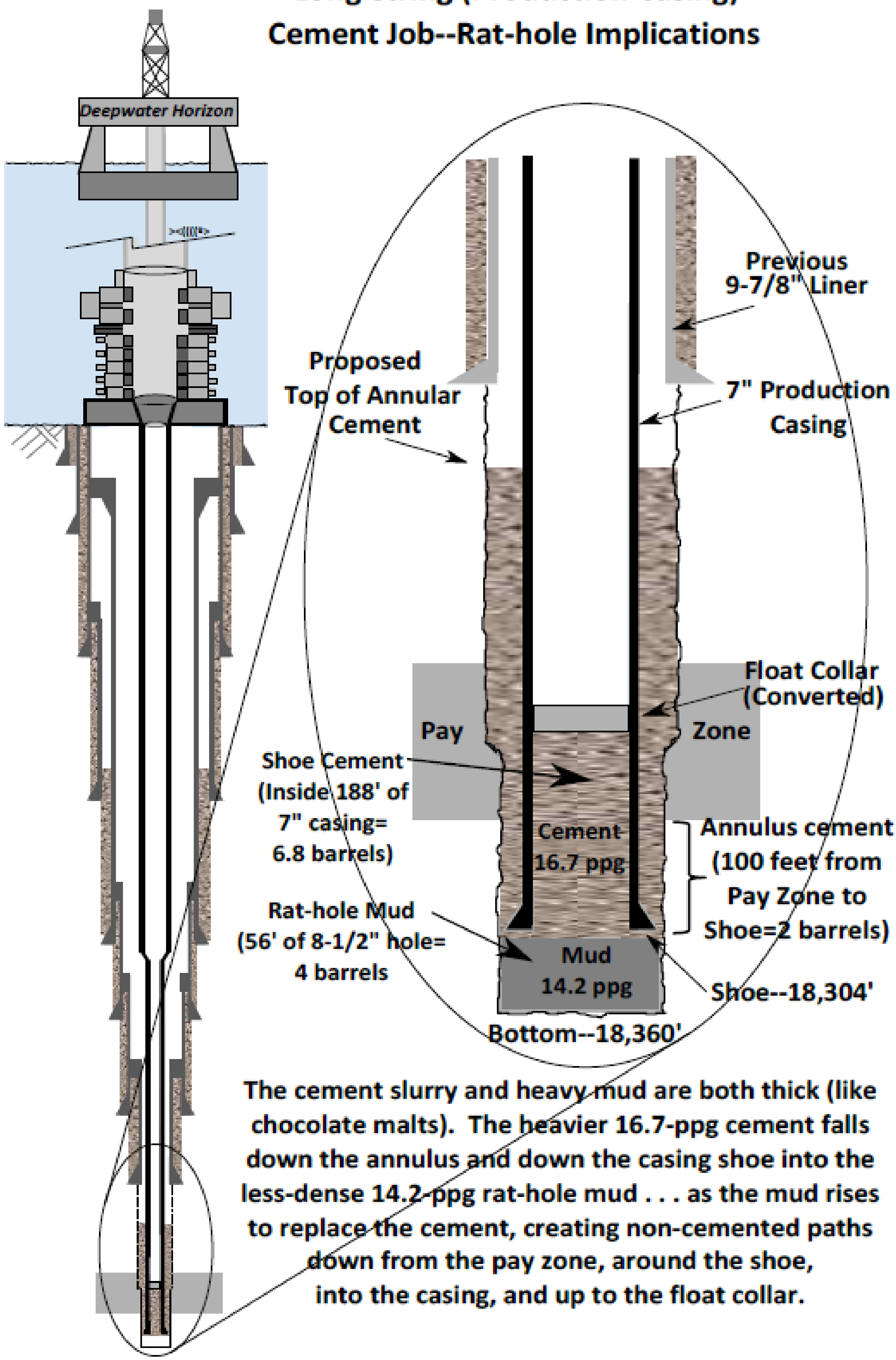


Diagram 17
Subsea Wellhead with
Casing Hanger & Lockdown Seal Ring
on top of 9-7/8" Production Casing
Deepwater Horizon
Lockdown Seal
Ring to be
installed
Casing hanger
(donut) on top of
9-7/8" production
casing
Wellhead on
top of
22" casing
Open annulus
from wellhead
to top of
production-casing
cement
(located below
17,000 feet)

Diagram 22
Long-string (Production Casing)
Cement Job--Rat-hole Implications



The cement slurry and heavy mud are both thick (like chocolate malts). The heavier 16.7-ppg cement falls down the annulus and down the casing shoe into the less-dense 14.2-ppg rat-hole mud . . . as the mud rises to replace the cement, creating non-cemented paths down from the pay zone, around the shoe, into the casing, and up to the float collar.

