

PFC Strategic Studies

August, 2002

SUDAN

Projected Oil Production and Revenues

Summary

Michael Rodgers



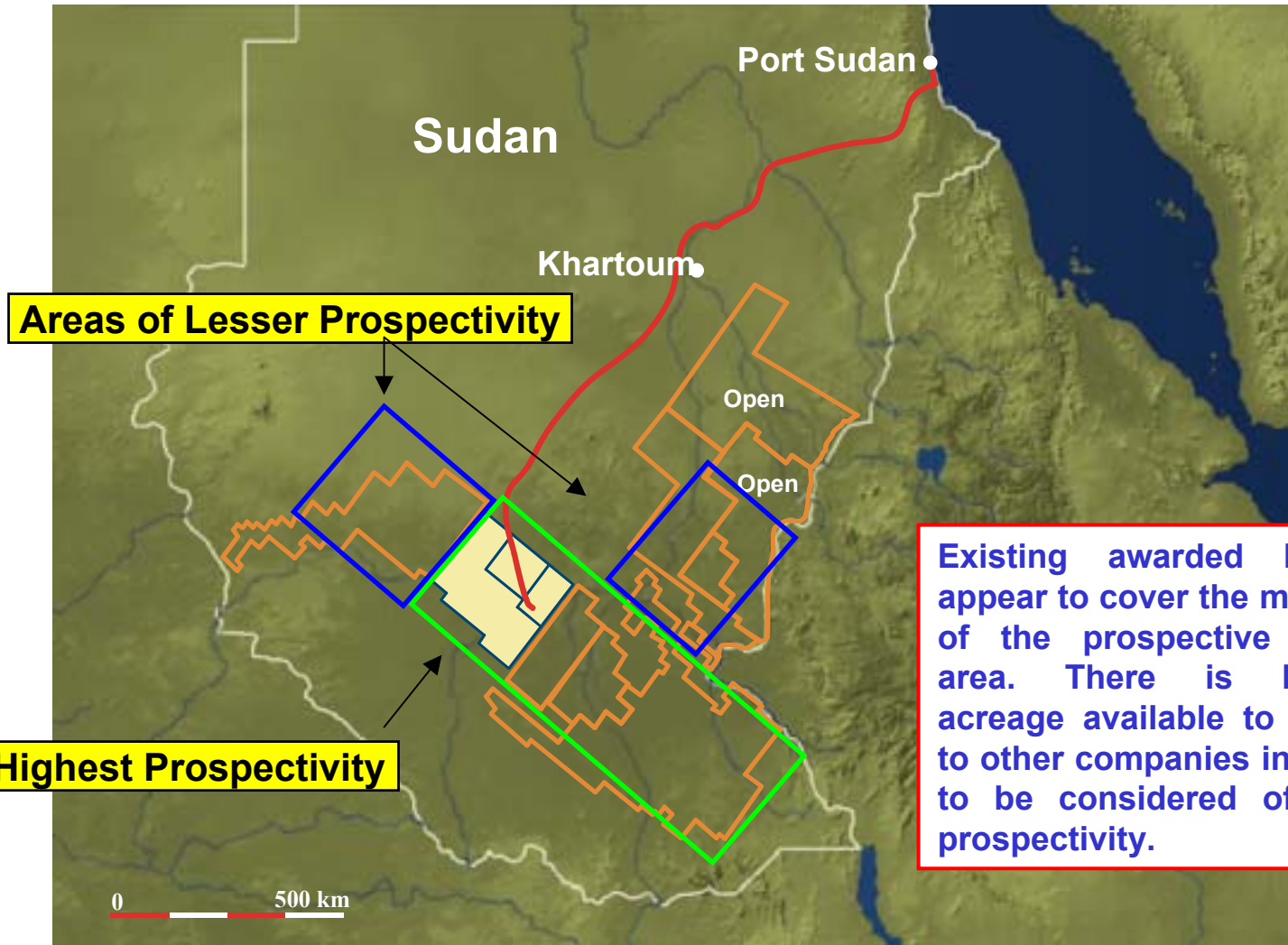
Sudan's Oil Potential – *Study outline and disclaimer*

- **Data Source** – *All of the data used for this analysis was extracted from publicly available sources such as company websites, IHSdatabases, published model contracts, press releases, etc. Software used for this analysis includes IHSAsset, Caesar Systems PetroVR, Rose and Associates Toolbox, Rose and Associates Playmaker,*
- **Objective** – *The main objective of this study was to use available data and information in a series of economic models in order to provide a general and realistic forecast of oil reserves, future production, and future government cash flow from rift basins of Southern Sudan*
- **Recommendations for Future Work** – *The accuracy of this analysis could be improved by reviewing all current production sharing agreements, reserve audit reports, development plans for existing and future producing fields, and current geologic/geophysical interpretations*

Sudan's Oil Potential – *Major geographic components of future petroleum revenue*

- **Red Sea Coastal Region** – *there have been quite a few wells drilled along the Red Sea Coast in Egypt, Saudi Arabia, Sudan, Eritrea To date only gas has been discovered and at this time this region is considered very high risk for discovering petroleum liquids*
- **Central Region Cretaceous Rift Basins** – *There are several basins in the central part of the country (Khartoum Region) which have been drilled by several wells (Industry invested approximately \$100mm in the early – mid 1980s). The basins are relatively small, most lack adequate source rock, reservoir quality is poor, and until future work reveals some encouraging data this area is considered to have some potential, but at a higher risk level.*
- **Southern Region** – *Muglad Basin area where there is slightly more than 1 billion barrels of proven and probable oil reserves*

Sudan General Location Map - *Most geoscientists would agree that available data from other exploration efforts in the country indicate that there is a low probability of finding significant reserves outside of the Muglad Basin*



Existing awarded blocks appear to cover the majority of the prospective basin area. There is limited acreage available to award to other companies in areas to be considered of high prospectivity.

Area of Highest Prospectivity

Areas of Lesser Prospectivity

GNPOC Interests

Pipeline

Muglad Basin – Major components of future oil revenue

Secure Areas (Blocks 1, 2, 4, and 6)

- Blocks 1 and 2 fields currently in production (7-10)
- Blocks 1 and 2 proven undeveloped fields (45)
- Blocks 1 and 2 undiscovered reserves
- Block 4 undiscovered reserves
- Block 6 discovered and undiscovered reserves

Insecure Areas (Blocks 3, 7, 5A, 5B and B)

Block 5A discovered reserves

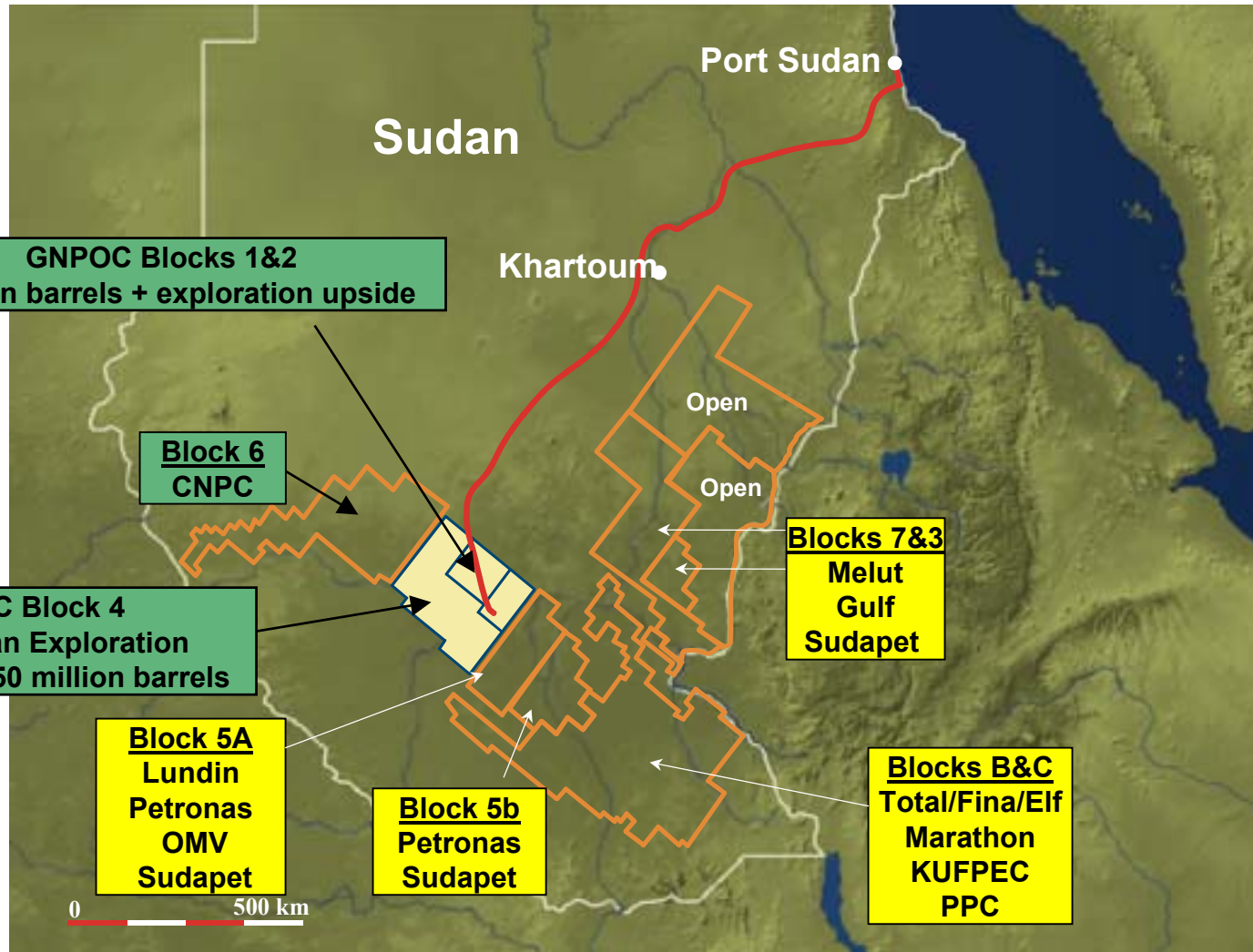
Block 5A, 5B, and B undiscovered reserves

Increasing Uncertainty

- 1) *Reserves*
- 2) *Cost to develop*
- 3) *Exploration success rate*
- 4) *Operating costs*
- 5) *Development schedule*
- 6) *Export capacities*

Peace Dividend

Sudan General Location Map – Areas where operations are currently underway (green) and areas with potential reserves where operations are not possible due to security risk (yellow)



