

were not significantly affected by erosion within the BOP since use of the reservoir and BOP pressures accounts for this possibility while use of the reservoir and ambient pressures does not. Any erosion in the BOP that affected flow rates therefore had to occur over the first few days such that the state of the BOP over the great majority of the 86 days was comparable to that at shut-in on July 15. If not, the alternative discharge based on the reservoir and ambient pressures would significantly exceed my best-estimate value of 5.0 mmsd, and this is not the case.

Figure 6. Scheme (BP) used in my calculations.

Best estimate of difference between pressures means illustrated by the... The first alternative between the fixed ambient pressure as indicated by... Second alternative between the maximum sea-floor pressure on the left.

Given that conclusions about the state of the calculation of discharge based on the red line of Fig. 6). This also coefficient of productivity index, the alternative value of the coefficient over the 86 days. Again, this productivity index therefore also wellbore over most of the 86 days, the state of the cement performed for BP conditions that most that the effective productivity index indicates that what whether this restriction failure at this rate.

<sup>10</sup> From "Deepwater Horizon Accident Investigation Report," September 8, 2010. Appendix W, Line 7, Page 54. To match data and observations, the pay zone was increased from 13 and 16.5 feet, corresponding to effective productivity indices of 7.4 and 9.4 stbd/psi based on the nominal value of 49 stbd/psi and maximum pay zone of 86 feet used in that report. At this rate, the productivity index would reach 43.8 stbd/psi in 8.6 hours.

over the 86 days. Again, this is not the case. Any variation in the wellbore discharge coefficient or productivity index therefore also occurred within the first day or so such that the state of the reservoir and wellbore over most of the 86 days were substantially the same as the state on July 15. And, this includes the state of the cement barrier in the bottom of the well. This view is also supported through calculations performed for BP by Add Energy that address the period just preceding the initial explosion. Under conditions that most closely replicate measured pressures and observable events, their analyses indicate that the effective productivity index increased by over 25% between 21:00 and 21:30 on April 20.<sup>10</sup> This indicates that whatever down-hole restriction existed at that time was failing rapidly, regardless of whether this restriction resided in wellbore debris, the float collar, or cement barrier. For continued failure at this rate, I estimate that the productivity index would further increase to my best-estimate value

in less than 9 hours.<sup>11</sup> At this point, the cement barrier or other impediments would provide no significant restriction to flow from the reservoir into the casing. Subsequent erosion in this region therefore could not have influenced later flow rates.

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These conclusions rigorously apply only for the period from May 8 to July 15, the dates over which BOP pressures were measured. While I conclude that erosion in the BOP during this period did not significantly affect flow rates or the cumulative discharge, erosion in the first few days following the blowout certainly did. The methodology I use here cannot address this early erosion directly, but can instead provide an alternative calculation of flow rates and discharge in the first few weeks based on the

Here the time between riser broken into a number of discharge for each period size of the BOP at that time. With the value from my best-estimate rates over the 36 hours from these results, I conclude most 3.3% to the overall

data, and the quality of the and checks. These were errors, and good agreement arose from scratch a second checked errors in the original against those of the original. These demonstrate that my in, accurately describes all rates regardless of which by BP during the methodology.

defined empirically falls very close to I believe that the of the reservoir and the that my methodology yields

gressive failure is erosion. In fully as small channels opened or found on the time to tion Rygg, ADD Wellflow, AS.

<sup>11</sup> Value of 37 stbd/psi is obtained from analysis of calculations by Tony Liao of BP presented in "BP-HZN-2170MDL04920969.xls." Value of 45 stbd/psi is from "Liao, Tony, 20130111\_Ex 11163.pdf" BP internal email from Tony Liao to Maria Nass, June 27, 2010.