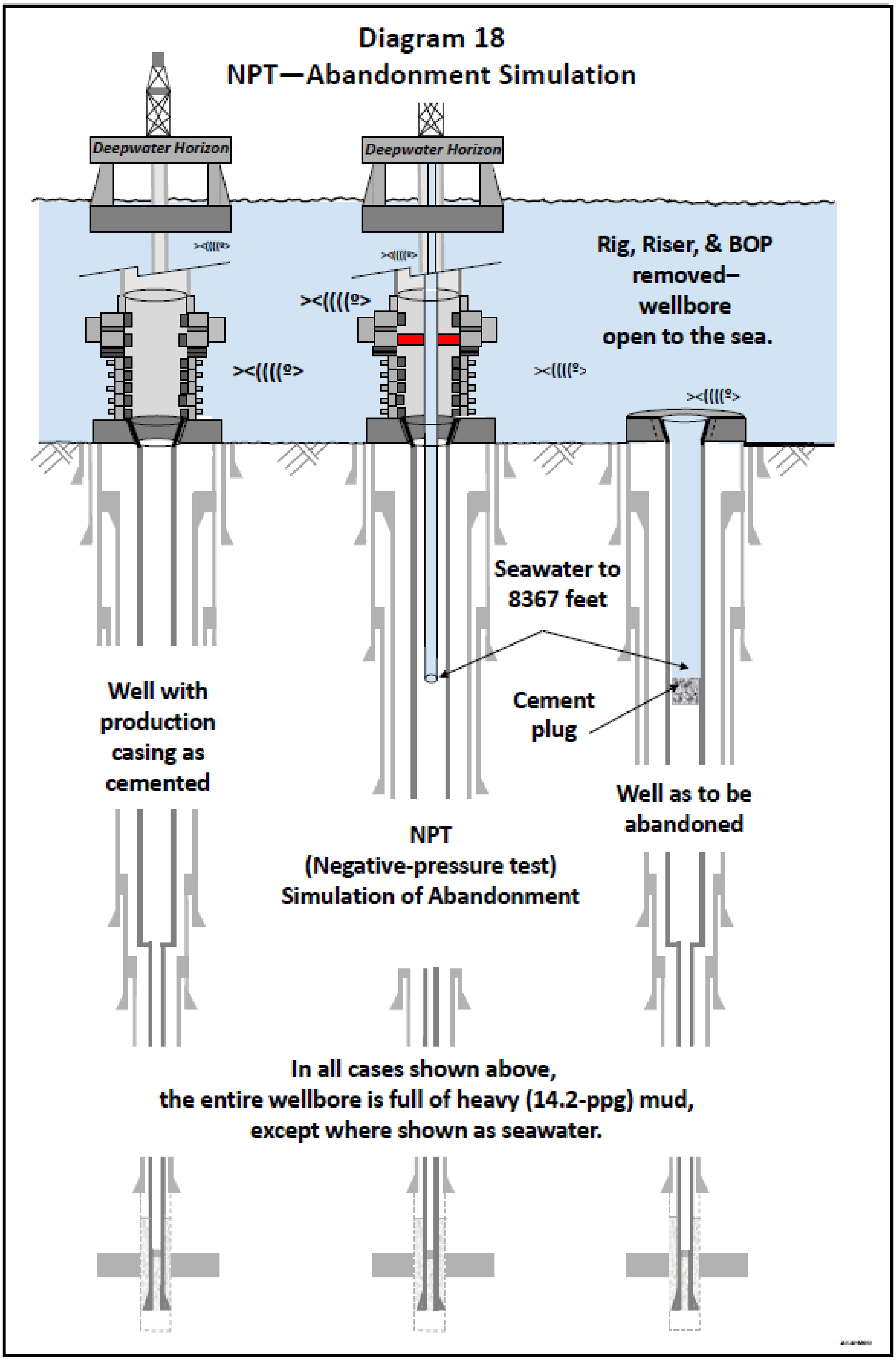


Diagram 18
NPT—Abandonment Simulation
Deepwater Horizon
Deepwater Horizon
Rig, Riser, & BOP removed– wellbore open to the sea.
Seawater to 8367 feet
Cement plug
Well with production casing as cemented
Well as to be abandoned
NPT (Negative-pressure test) Simulation of Abandonment
In all cases shown above, the entire wellbore is full of heavy (14.2-ppg) mud, except where shown as seawater.

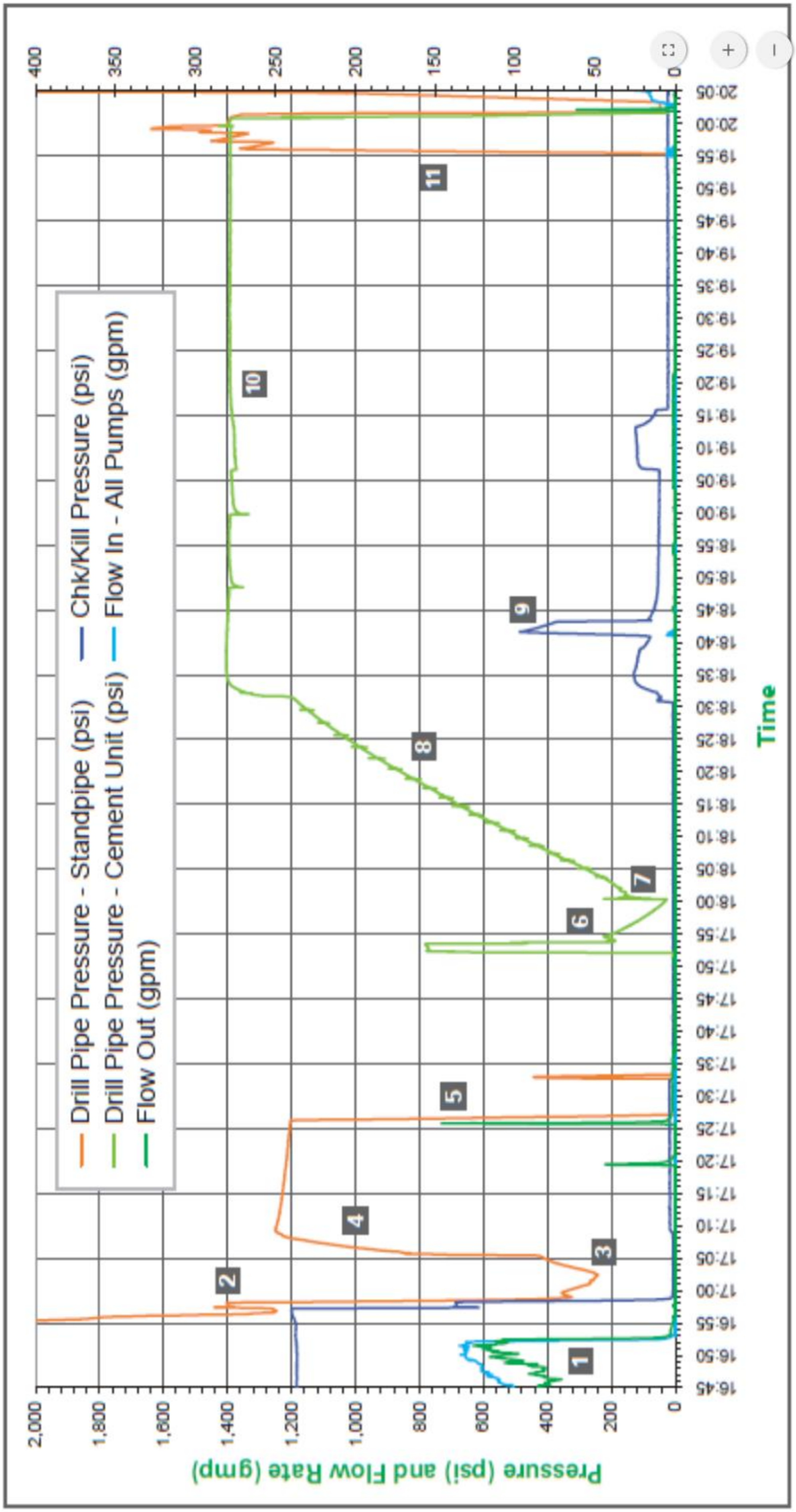
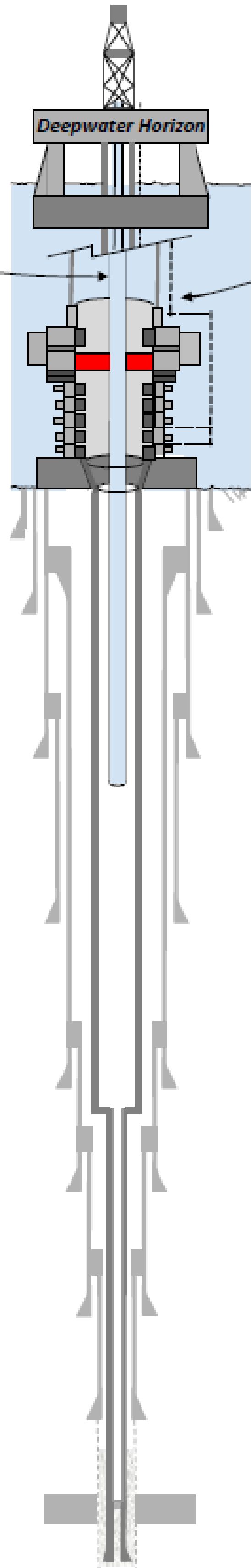