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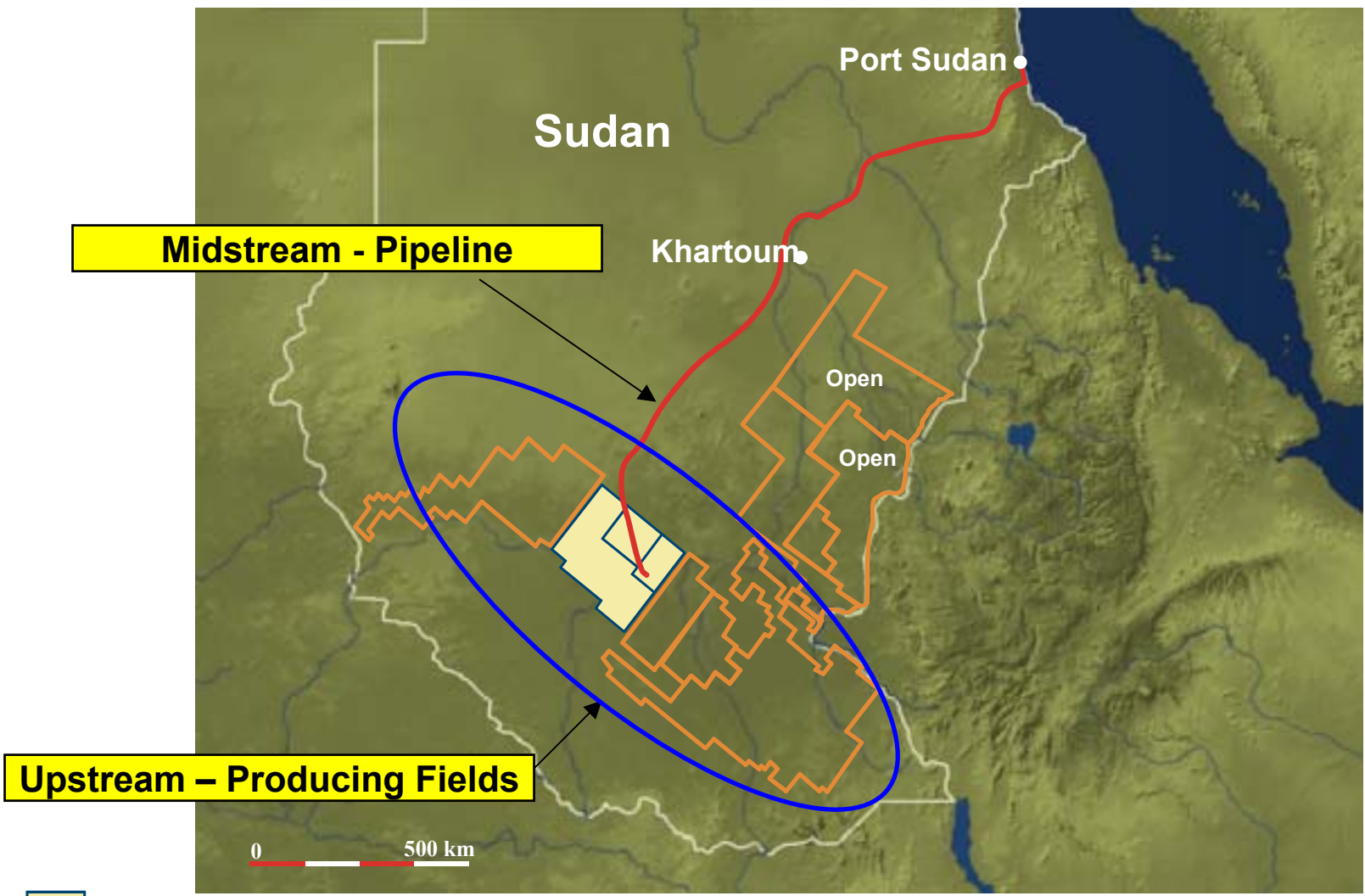
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Current Realities and Oil Sector Projections for Areas where Operations Are Currently Possible

Michael Rodgers



Sudan General Location Map – The business in Sudan is separated into two distinct segments with separate contract structures



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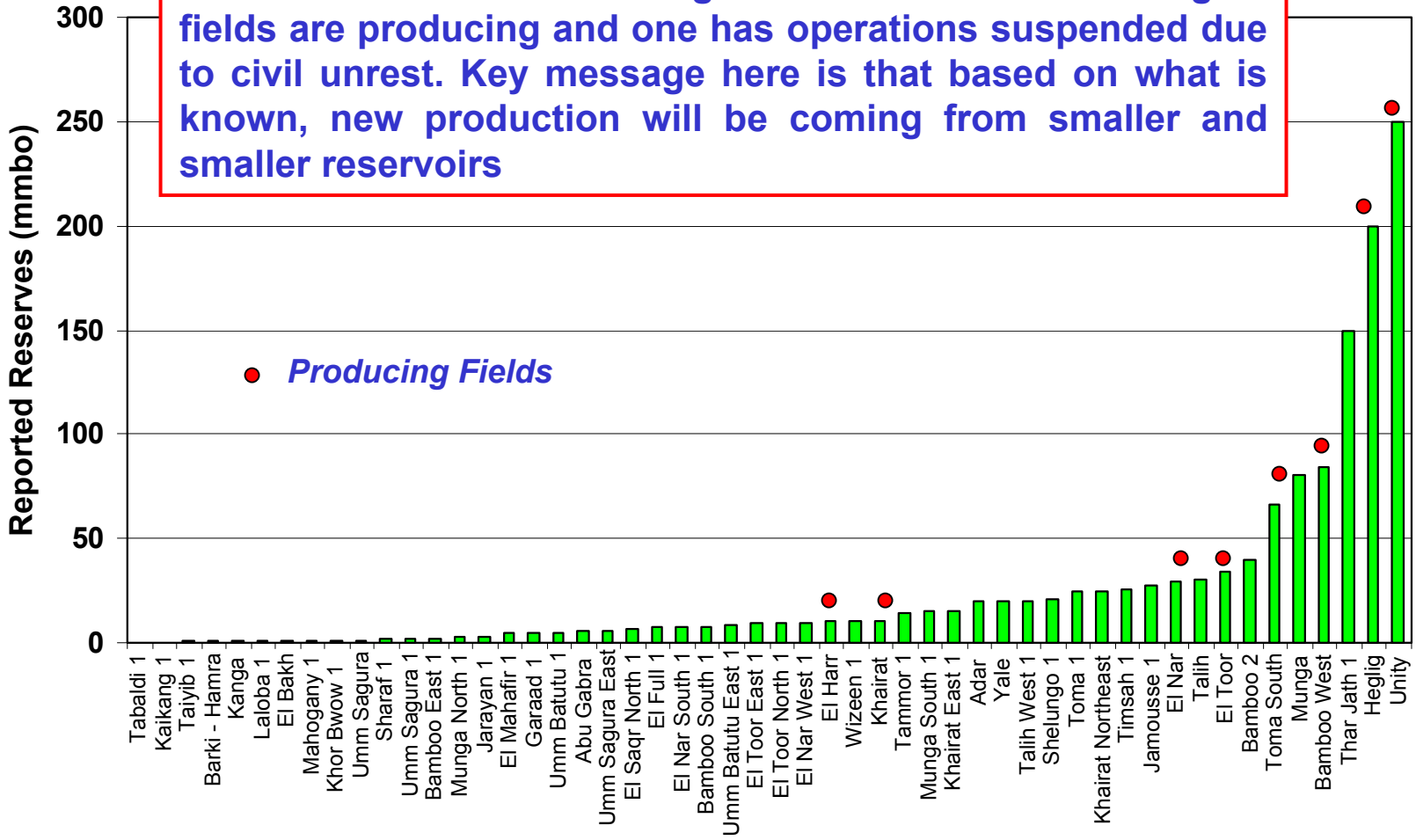


Muglad Basin – Blocks 1 & 2 conclusions

- Existing reserve base in Blocks 1 and 2 (including expected new reserves) is expected to be somewhere between 1 billion and 1.45 billion barrels with an expected mean reserve of 1.25 billion barrels
- Government will have a mean expected profit oil flow worth \$1,000 - \$1,200 billion per year during peak production of this reserve base – difficult to be precise about this value because of the combined effect of reserve uncertainty and price uncertainty
- The reserve base in Blocks 1 and 2 will likely not be able to sustain production levels above 250,000 bopd beyond 2006 – *without new reserves in areas outside of Blocks 1 and 2 production will begin to decline at a significant rate after mid decade*
- When production from the existing reserve base declines so will the government's cash flow
- The expected mean government share of the profit oil is expected to be \$13.7 billion and the mean company share is \$3.5 billion – *government take is between 75% and 80% for this volume of oil (1.25 billion barrels)*

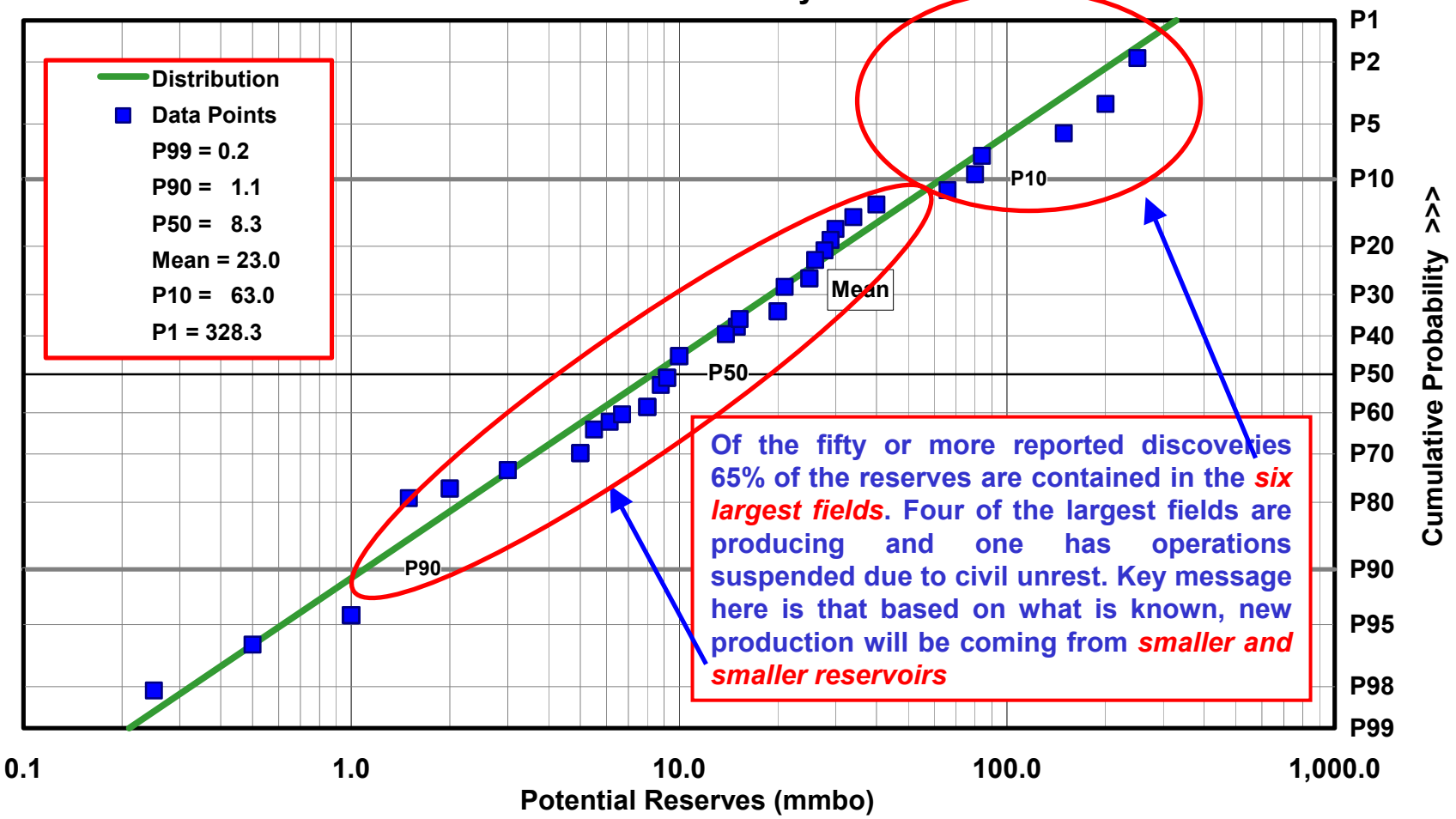
Southern Sudan – Reserves by field

Of the fifty or more reported discoveries 65% of the reserves are contained in the six largest fields. Four of the largest fields are producing and one has operations suspended due to civil unrest. Key message here is that based on what is known, new production will be coming from smaller and smaller reservoirs