Drill Pipe Pressure - Standpipe (psi)
Drill Pipe Pressure - Cement Unit (psi)
Flow Out (gpm)
Chk/Kill Pressure (psi)
Flow In - All Pumps (gpm)
Pressure (psi) and Flow Rate (gmp)
Time
1
2
3
4
5
6
7
8
9
10
11

Diagram 19—NPT-1 versus NPT-2

Negative-Pressure Test (NPT #1)

Negative-Pressure Test (NPT #2)



Drillpipe (gauge on top)

Kill line (gauge on top)

(1) For NPT #1: With the BOPs closed and drillpipe filled with seawater to 8367 feet, the drillpipe pressure was bled to zero. On its own, the drillpipe pressure built back up (kicked) to 1400 psi—a valid indicator of a casing leak. But NPT #1 was considered invalid, so commenced NPT #2

(2) For NPT #2: The BOP remained closed around the drillpipe, still full of seawater. The kill line was also filled with seawater. The kill-line pressure was bled to zero, which held for 30 minutes. NPT #2 was therefore declared a valid indicator of well security (no leak).

(3) BUT—during NPT #2, the drillpipe pressure remained at 1400 psi. Because the drillpipe and the kill line were separated only by fluid below the closed BOP, they were measuring the same pressure environment. Hence, the two results (1400 psi on the drillpipe, and zero psi on the kill line) were mutually exclusive; i.e., a kill-line valve was closed or the kill line was plugged.

(4) Which means "valid" NPT #2 was not valid, and "invalid" NPT #1 was valid. The 1400 psi on the drillpipe pointed to a real problem (casing leak) that needed resolution. The source of the 1400-psi pressure was the pay zone leaking (kicking) into the casing.