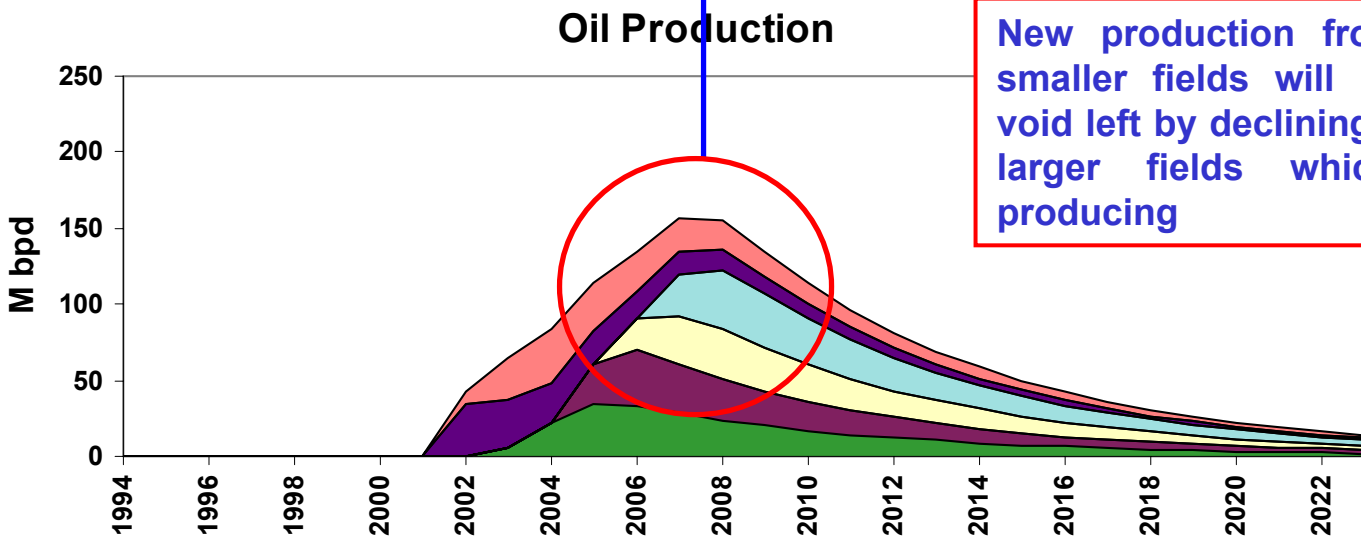
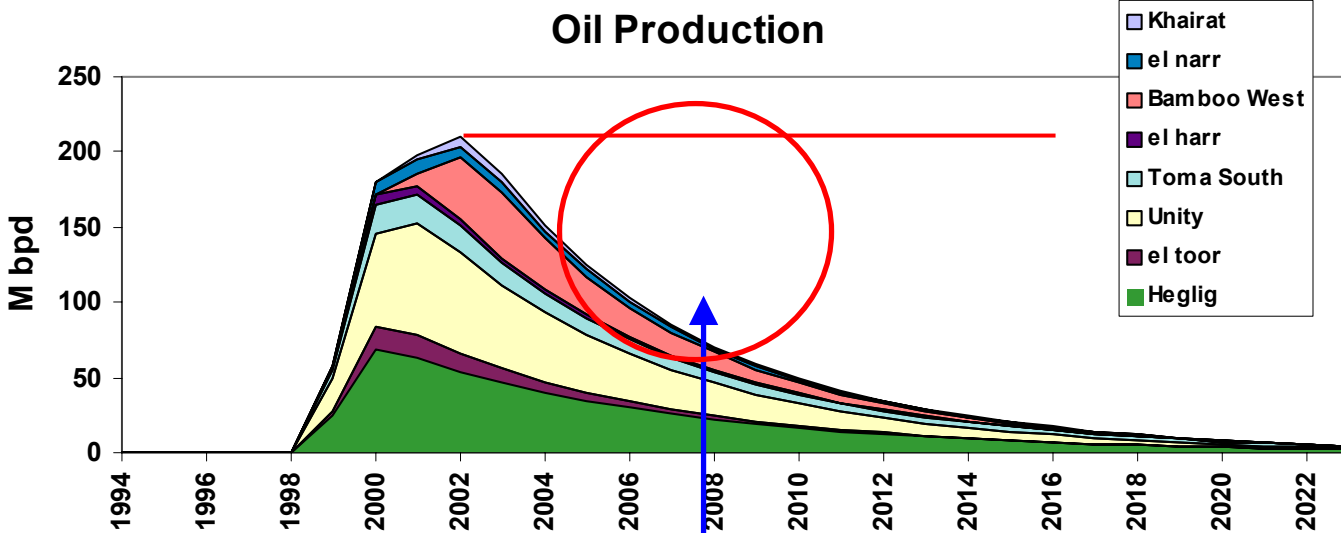


Southern Sudan – Log probability chart (Sudan’s fields fit a lognormal distribution as is the case in most basins)

Southern Sudan Rift System



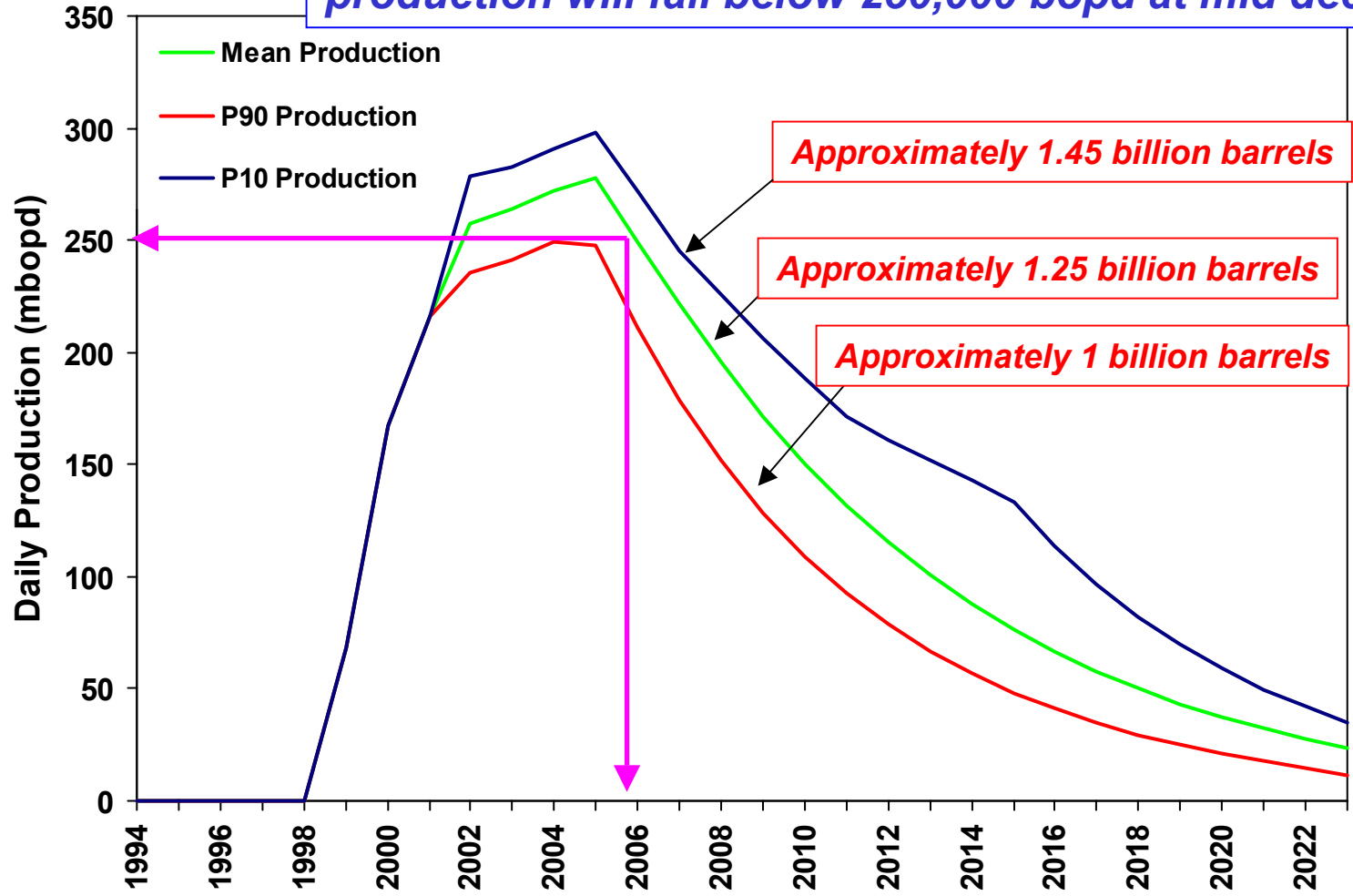
Southern Sudan – Numerous small fields will have to fill the void left by declining production from larger fields that are already in production



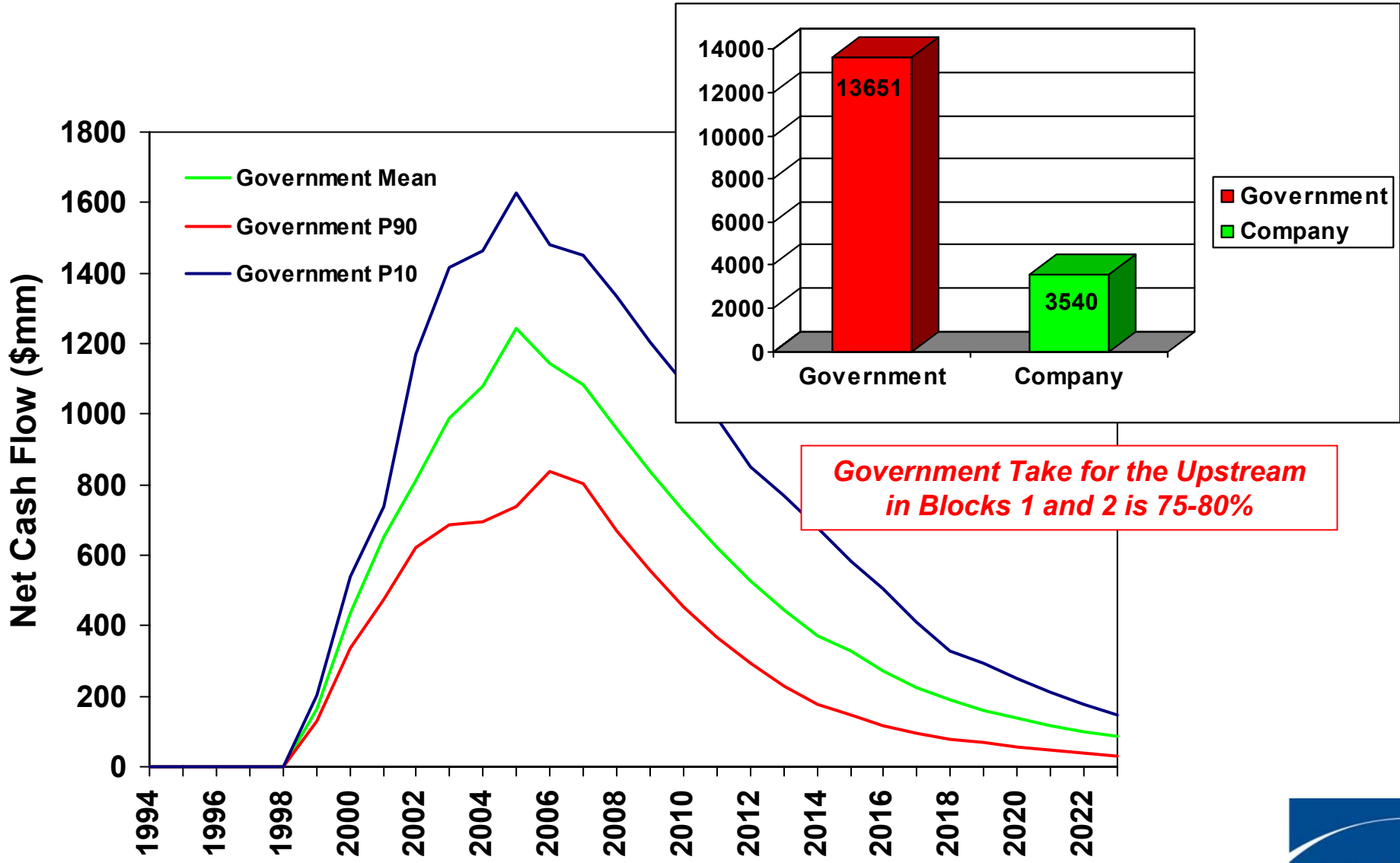
New production from progressively smaller fields will be replacing the void left by declining production from larger fields which are already producing

Heglig Unity Trend – Modeled probabilistic production profile for existing producing fields, proven undeveloped fields and expected additional new reserves

Without new discoveries in Block 4 or 6 it is likely that production will fall below 250,000 bopd at mid decade



Heglig Unity Trend – Modeled probabilistic government net cash flow profile for existing producing fields and proven undeveloped fields and expected additional new reserves (mean reserves of 1.25 billion barrels)



Government Take for the Upstream in Blocks 1 and 2 is 75-80%



Muglad Basin – *Block 4 conclusions (most significant exploration area within the area which is currently considered secure)*

- Exploration in Block 4 is at an immature stage
- Some level of reserves is almost certain to exist but the range of potential reserves varies from less than 100 mmbo to as much as 1 billion barrels – mean expected risked reserves are 450 million barrels
- Given the time lag from exploration to appraisal to development these new reserves won't contribute significant production until 2005 or later
- Most new production from Block 4 will come on stream when expected mean production from Blocks 1 and 2 go into decline – *when expected mean production from Blocks 1, 2, and 4 are combined it is conceivable for production to reach 300,000 bopd for a few years*
- Considering total expected mean production from Blocks 1, 2, and 4 (*considered to hold the vast majority of oil potential in areas which are currently considered safe for operations*) production levels will fall below 250,000 bopd near the end of the decade (2010) and decline rapidly thereafter