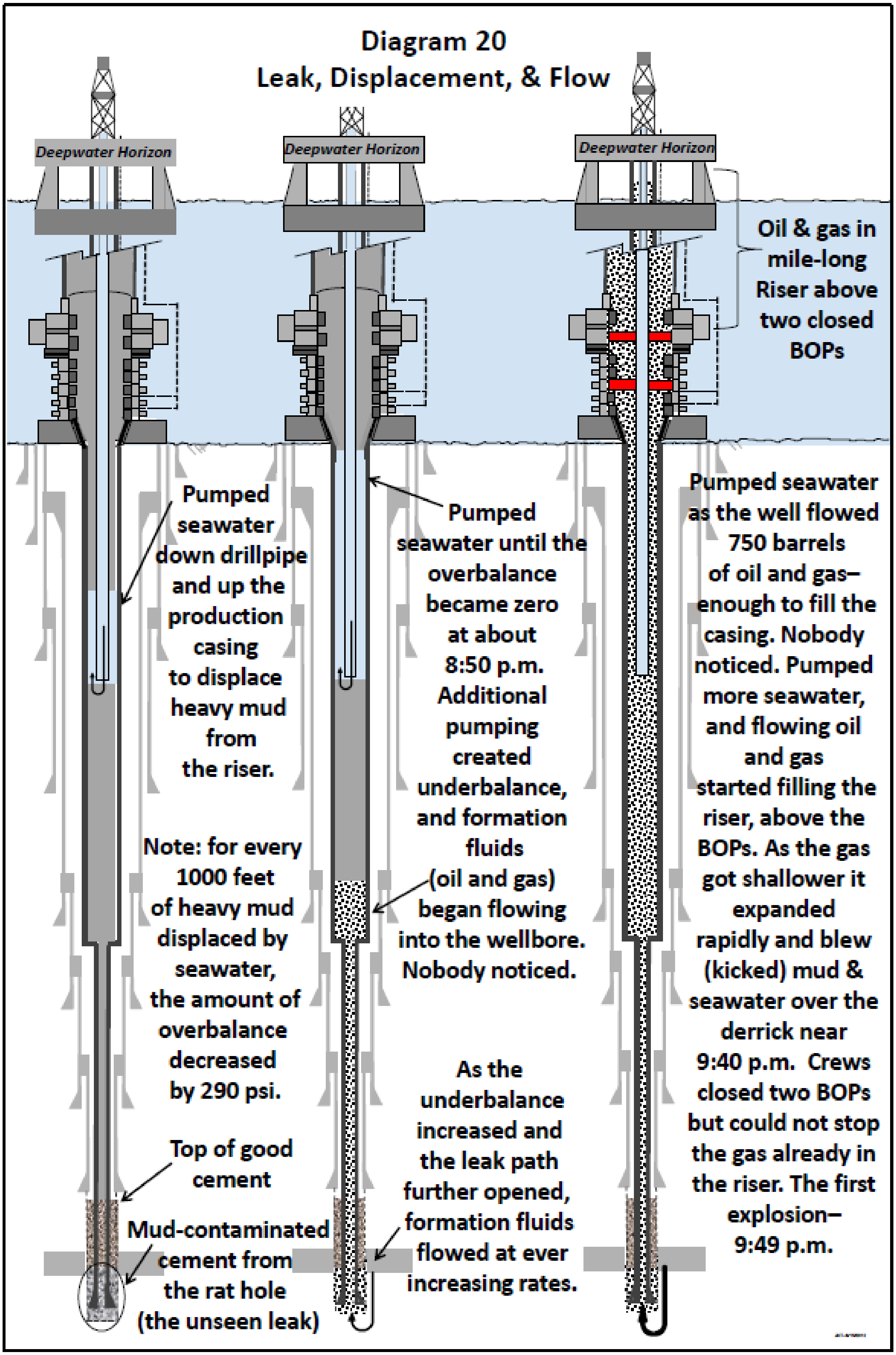


Diagram 20
Leak, Displacement, & Flow
Deepwater Horizon
Deepwater Horizon
Deepwater Horizon
Oil & gas in mile-long Riser above two closed BOPs
Pumped seawater down drillpipe and up the production casing to displace heavy mud from the riser.
Note: for every 1000 feet of heavy mud displaced by seawater, the amount of overbalance decreased by 290 psi.
Top of good cement
Mud-contaminated cement from the rat hole (the unseen leak)
Pumped seawater until the overbalance became zero at about 8:50 p.m. Additional pumping created underbalance, and formation fluids (oil and gas) began flowing into the wellbore. Nobody noticed.
As the underbalance increased and the leak path further opened, formation fluids flowed at ever increasing rates.
Pumped seawater as the well flowed 750 barrels of oil and gas– enough to fill the casing. Nobody noticed. Pumped more seawater, and flowing oil and gas started filling the riser, above the BOPs. As the gas got shallower it expanded rapidly and blew (kicked) mud & seawater over the derrick near 9:40 p.m. Crews closed two BOPs but could not stop the gas already in the riser. The first explosion– 9:49 p.m.

Diagram 21
DEEPWATER HORIZON
21 April 2010

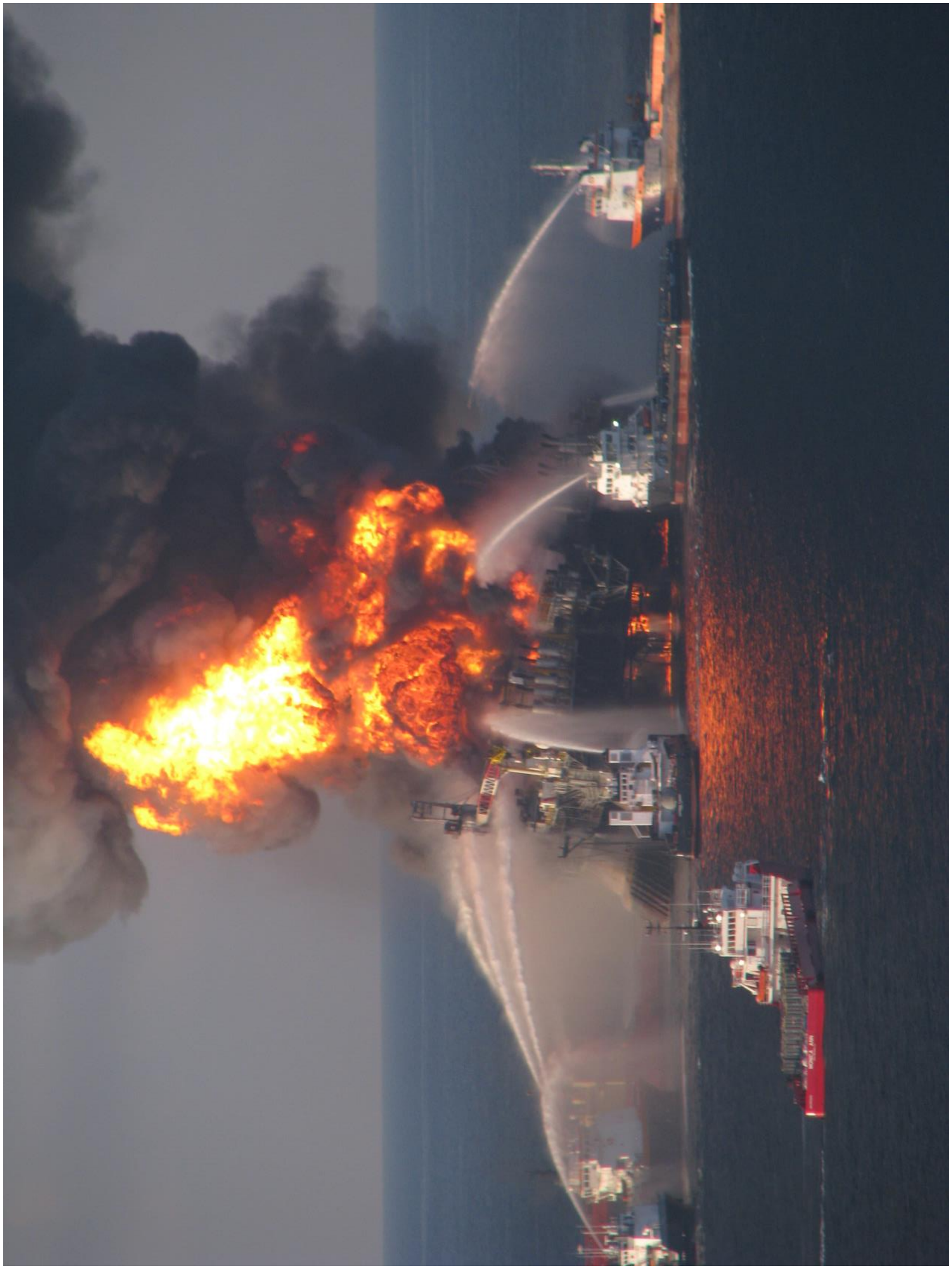


Photo Credits: Richard Braham, U.S. Coastguard, 21 April 2010

ADDENDUM TWO

EXCERPT No. 1 FROM

THE SIMPLE TRUTH:
BP's Macondo Blowout

PROLOGUE

20 April 2010—9:49 P.M.

Jessica Pherma's world exploded. Not the planet, but the *Deepwater Horizon*, her half-billion-dollar, drilling-rig home in the Gulf of Mexico. The event started fast, but only after hours of warnings, unheeded until too late. From under the rig an ugly growl thundered, echoed in her chest, a mere prelude to the black-geyser eruption of mud and water that blew through the rig floor and dwarfed the 24-story-tall derrick.

"Shut it in!" Jessica screamed, tally book in hand, waving her arms toward the men on the rig floor, toward the deluge that threatened to drown them all. "Shut it in, now!" she bellowed again.