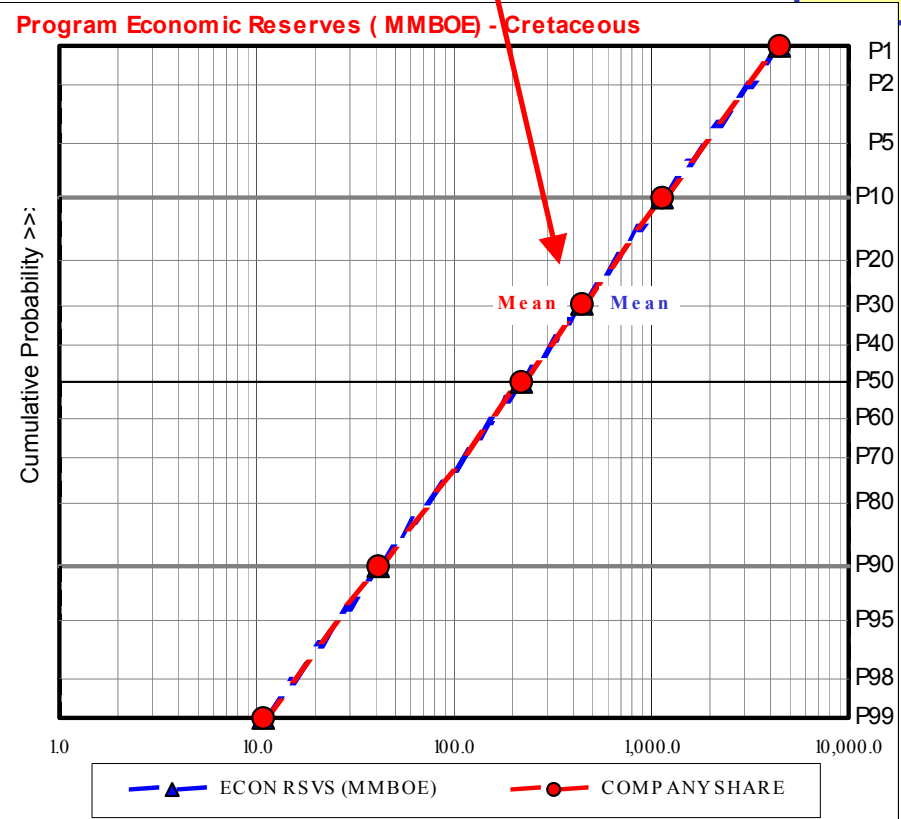
Unexplored Areas in the Muglad Basin – *Key distinctions between development areas and exploration areas*

- Reserves in exploration areas (with few or no wells) which is how all areas outside of Blocks 1 and 2 are classified depend on the following factors – *(source rock, migration and trapping efficiency, reservoir quality, the size of the trapping structures)*
- Without more wells and more seismic data there are considerable ranges of uncertainty for the above parameters – *geologic conditions can change dramatically over short distances in basins of this type so that conditions in Blocks 1 and 2 are not necessarily going to be found in other blocks (could get worse or could get better)*
- When geologists talk about reserves in exploration areas they typically talk about them in terms of probability given the probable ranges of those factors highlighted above

Block 4 – Risked reserves for Block 4 (see detailed presentation)

Results	Total Economic Reserves	Co Share Economic Reserves
P90	41.4	41.4
P10	1,147.1	1,147.1
P99	10.7	10.7
Mode	40.7	40.7
P50 (median)	218.0	218.0
Mean (average)	441.6	441.6
P1	4,441.2	4,441.2
	MMBOE	MMBOE

Mean reserve

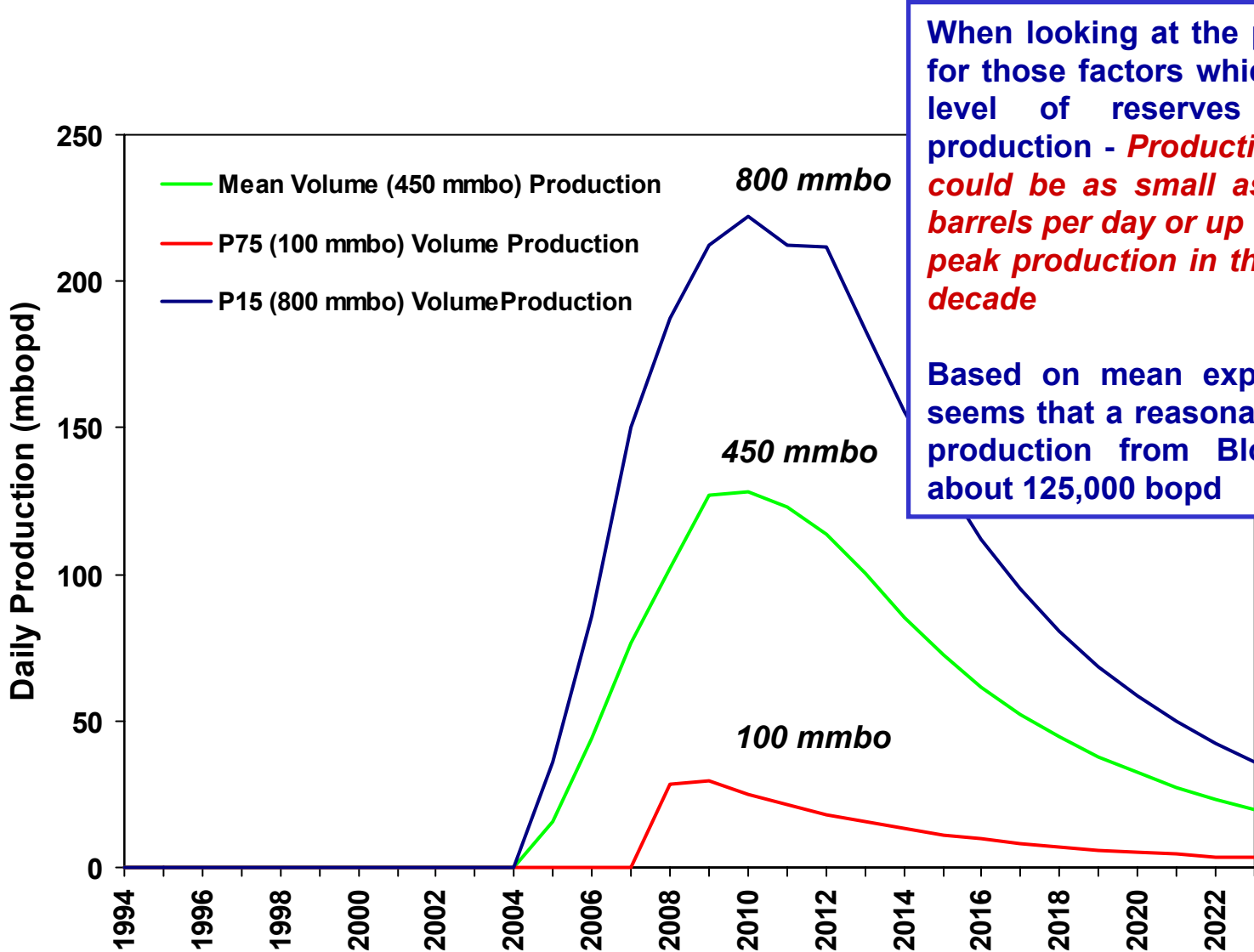


When looking at the probability ranges for those factors which will control the level of reserves in Block 4 the following reserve distribution curve is derived

There is a 90% chance that reserves will exceed 41 mmbo and only a 10% chance that reserves will exceed 1.15 billion barrels – *large range but about as precise as possible until more wells are drilled*



Block 4 – Modeled probabilistic production profile for risked portfolio of exploration prospects (modeled volumes taken from the proceeding reserve distribution)



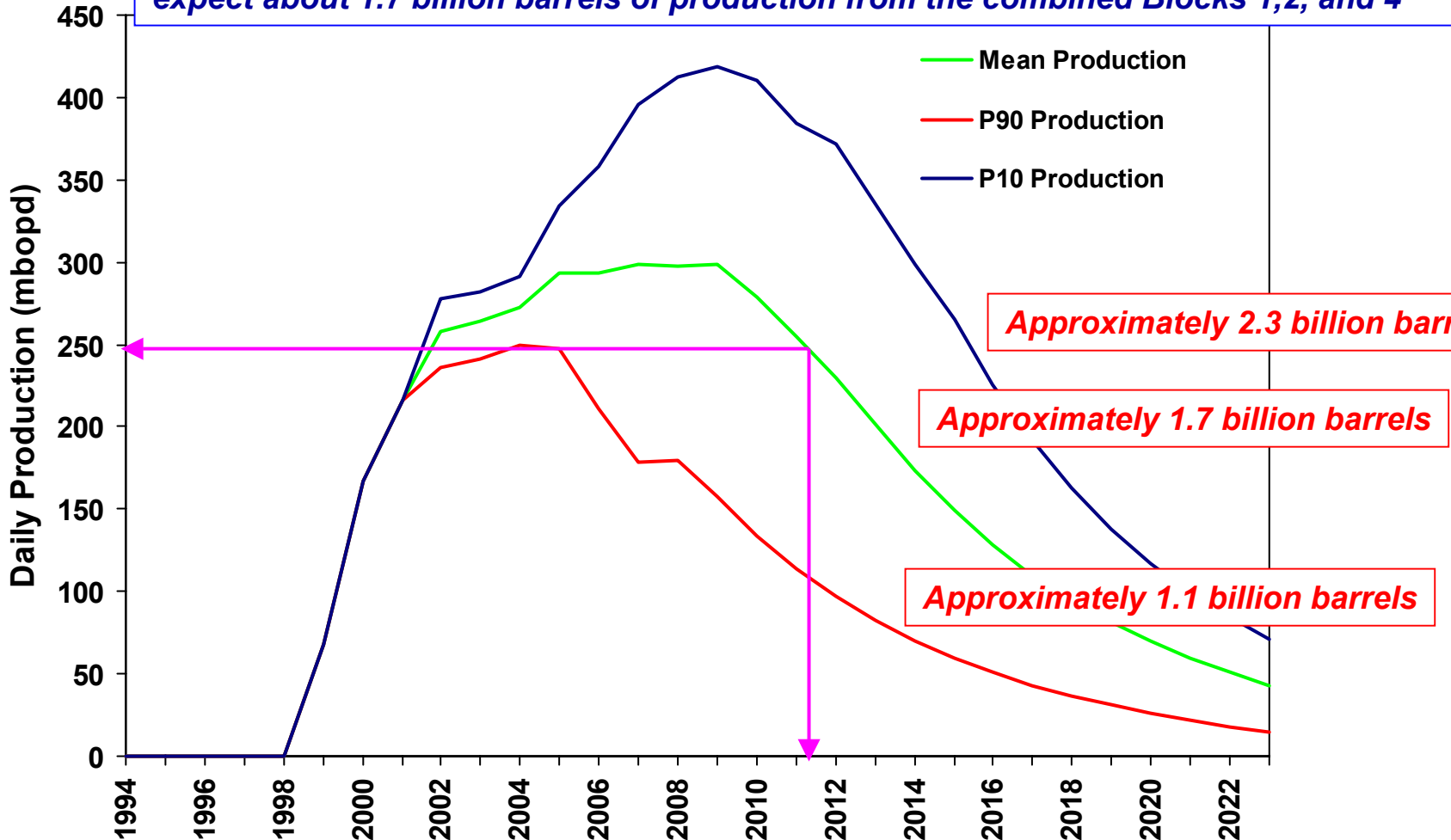
When looking at the probability ranges for those factors which will control the level of reserves and ultimately production - **Production from the block could be as small as a few thousand barrels per day or up to 200,000 bopd at peak production in the later part of the decade**

Based on mean expected reserves it seems that a reasonable expectation of production from Block 4 would be about 125,000 bopd



Heglig Unity Trend and Block 4 Combined – Modeled probabilistic production profile for existing producing fields, proven undeveloped fields and risked exploration prospects (a mean 1.7 billion barrels in total)

This diagram summarizes the likely range of production probabilities for the combined areas of Blocks 1 and 2 and exploration Block 4 where operations are currently underway – geologists would argue that based on what is known today it would be reasonable to expect about 1.7 billion barrels of production from the combined Blocks 1,2, and 4

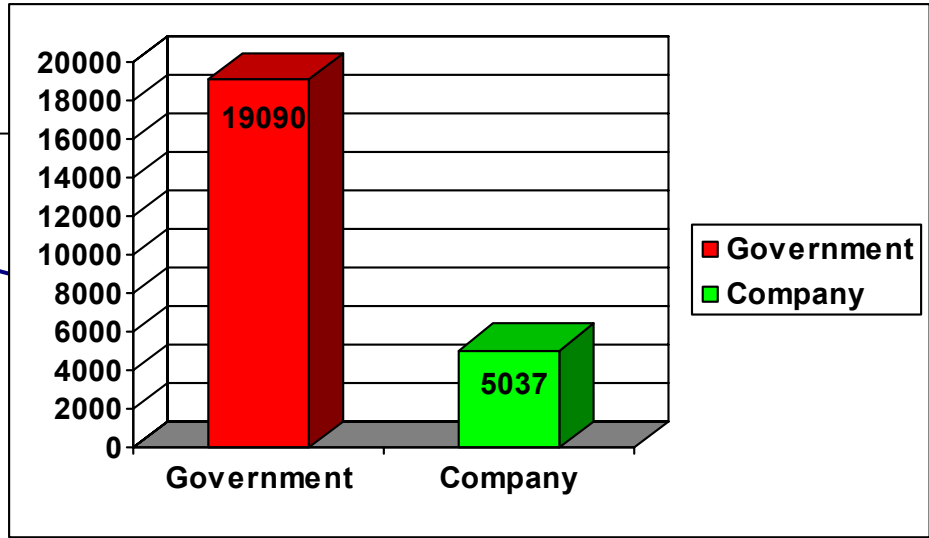
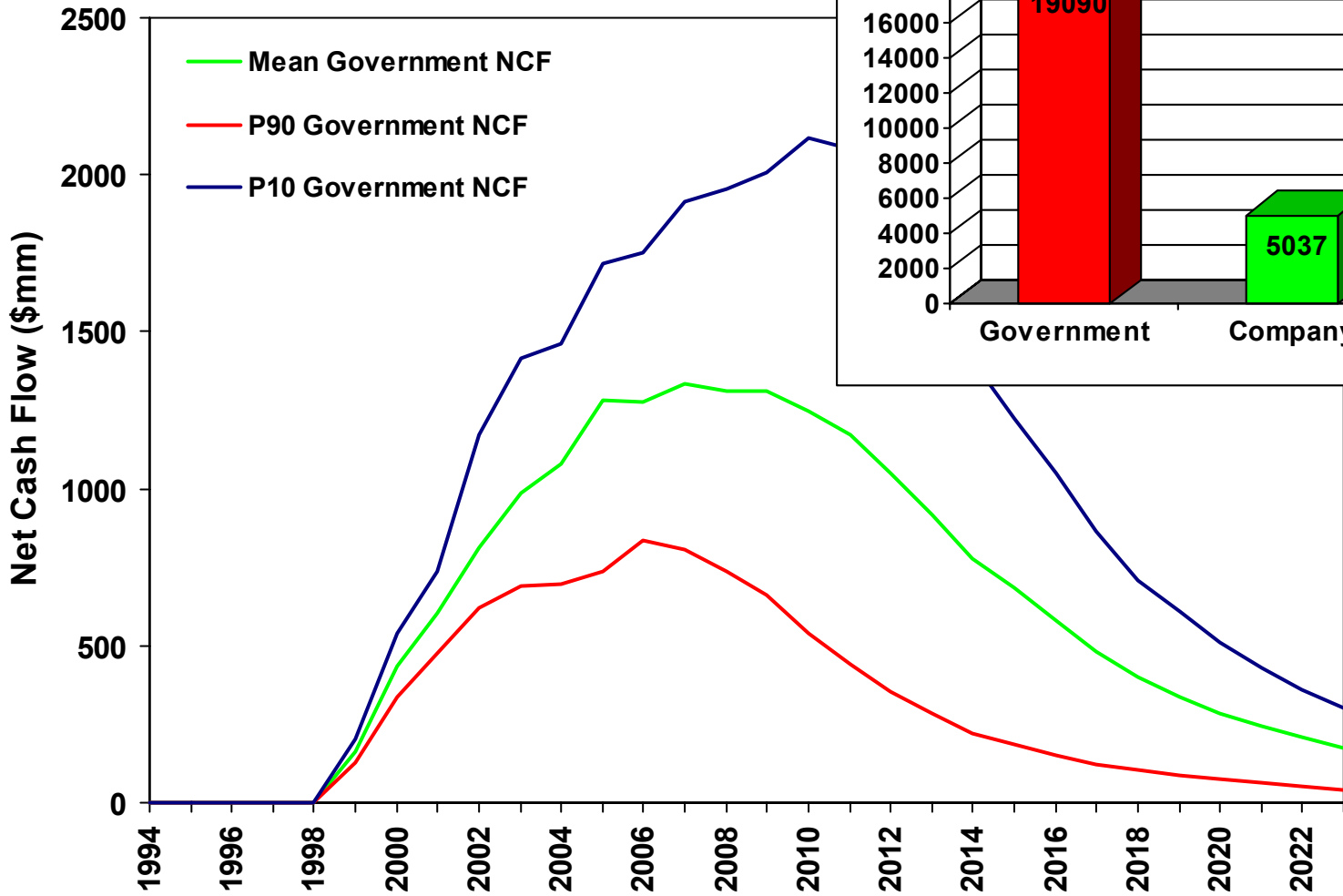


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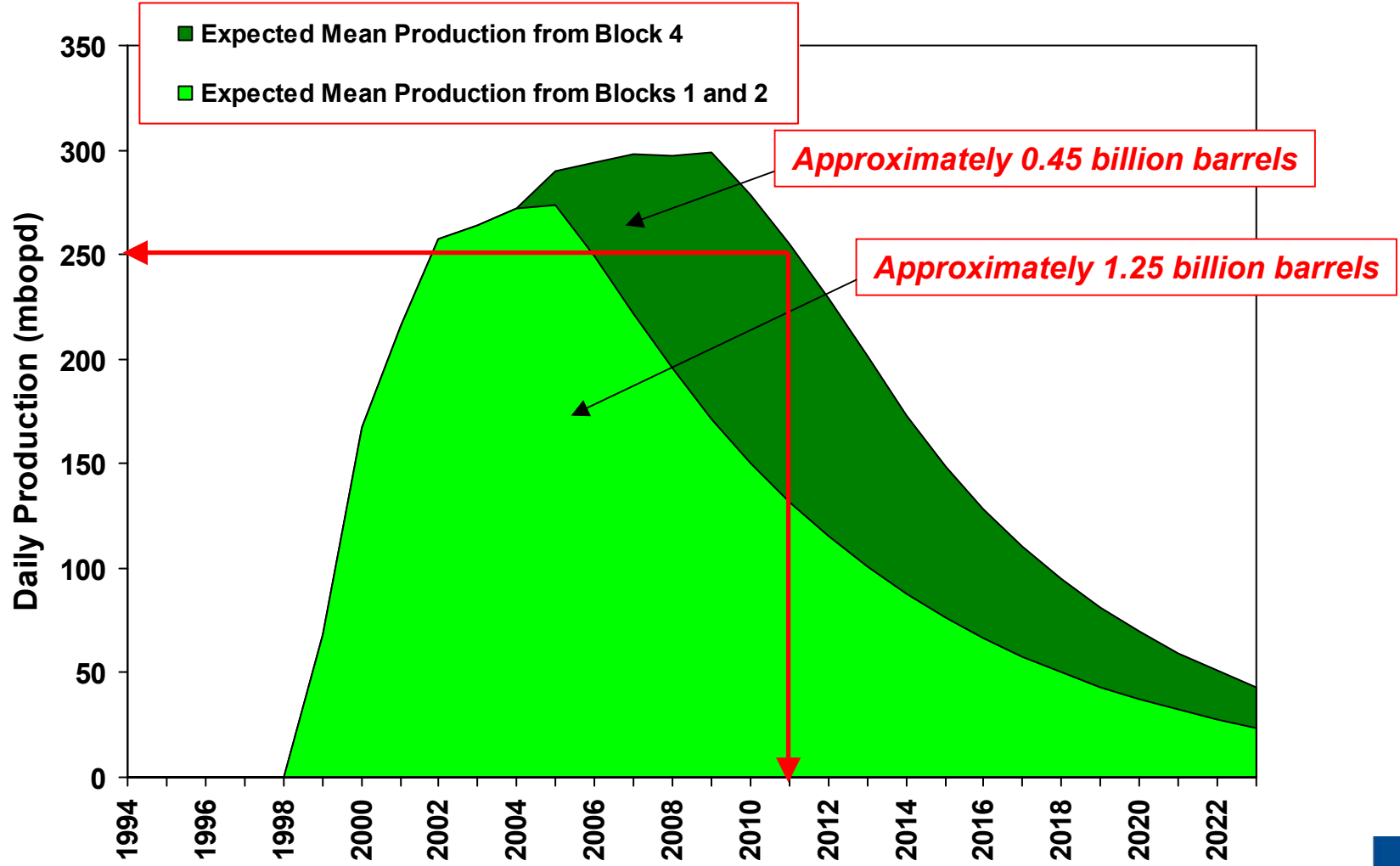


Heglig Unity Trend and Block 4 Combined – Modeled

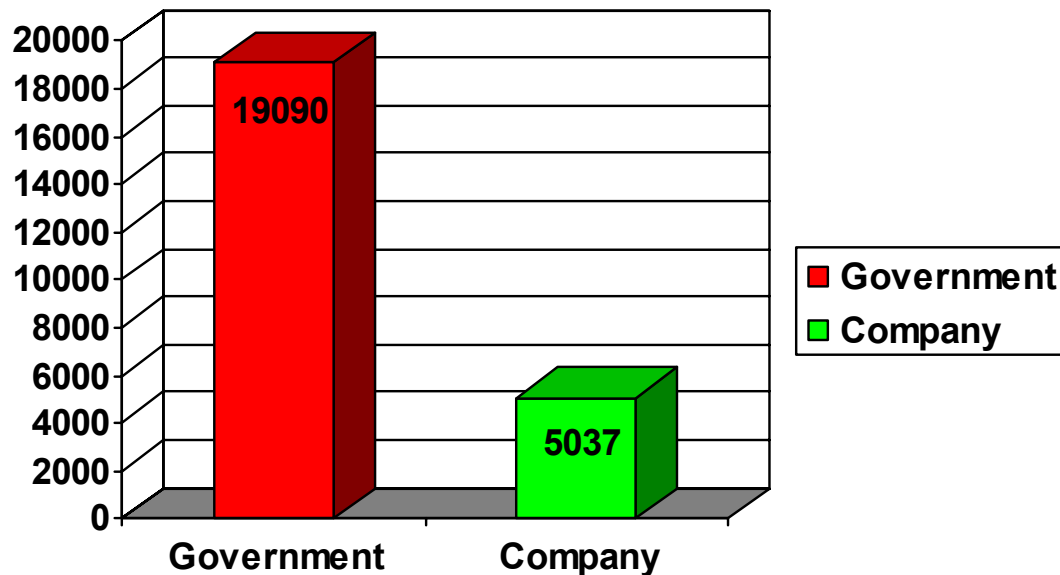
probabilistic government net cash flow profile for existing producing fields, proven undeveloped fields and risked exploration prospects (a mean 1.7 billion barrels in total)



Blocks 1, 2 and 4 (Area Currently Secure for Operations) – Modeled expected mean production profile for existing producing fields, proven undeveloped fields and expected additional new reserves (approximately 1.7 billion barrels in total)



Southern Sudan – Modeled probabilistic government net cash flow versus company net cash flow for mean reserves in producing fields, proven undeveloped discoveries and risked mean exploration potential for blocks (1, 2, and 4 – total mean reserves of 1.7 billion barrels) where operations are currently operating