A new noise—gas roaring from a vent line attached high in the derrick. Natural gas and atomized oil—a lethal concoction—its thick, acrid aroma unwelcome on any rig. The black cloud grew, swallowed the derrick, blanketed the rig floor. Jessica, an experienced geologist with a life-long fire phobia, feared the worst—the end of life, a spark away.

"Open the diverter!" Earthquake-size rumblings racked the rig and shook her body, and she wondered if the words had even left her mouth.

Men ran—some from the fury, others into the maelstrom.

Jessica, too, ran. Grabbed a life vest. Slid one arm in—

A blinding fireball of reds and oranges and yellows filled the night sky, the sound and concussive force beyond movie magic. The blast—a mix of fire, steel, and hardhats—slammed her body and drove her across the deck and against a four-inch-high drainage rail. She grabbed what she could and held on tight. Eyes locked open, looking over the edge and into the abyss, all she could see was water. Black water—the sea 60 feet below. And her tally book, dropped and falling, its white wings flapping on the way down, beckoning a vision of her dad's face, framed on a white pillow in his open black casket.

Another chest-crushing blast scooted her down the rail, covered her in debris. Something heavy, metal, on her back, pushed her down. Visions of death filled her skull, oozed from pores in baking skin. With brute strength, she commanded hands, elbows, knees to take over, lever her up, free the rubble, and shake it off. Dizzy and numb, she turned to face the billowing blaze that engulfed the giant derrick as if kindling in a campfire.

Words flashed. Daddy. Death

No. Not yet. Not this horrid night. Not by fire . . . though the radiant heat cooking her face and penetrating her body to the core of her bones threatened to incinerate her on the spot.

More people, silhouettes, running, stumbling, in silent slow motion, away from the inferno.

Jessica stayed low. Crawled away from the edge. Away from the fire, its brutal roar behind her growing louder, as if hungry, carnivorous, closing the distance, daring her to slow down. She found a stairwell, up to the helideck. On her knees, gasping for air, she scaled first one step, then another, her own flesh and bone and blood on steel.

A wailing man, a face she knew, stepped from the crowd, helped her up. The man, his face defined by anger and blame, grabbed her shoulders and shook hard. "You're BP," he howled. "Do *you* know what happened?"

Jessica yanked herself free, his question less important than the next minute of her life. She hugged her chest. Piercing heat attacked her back, while adrenaline chills tormented her body, her torso a conflict of fire and ice. She turned as if flipped on a barbecue grill and welded her gaze onto the growing inferno consuming the rig, fifty miles from shore, perched on top of water deep enough to drown a nation, its late-night background as dark as death.

Unable to stand the heat, she turned back to the helideck crowd, her legs weak, the horizon tilting. She studied faces. Faces of men. Fewer women. Illuminated by fire. Huddled in terror. Colleagues. Acquaintances. People she hadn't met.

She wondered about missing friends—Barry, Tanker, Daylight, others. No doubt fighting the battle. Maybe their last.

Her dad. She missed him. Would miss him forever.

And Mom and Sissy. She would always love them, though they were so wrong about her dad's death.

Like last rites. Something important to say. To confess. To get off her chest.

And one more thing. The truth. *THE SIMPLE TRUTH*.

While someone bellowed commands about mustering, and lifeboat stations, and abandoning ship, she found the man who'd asked her the question. A question that deserved an answer.

"Yes," she told the man, her voice weak, her body crashing. "I know . . . *exactly* what happened."

While able crew members helped Jessica and others to lifeboats under fire-lit skies, she found her stamina increasing, driven by a passionate goal: stay alive, tell the story.

* * *

The story is the book: *THE SIMPLE TRUTH: BP's Macondo Blowout*

* * *

I hope the PRESENTATION and the PROLOGUE got your attention. I've also included the CLOSING CHAPTER, Chapter 52 (don't read it if you don't want to know the ending). Please know there's an entire book between the PROLOGUE and the CLOSING CHAPTER that's about people integral to the *Deepwater Horizon*, the Macondo well, and the CAUSE of the disaster. The book includes details the entire industry should know, in an easy-to read format that you, your non-engineering friends, relatives, and neighbors, and your boss and your colleagues will appreciate.

EXCERPT No. 2 FROM

THE SIMPLE TRUTH:
BP's Macondo Blowout

CHAPTER 52—Count Down

20 April 2010—9:42 P.M.
00:07m:00 to Zero Hour

Barry and Tanker and a number of others got to the rig floor at the same time. Barry, disoriented by the falling deluge of mud and seawater, couldn't find Tanker. He scrambled man to man. Found assistant drillers. Derrick men. Roustabouts. He found Tanker at the BOP control panel with Daylight. They were huddled, ear to mouth, mouth to ear. Barry moved in, deafened by the roar, ready to help.

* * *

00:05m:00 to Zero Hour

Through yells and sign language, Barry got the message from Tanker. Situation critical. Annular BOP and VBR—closed, but oil and gas already in the mile-long riser, above the BOPs. Diverter—closed. Mud-gas separator—open. Kicking fluids—increasing. Drillpipe pressure—rising. Barry—astounded both by the freight-train of mud blasting through the rig floor, and by the ugly words that slashed through his brain: *Oil and gas on the way up. Up the annulus, up the casing, up the riser, doesn't matter*. Jessica's words.

The captain of the MV *Damon B Bankston*, his workboat covered by heavy mud, radioed the rig.

He was told: trouble with the well, move away, five hundred meters.

* * *

00:03m:00 to Zero Hour

Something changed. The noise level increased. Gas. Hissing. Screaming. Beyond hearing. Erupting from the derrick-mounted mud-gas-separator vent. A gas-sensitive alarm blasting into the night, all but silenced by the jet-engine-loud maelstrom. Gas enveloping the derrick. The rig floor. The pipe rack. Cranes. Buildings. People.

* * *

00:02m:00 to Zero Hour

Multiple gas alarms—all directions. The roaring louder, deafening. Vibrations like an earthquake. The facility and derrick creaking and groaning. As if alive. As if trying to expel an unwelcome visitor.

* * *

00:01m:00 to Zero Hour

Gas too thick to breathe. Rig floor packed with hands. Doing. Helping. Barking orders. "Clear the stairs." "Open the goddamn diverter!" "Close the blind shears." A big man, broad shoulders, stood alone, his head bowed in prayer. Gas volume increasing, pressure escalating. The mud-gas separator gagging from the overload, trying to vent gas turned black with oil. Crude oil.

Natural gas and atomized crude oil being sucked into the fresh-air inlets to the rig. Down into the engine room. Feeding the diesel engines like nitromethane in a top-fuel dragster. The engines winding up. Turbocharged. Beyond red line.