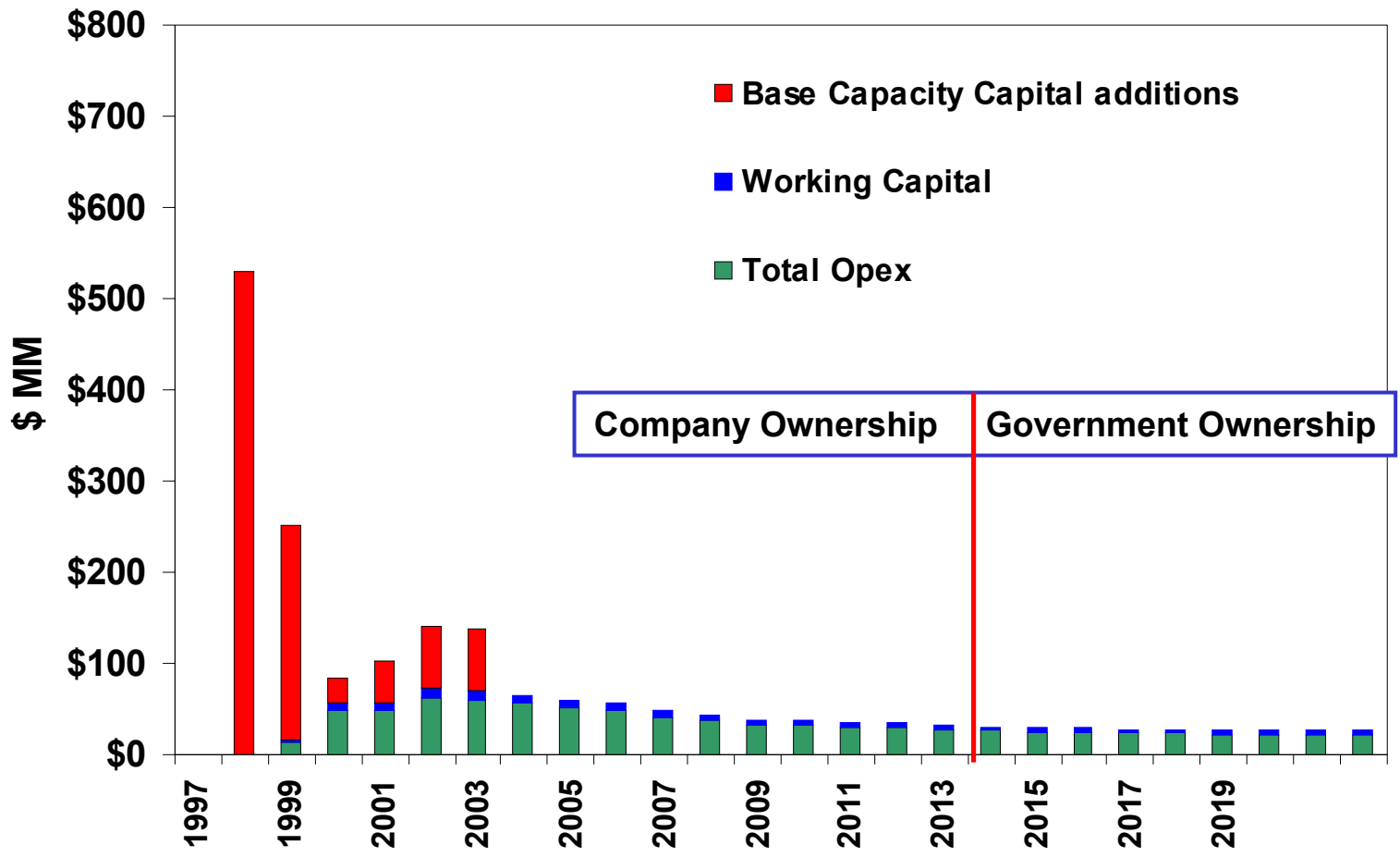
PFC's analysis of the after tax cash flow for a long term exploration/development program in southern Sudan suggests that in the Upstream sector the government will net approximately \$11.22 per barrel and the foreign companies who invested the risk capital will net \$2.96 per barrel. Overall estimated government take is 79% of upstream net cash flow.

Southern Sudan Pipeline – Conclusions

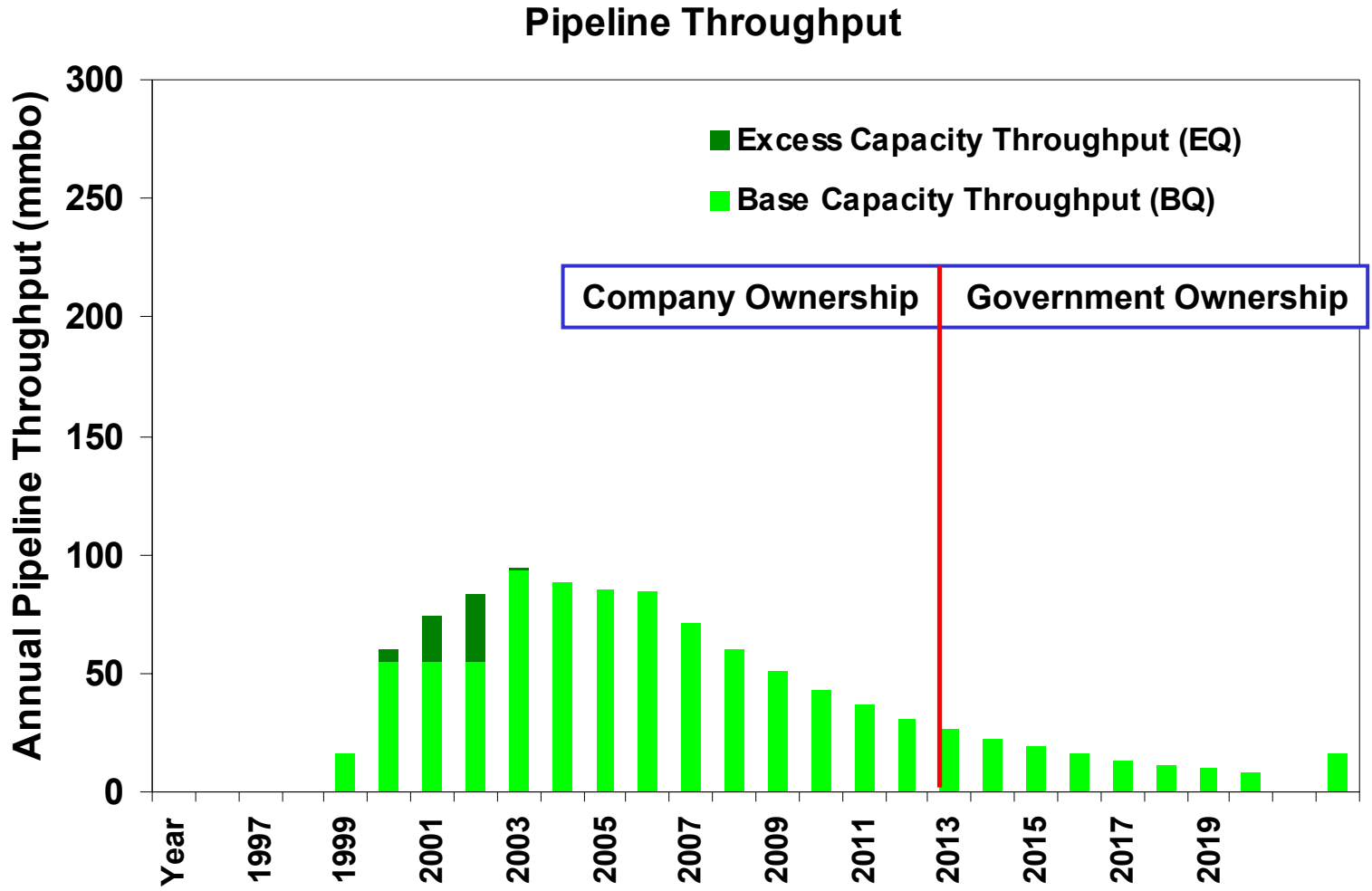
- Building the pipeline was a significant investment (approximately \$1 billion) prior to production
- Unlike the upstream contracts, foreign investors get the largest share of the net cash flow generated by the tariff revenues – *this is the only way a contract could be structured which would provide an acceptable rate of return that would justify investing the necessary capital*
- The contractors turn over the pipeline to the government after 15 years of production
- Prior to first production the contractors had nearly \$1 billion invested in the project before there was any revenue generation – *producing only P1 and P2 reserves (approximately 1 billion barrels) would yield a marginal IRR of 15 – 17%*
- If reserves and production are considerably higher (2.9 billion barrels) cash flow would be considerably higher but IRR would still only reach the low 20% range

Sudan Crude Oil Pipeline Agreement (COPA) - *Cost to build and operate pipeline*

Pipeline Costs

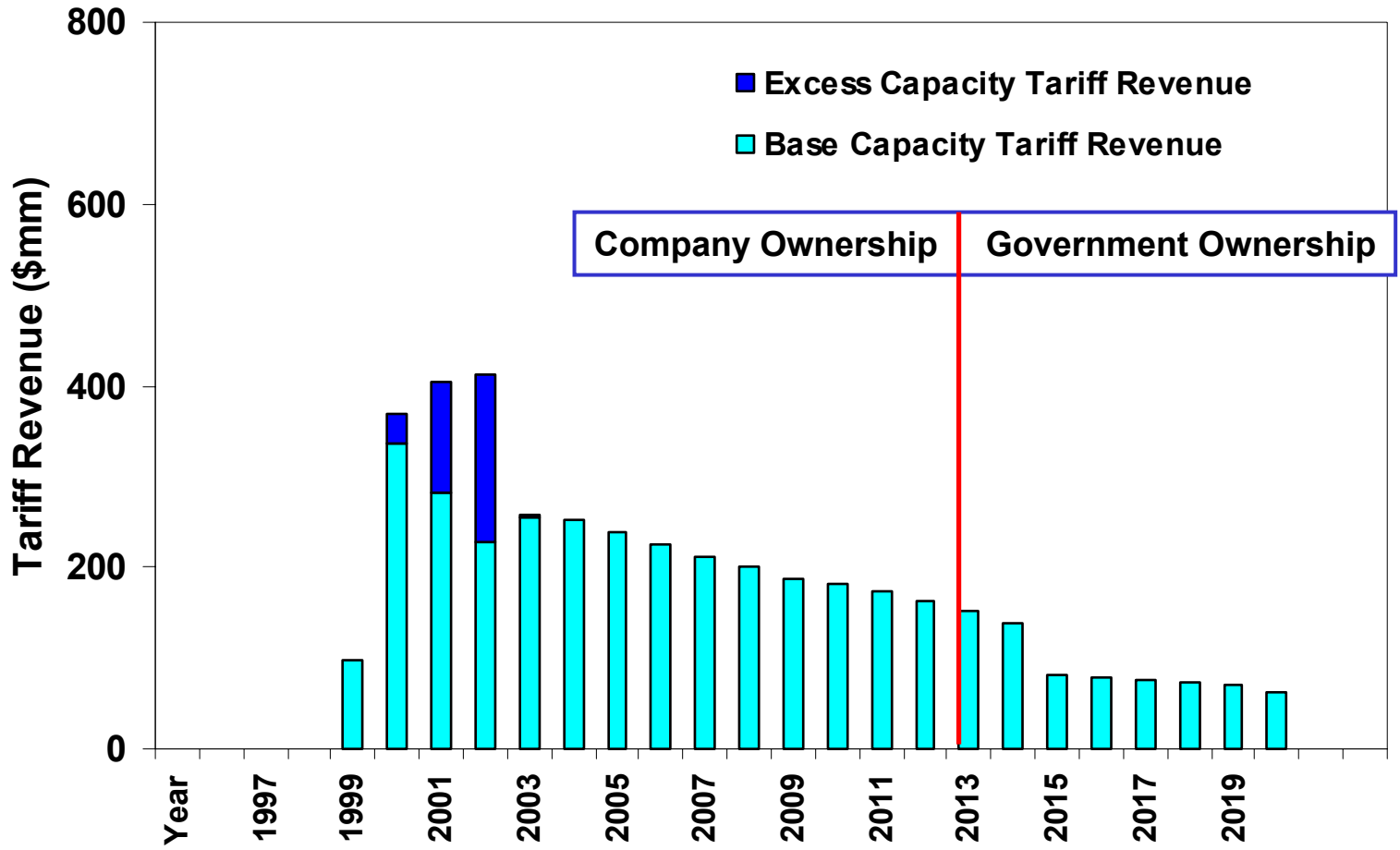


Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline throughput for a conservative reserve/production projection of 1 billion barrels