Barry spotted a figure on the pipe rack, looking up. Lime green coveralls. He screamed, "Go back!"—couldn't hear his own words. He hurdled steps three at a time down to the pipe deck, slick with oil mud and crude oil, fell hard, and—

* * *

20 April 2010—9:49 P.M.
00:00:00 . . . Zero Hour

The explosion and fireball consumed all in its path. In the first tick of the second hand, the hungry fire fed on plastic, rubber, flesh. The next second, aluminum. Then steel.

Those who could, ran, walked, crawled. Mustered strength. Ignored pain. Survival the goal. Clock ticking.

The second explosion followed the first by ten seconds. The driller's station collapsed. The drill floor evaporated. BOP control lines disappeared. The traveling blocks fell. The mudlogging unit vaporized. Cranes melted. Doors blew open. Walls became doors. The Halliburton unit glowed red—then black. The engine room ceiling fell to the floor, and the floor fell even deeper.

And all went black. Every light on the *Deepwater Horizon*. The supercharged engines—down. Rig power—off. The galley—dark. Quarters—dark. Walls collapsed into hallways. Ceilings down. Air filled with volatile gas fumes. Personnel scrambling to get dressed. Every living person on the rig, in adrenaline overload, swimming in blackness and tears, defined life by the fight for survival, the love of parents and spouses and kids, the incessant roar, and a litany of where the hells, sonsofbitches, oh Gods.

Barry struggled to his feet—Jessica gone.

Then, emergency lighting, flashlights, in rooms, down smoke-filled hallways—a glow of hope.

* * *

Through the public-address system, the words *Abandon ship* met a willing audience. Barry made his way between muster stations and spotted Jessica among the mass confusion as a number of helping hands got her and others into one of the first lifeboats to be lowered from the rig. On his way back to his assigned station, the guys he met on the main deck—most wearing life vests—were either stunned mute or barking orders, being brave or looking lost, helping the injured or being helped. This, while the deafening, roaring, oil-and-gas-fueled fire melted steel less than a hundred feet away.

For some, the fire and the waiting for a seat on a lifeboat were too much. Twice, Barry could only watch as individuals crawled over handrails, hesitated, and dropped to the sea. He remembered the numbers—a 60-foot drop, two seconds, 35 miles per hour. Fearing for the jumpers' welfare, he imagined the same scene at the aft end of the rig, at other muster stations, though the fire had already claimed major portions of the deck area as no-man's land.

Barry stayed and helped lift injured parties into the second lifeboat and a life raft, all the while twisting and turning to cool his bare head and smoldering body parts.

As the conflagration continued to consume the massive drilling rig and derrick, Barry took one of the last escape-vessel seats. Crowded. Hot. Panicked voices. His knotted guts on fire, he thought of Jessica. The same Jessica who feared deep water, heights, fire.

She would have rightfully called the blowout a ten.

Like Spindletop. Except at sea. And on fire.

He wondered, too, what she might call him.

* * *

For a long hour, then an even-longer second hour, Jessica Pherma shivered on board the MV *Damon B Bankston*, still wearing her torn and blackened life jacket. After midnight, she walked among the survivors, touched hands, and shared tears, like a nurse on a battlefield.

Crew on the *Bankston*'s fast-rescue runabout had collected survivors and delivered them back to the mother ship, then had teamed with Coast Guard helicopters as they hovered impossibly close to the burning rig, their spotlights working the water, checking shadows, looking for survivors. Looking for bodies.

* * *

Tanker was missing. As was Daylight. The mud engineers. Floor hands. The crane operator. And others. Jessica kept vigil. Watching boats, watching choppers, afraid to think the worst, to rehash her dad's warning, to speak the words—*nowhere to run*. Yet, rumors and stories about injuries and deaths ricocheted around the cabin and onto the decks, filling the night with manmade white noise, albeit a whisper in the roaring dirge a quarter mile away.

She'd watched as Barry found a seat on the forward port corner of the aft deck. Alone in his private little world, the only sound the roar of the fire in the distance, he sat quietly, his arms wrapped around his knees. Hair fried. Coveralls blackened. Boot on one foot, a soggy, blackened sock on the other. He hadn't moved since. Just stared into space. Yet he nodded when they were face to face.

She closed in, stood at his feet. He looked like he needed a few kind words, perhaps a friend, maybe a hug. Not unlike every demoralized soul who shared the boat, who waited for a miracle, a miracle that would turn back the clock.

A miracle that wouldn't happen.

She knelt in front of her mentor, eyes on eyes. He was a good man. A smart man. Highly experienced. Dedicated to doing his job. Driven by budget and schedule.

His mouth twisted as if looking for a word.

She shifted her body weight, favoring her bloody knees, then pointed over his shoulder toward the rig, burning bright in the night sky. "Your well, Barry. Your well."

He looked through her, didn't answer.

She had more to say, words she'd practiced since leaving the helideck and abandoning the rig. A simple summary of exactly what happened. He could have prevented the leak, but hadn't. He could have found and repaired the leak, but hadn't. He could have made sure the well was secure, but hadn't. He could have noted the well was flowing, but hadn't, until it evolved so extensively as to mimic the irony of Piper—oil and gas on the wrong side of the closed BOP. Which was way too late to stop.

But he already knew such things. Would know them forever. Would know forever that he was the man, the man in charge of managing the well, who could have, should have, saved the day.

Unable to comprehend the horror and complexity of the days and weeks to come—putting out the fire, recovering bodies, mourning the dead, securing the well, unraveling the cause of the disaster—her personal and family issues seemed mere puffs of smoke.

She had no doubt that Barry would get his day in court.

And that she would be on the other side of the aisle.

Jessica Terra Pherma got off her knees. She looked toward the burning remains of the *Deepwater Horizon* and said goodbye to Tanker, and to Daylight, and to both mud engineers, and to her favorite crane operator, and to other missing friends and colleagues, then walked away.

In the wheelhouse, she waited her turn to use the phone.

Wiped her eyes. Dialed.

A raspy voice answered.

"Mom, it's Jessica."

End

ADDENDUM THREE

DEEPWATER HORIZON

MOVIE REVIEW

By John Turley

I've seen the movie *DEEPWATER HORIZON* three times. My emotions are mixed, none involving humor. YES, the movie may get an Oscar for spectacular visual effects. YES, noteworthy actors play key wellsite leaders who will shock viewers with disturbing actions and decisions. YES, the movie treats with great respect those who survived and the eleven who died. But NO, an abundance of ambiguous technical snippets, both verbal and visual, do little to inform those who WANT and NEED to know the answer to . . . WHAT CAUSED THE BLOWOUT? So, why this note? As a 2015-16 SPE Distinguished Lecturer (DL) on the CAUSE of the Macondo-blowout in the Gulf of Mexico, my passion is to ensure every member of our industry learns from and works toward never allowing a repeat of the catastrophe. I trust you will see the movie, but I invite you to also read "THE SIMPLE TRUTH: BP's Macondo Blowout." The book focuses on the CAUSE of the disaster (no politics, no hearsay, no finger pointing, no Hollywood), and is available through Amazon.

*** * ***

I wrote the above succinct review of the movie *DEEPWATER HORIZON* as an introductory comment for my new "Connections" on LinkedIn. But for those in the industry who truly do care, a review of such a critical movie deserves more detail; hence, the following.

I'll use a recent experience as the basis for my review.

On 13 October 2016, I joined a hundred CSM (Colorado School of Mines) petroleum engineering students and faculty for a private screening of the movie. I had been invited to emcee the event, where I watched the movie for the third time and then led an energetic hour-long discussion and Q&A session.

Every attendee had a vested interest in the career-related movie, and each is intellectually capable of understanding every aspect of what appeared on the screen.

Afterwards, audience comments ranged from *OMG*, and *Unbelievable*, to *How could anybody have survived*? Some comments were in the form of body language only, without words to describe tear-moistened emotions. I felt the same.

We took a break, then discussed three aspects of *DEEPWATER HORIZON*—the movie, the people, and the technology.

The Movie

First, the entire setting, all family members, the rig hands, onshore and offshore facilities, and the massive *Deepwater Horizon* drilling rig, are exactly right. Even as the story unfolds on the rig with 126 people aboard, we get to see good renditions of the control room, shops, the galley, offices, the rig floor, a workboat, and working personnel everywhere. Then, once the disaster unfolds, with fluids—mud, oil, gas—blowing violently over the derrick, followed by explosions and fire throughout the facility, the situation on the rig could not have been more horrific, nor could the visual effects have been more stunning, more realistic. For those who have ever been on, or who will ever be on, or who never want to be on a drilling rig, whether onshore or offshore, the movie is a harsh view of a world we must strive to never see again.

With strong agreement among students and faculty, the bottom line for the film, as a good package of entertainment: kudos, job well done.

The People

Also important to those who care are the relationships among the players, on several fronts. First, there's a well-portrayed rig worker (key to the story) and his wife and daughter as he prepares to go to the rig for his 21-day hitch. Associated scenes do a good job of showing family dynamics, and remind the audience that all persons out there, and those they leave at home, are real people with emotions and concerns and love for life.

On a different scale, the dynamics of relationships among leaders on the *Deepwater Horizon* are entirely different, albeit handled quite well in the movie. Though there are four key leadership positions on the rig (plus four visiting executives with minor roles), the conflict is simple: (1) the well belongs to BP, who pays all the bills, and BP's senior guys (*company men*) on the rig make all technical and operating decisions about the well, and (2) the rig owner, Transocean, has three senior leaders: (a) the *toolpusher*, who is in charge of the drilling rig and all its functions and personnel; (b) the *OIM,* offshore installation manager, who is responsible for the non-drilling facilities (i.e., the "hotel"); and (c) the *captain*, who is in charge of keeping the floating rig (considered by the USCG as a vessel at sea) on station, hovering above the well head a mile below.

In a departure from reality, the movie OIM is given a major authoritarian leadership role throughout the movie, including critical rig-related matters (normally handled by the toolpusher), likely because the real-world OIM survives, while the toolpusher does not.

The rig status on the critical day is that the discovery well has been drilled, cased, and cemented. In preparation for temporary abandonment (*temporary* because it will take several years to evaluate and build the deep-water facilities), the well must be pressure tested to ensure casing and cement integrity. The high-pressure test goes well. But the negative-pressure test (designed to manually reduce the wellbore pressure to ensure there are no leaks from outside the casing) fails to prove the well is secure, and generates "anomalous" data. The predominant heated-argument on screen is that: (1) the BP leaders (company men) agree that the test data was bad, but argue it was bad only because of the "bladder effect." The movie does a good job with characters arguing about the technical aspects of the bladder effect (which, in the real world, does not exist, leaving an unnecessary open issue with the audience), and (2) Every other non-BP leader, even the workboat captain, argues that the test data prove the well has a leak (information they would not know), and that the BP leaders don't want to admit the failure as it would lead to a major time-and-money cement repair job. The audience does not know what's right or wrong, but by now they rank the BP rig leaders as bad guys, an apparent goal of the movie. The movie shows BP's fallback decision is to rerun the test a different way (using the kill-line), which "successfully" shows the well has pressure integrity.

Yet, an argued one-liner in the movie proposes it's possible the second test was invalid, because the kill-line might have been plugged. In reality, it *was* plugged, and the second test was indeed invalid . . . with catastrophic results, though not mentioned again in the movie.

The falsely "successful" kill-line test justifies for BP (and reluctantly for the other rig leaders, at least in the movie) the next step in the temporary abandonment process—pumping seawater into the well to displace heavy drilling mud from the 5,000-foot-long drilling riser. Given that the well had a serious undetected casing/cement leak (a documented, albeit off-screen, failure of the company men to correctly interpret the negative-pressure test), such displacement of riser mud with seawater allowed the well to flow (AKA, a kick . . . though unseen), even as more seawater was being pumped, exacerbating the accelerating flow.

The result was BP's Macondo blowout.

As soon as the well commences blowing out, rig personnel rightfully actuate a BOP unit (blowout preventer), but they panic verbally to each other, making the point that the BOP, in apparent total failure, did not stop the violent flow. The flow of oil and gas, like Old Faithful, finally explodes and burns, with blow-torch-like flames from the moon pool to the top of the derrick and throughout the living facilities . . . the cataclysm seemingly beyond belief . . . but very real.

Understandably, as the fire escalates, personnel conflicts go away, replaced by individual instincts for survival. The choices (well done in the movie) were few—either fight your way through the fire and get to a lifeboat, or jump overboard. Yet, as successfully portrayed in the movie, and as supported by testimony during the USCG depositions after the disaster, injuries were abundant, as were individual life-saving acts of heroism worthy of military-type honors.