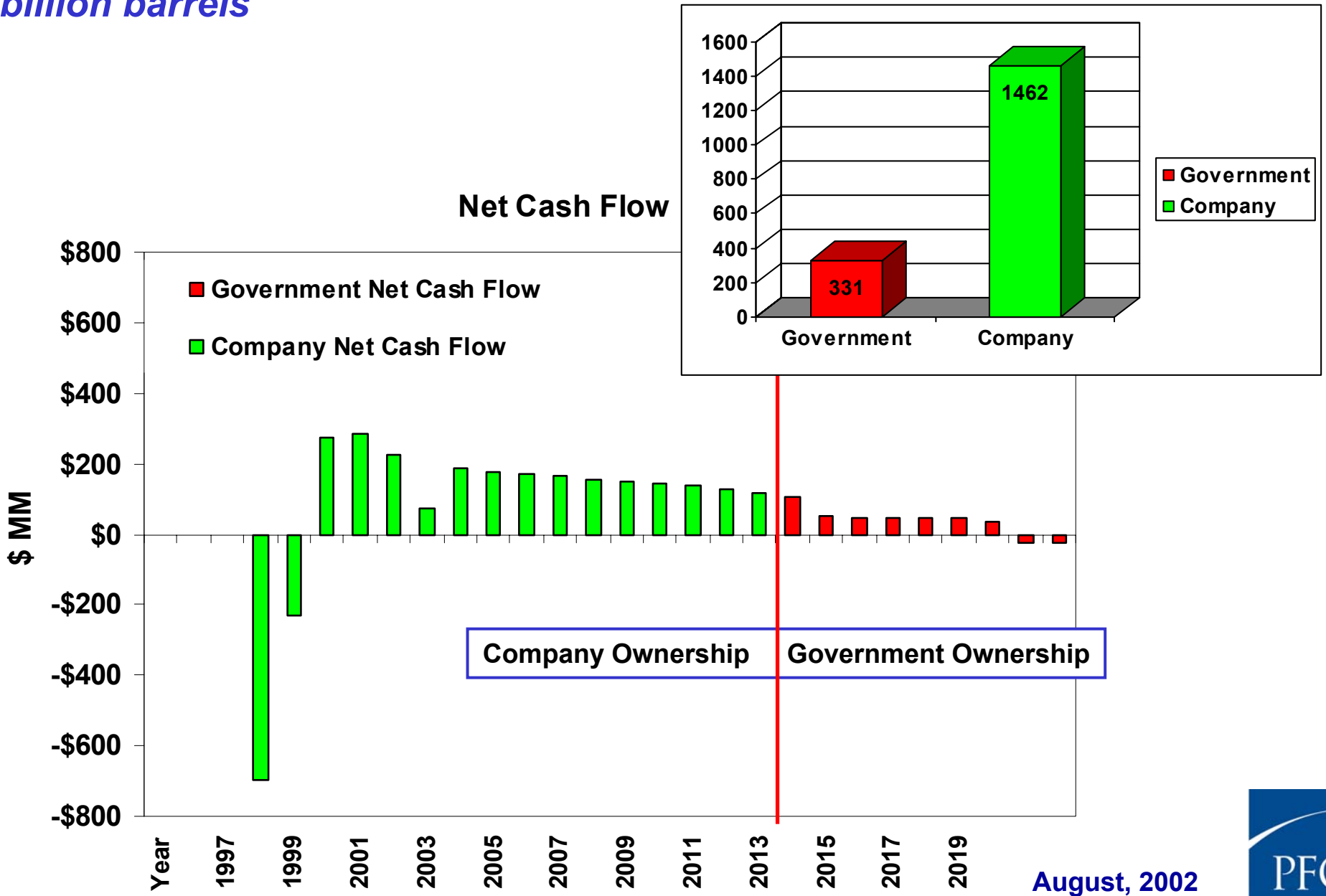


Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline tariff revenues (estimated) for a conservative reserve/production projection of 1 billion barrels

Tariff Revenues



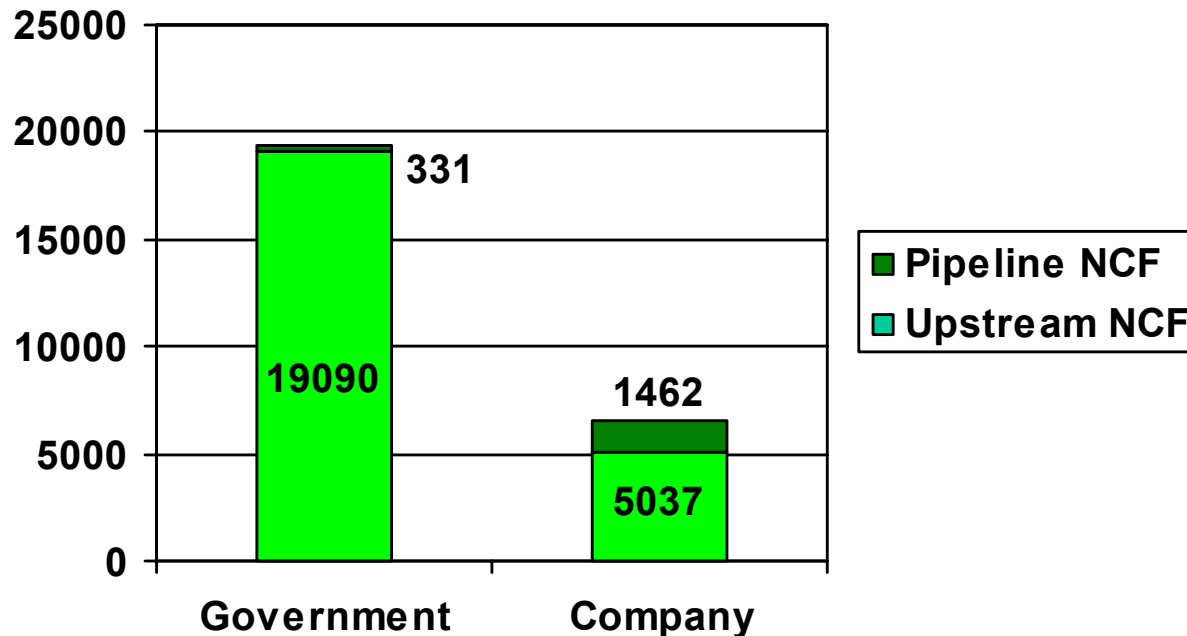
Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline net cash flow (estimated) for a conservative reserve/production projection of 1 billion barrels



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Southern Sudan – Modeled probabilistic government net cash flow versus company net cash flow for pipeline and mean reserves in producing fields, proven undeveloped discoveries and risked mean exploration potential for areas which are currently secure



PFC's analysis of the after tax cash flow for those areas where exploration/development activity is currently underway (secure areas) suggests that in the combined upstream and midstream sector will ultimately provide the government with 75% of the net cash flow generated

Southern Sudan – *Conclusions for areas which are currently secure for operations*

- It is reasonable to expect that as much as 1.7 billion barrels could ultimately be produced from this area
- Production levels at or near current levels (250 – 300 mbopd) should be sustainable through the end of the decade – *this means that the profit oil share to the government of at least \$1 to \$1.2 billion per year should be sustainable through the end of the decade*
- The government will receive a profit share of the oil worth somewhere in the area of \$20 billion (assuming an oil price range of \$18 - \$25 per barrel) over the life of this project
- The companies will receive a profit share of the oil worth somewhere in the area of \$6.5 billion (assuming an oil price range of \$18 - \$25 per barrel) over the same period
- *Without a dramatic improvement in the field size distribution pattern and success rates, annual oil production and annual net cash flow to the government will decline at a significant rate after 2008-2010*

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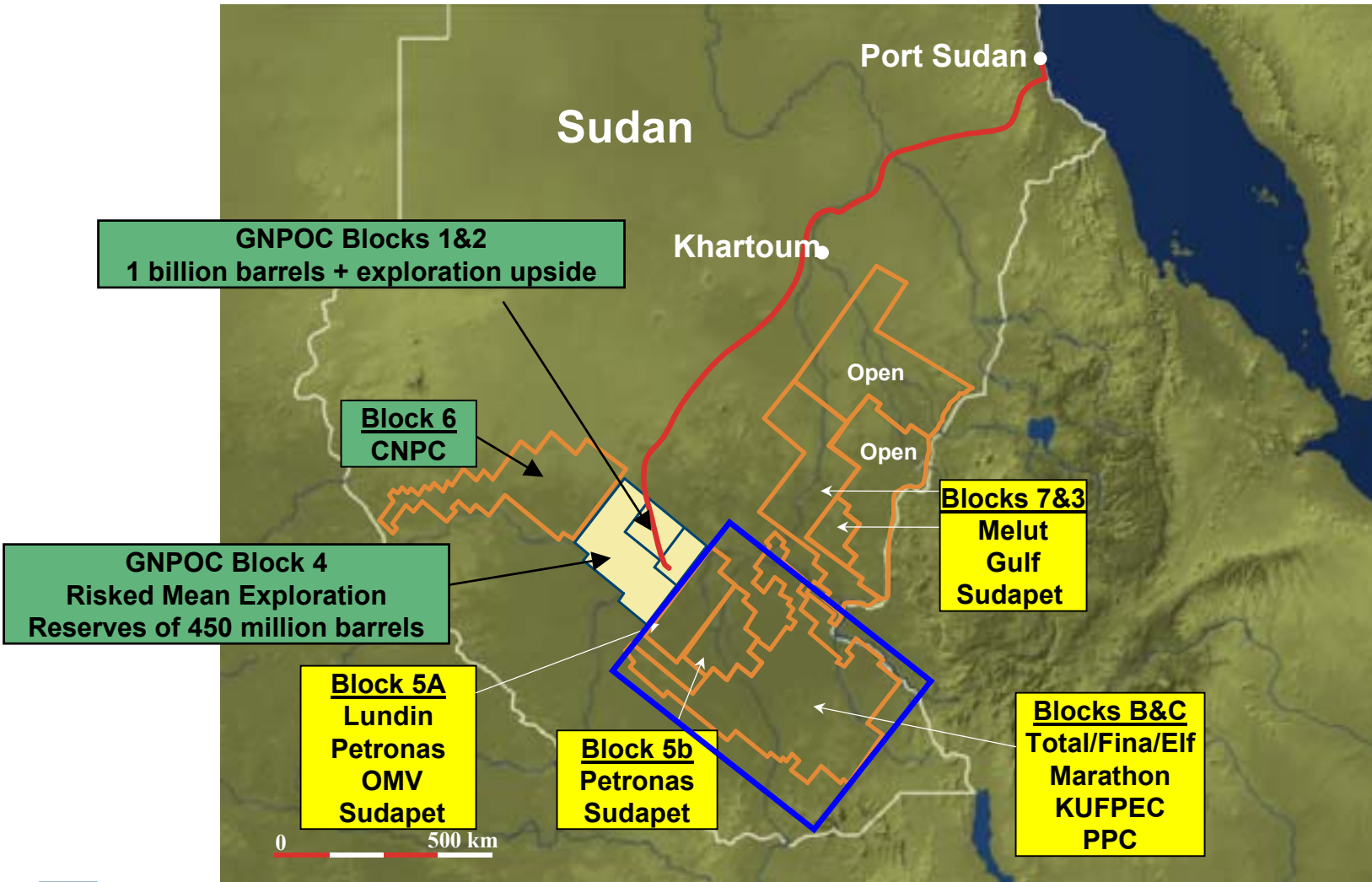
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***How Could Exploration in Areas
Which are Currently Insecure
Change the Future Projections***

Michael Rodgers



Sudan General Location Map – Areas where operations are currently underway (green) and areas with potential reserves where operations are not possible due to security risk (yellow)



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 Pipeline

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Muglad Basin – Areas where operations are currently not possible due to security (Blocks 3, 7, 5A, 5B, and B)

- Exploration in these blocks is at an immature stage
- Some level of reserves is almost certain to exist but the range of potential reserves varies from less than 500 mmbo to more than 3 billion barrels – *important to keep in mind that areas where operations are not possible are exploration areas and as such carry considerable uncertainty in reserve levels*
- It is considered likely that given security, companies could carry out exploration programs of significant magnitude to prove up a mean expected reserve of 1.2 billion barrels before the end of the decade – *this is not the total expected reserve level in this area (only what might be found by the end of the decade)*
- Given the time lag from exploration to appraisal to development these new reserves won't contribute significant production until 2006 to 2010 – *immediate peace will not result in immediate new production and cash flow*