And though the viewing audience likely will not recognize on-screen real-life names unless they live and work on the Gulf Coast, they will have watched eleven good men, played by surrogate actors in the movie, just doing their jobs, on this, their last day. Their bodies were never found.

From the student perspective, the film vividly portrayed the importance of understanding data, reacting to change, respecting authority, standing up to incompetence, and accepting and executing technical job responsibilities, without fail.

The Technical

The third aspect of the limited 100-minute movie that needs clarification is the necessarily rapid coverage of abundant technical issues that took place during the rig's 12-hour countdown to disaster. A number of issues were visual only, or introduced as one-liners, requiring attendees to ponder the significance. For example, natural gas was seen erupting on several occasions from the seafloor around the BOP, increasing in frequency and violence proportional to the tension on the screen and the ticking of the clock. Not true. No gas evolved around the wellhead, either before, during, or after the blowout. Sorry to say, this was for show, and though it successfully looked ominous, it detracted from movie credibility.

There was also a conflict about a service company leaving the rig before running a CBL, or cement bond log. Every named player on the rig (and again, even the workboat captain) was astounded that BP had released (as per the movie) the logging team without the CBL, while the BP leaders, when challenged, were confident with their decision. The concern was that the cement outside the casing at 18,000 feet (not the structural-casing cement at 5000 feet, just below the seafloor, as wrongly shown in a diagram during the movie argument), could be bad, and the CBL would tell them so. Not true. The CBL does not test the cement. In reality, the tool is used in limited circumstances when there's been a significant problem during a cement job (and more so during standard completion operations). That was not the case on Macondo, where BP showed the deep cement job, given enough time to set up, met the criteria for no CBL. Conversely, the negative-pressure test directly tests the pressure integrity of the deep cement and the rest of the wellbore. Unfortunately, so much movie time was spent on the CBL debate that attendees were surely *wrongly* convinced that it was one of the leading causes of the blowout.

And with that being just one of many similar examples of credibility gaps, I'll give credit to a friend who wisely stated, "If you enter the theater as a layman, you'll leave as a layman."

The BOP (blowout preventers) also got a lot of attention. Two key items here. First, deep-water operations require the BOP stack (comprised of several BOP units) to be on the seafloor. For Macondo, that's about a mile below the rig. The rig and the BOP stack are connected by a mile-long large-diameter pipe, called the drilling riser. And that means when the Macondo well kicked, unseen, and with the flow further enhanced by the continued pumping of seawater to displace even more heavy mud, the entire wellbore—casing and riser—filled with oil and gas. That means when flow was first seen on the rig floor, and two BOP units were finally closed, there were almost 1,600 barrels of oil and gas already in the riser between the closed BOP units and the rig. To make matters worse, the gas in the riser had risen to be so shallow that the low hydrostatic pressure allowed the gas to break out of solution. The resulting explosive expansion of the gas mimicked a Mentos-Diet Coke experiment . . . violent and unstoppable, because it was above the BOP. It was that oil and gas, from the riser, that blew over the top of the 244-foot-tall derrick, just before gas and atomized oil were sucked into the engine room—the catalyst for the first explosion and resulting fire.

The second BOP-stack issue centers on a third BOP unit, the BSR (the blind shear ram), located between the two other closed BOP units. Closure of the BSR is the critical first half of a last-ditch emergency operation designed to release the rig from the BOP stack (to get away from the fuel source and stop the fire). But, a serious consequence of the massively flowing Macondo blowout was that the drillpipe between the two closed BOP units was so severely uplifted and deformed that the BSR was unable to close. The movie tempts the audience with a "big red button" that would save the day. When the red button is finally pushed (after much debate), we see sharp blades move toward each other . . . then stop. Consequently, the pipe is not cut, the well is not sealed, and the rig is stuck on location, burning on top of the fountain of oil and gas. No further mention in the movie about the BSR, other than that the BOP failed.

Summary

The CSM students in the theater were hungry for real data, wanted to understand the nuances of the one-liners, and did not want to be taken in by misinformation, all of which made for lively Q&A. And yes, because they WANTED and NEEDED to know, we thoroughly discussed "WHAT CAUSED THE BLOWOUT," which, to be candid, was beyond the scope of the movie.

Nevertheless, though there are other technical sub-topics worthy of debate, it's fair to say the *DEEPWATER HORIZON* writers, producers, actors, and consultants did a respectable and credible job of creating dialog, building tension, and revealing important issues *before anybody on the rig knew there was any chance of a blowout* . . . then wrapped it up with spectacular visual effects. And that takes true creativity.

Bottom line. For the movie, the people, and the technology . . . job well done . . . albeit with a few caveats.

DEEPWATER HORIZON is a must-see movie.

ADDENDUM FOUR

FUTURE PUBLICATIONS

EXCERPTS from soon-to-be-published (2017)

Novels by J. A. (John) Turley

DRY HOLE

A Novel

By J.A. Turley

PROLOGUE

June 2005

Dr. Francine Elizabeth Rach outdrove the arrogant bastard and his high-beam headlights as he chased her in and out of traffic southbound on Houston's Beltway 8. Looking ahead, she blasted her well-tuned Mazda 929 up the high-elevation Highway 59 overpass and backed off the gas only slightly as she approached the curve at the top, where he caught up, pulled alongside, and shot her in the face.

Had the brilliant Ph.D. geophysicist not been dead when her bright-red coffin spun out of control, flipped end to end, jumped the retaining wall, and fell to the roadway below in a ball of flame, she might have screamed his name.

Accident investigators took pictures, measured skid marks, interviewed shocked witnesses, and eventually credited Houston statistics with one more tragic, random, road-rage death.

They were right only about it being tragic.

ARACHNID RED

A Novel

By J.A. Turley

PROLOGUE

Jasper Boswell, 47, died alone in his Louisville, Kentucky, apartment. A blood clot, the county pathologist later determined, had moved from Boswell's engorged dying penis into his lungs, where rupturing occurred and he drowned in his own blood.

"Cause of death . . ."

Dictating, the doctor hesitated.

". . . pulmonary embolism, following severe alcohol poisoning and acute, untreated priapism."

The doctor waited more than a week for the toxicology report, then redacted the autopsy file: "Trace of virulent, hemotoxic contaminant in blood, perhaps an insect bite, identity unknown."

Had the doctor remembered details of a short article he'd scanned in the Journal of Clinical Pharmacology the previous year, he might have linked Boswell's death to Horiz'n Pharmaceutical's aborted *Phoneutria Nigriventer* erectile-dysfunction project.