Muglad Basin – *Areas where operations are currently not possible due to security (Blocks 3, 7, 5A, 5B, and B)*

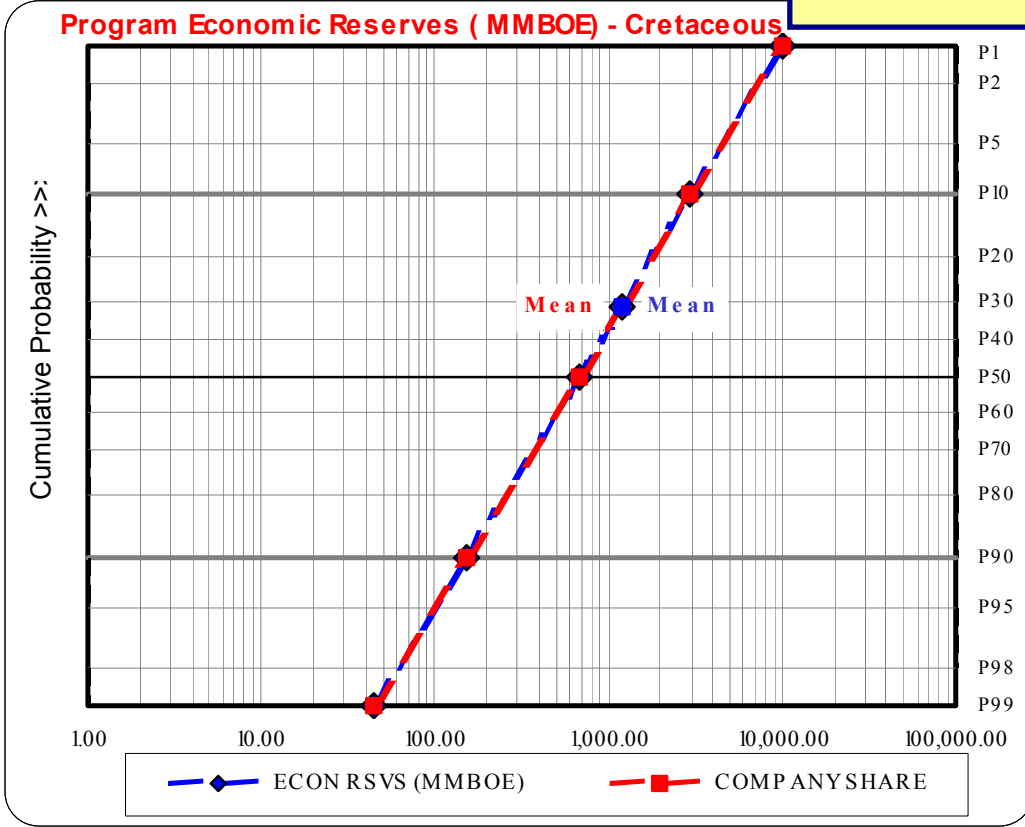
- In order to have a high probability of ramping countrywide production significantly higher than 300,000 bopd it will be necessary to explore for and develop reserves in areas which are currently inaccessible due to security concerns

- If security is established and exploration is carried out in all areas of the basin it is considered likely that production levels could be maintained at or above current levels over the next two decades

Blocks 3, 7, 5A, 5B, and B – Potential reserve distribution curve for what may be found by 2010

This model takes into account an upper limit of 200 prospects, a P10 field size of 63 mmbo, and a 50% geologic success rate.

Results	Total Economic Reserves	Co Share Economic Reserves
P90	151.2	151.2
P10	2,957.7	2,957.7
P99	45.0	45.0
Mode	174.1	174.1
P50 (median)	668.7	668.7
Mean (average)	1,184.2	1,184.2
P1	9,939.3	9,939.3
	MMBOE	MMBOE

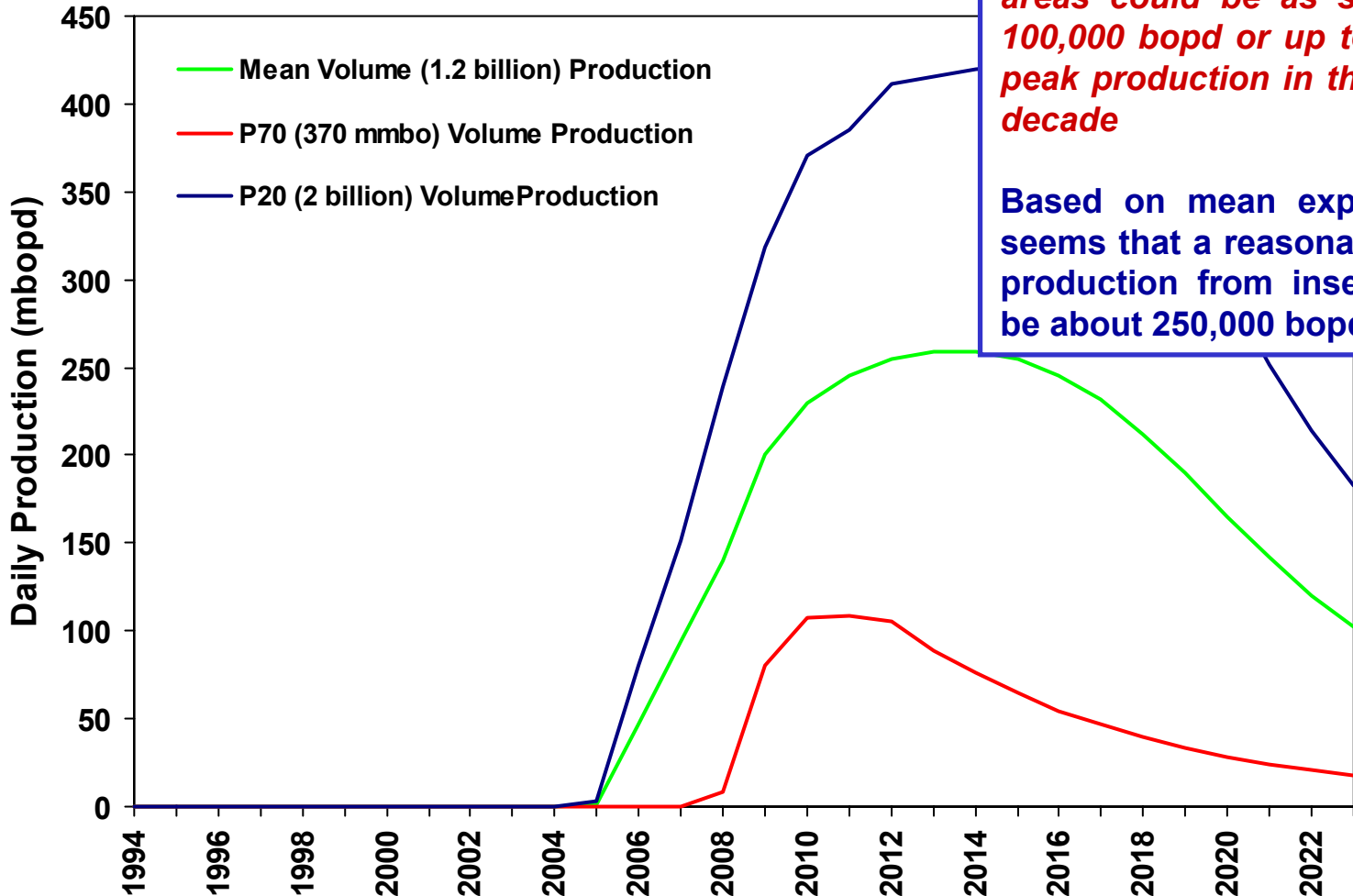


When looking at the probability ranges for those factors which will control the level of reserves in Blocks 5A, 5B and B the following reserve distribution curve is derived

There is a 90% chance that reserves will exceed 150 mmbo and only a 10% chance that reserves will exceed 2.9 billion barrels – *large range but about as precise as possible until more wells are drilled*



Blocks 3, 7, 5A, 5B, and B – Modeled probabilistic production profile for risked reserves that might be found by the end of the decade

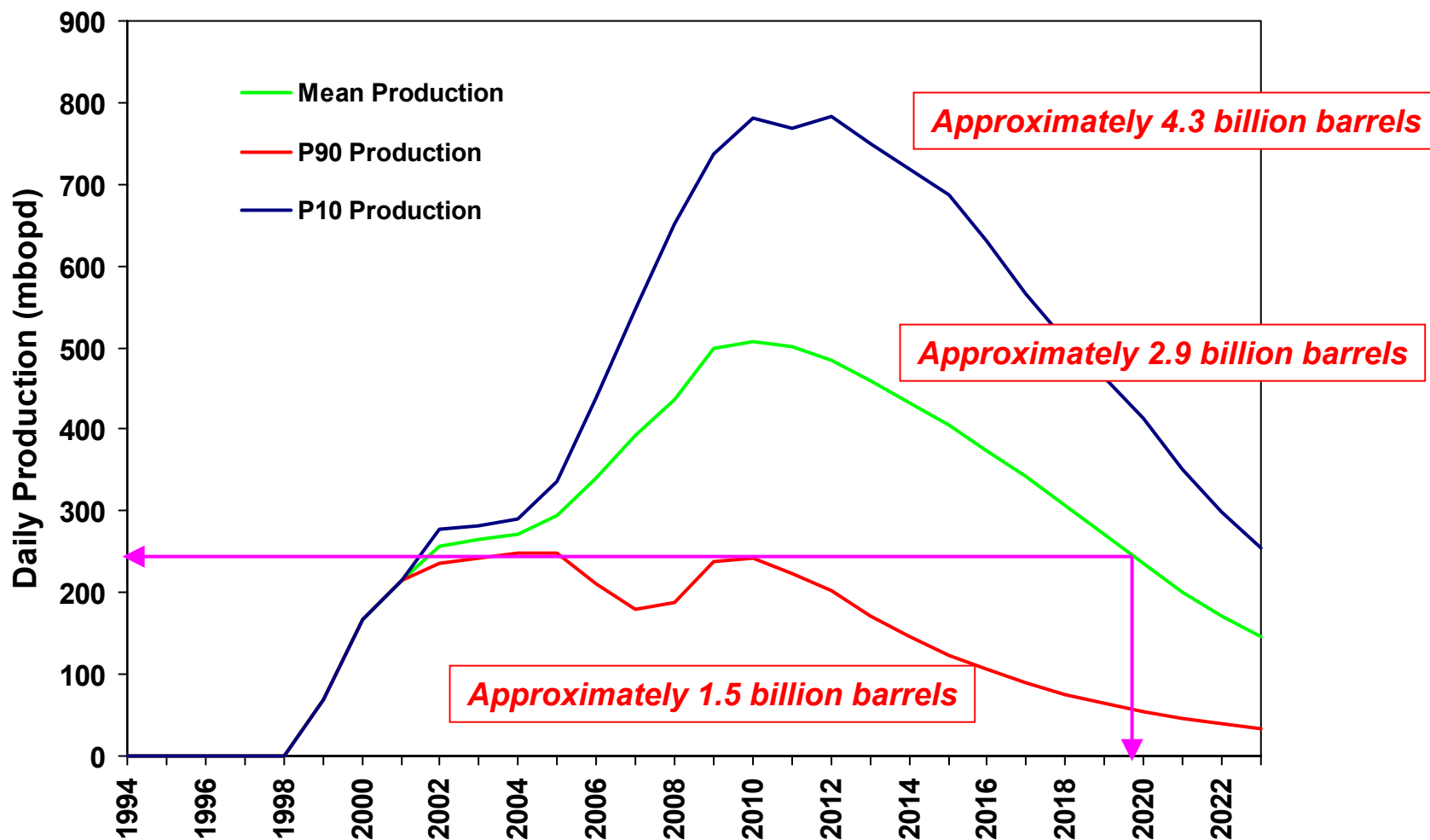


When looking at the probability ranges for those factors which will control the level of reserves and ultimately production - *Production from insecure areas could be as small as less than 100,000 bopd or up to 400,000 bopd at peak production in the later part of the decade*

Based on mean expected reserves it seems that a reasonable expectation of production from insecure areas could be about 250,000 bopd

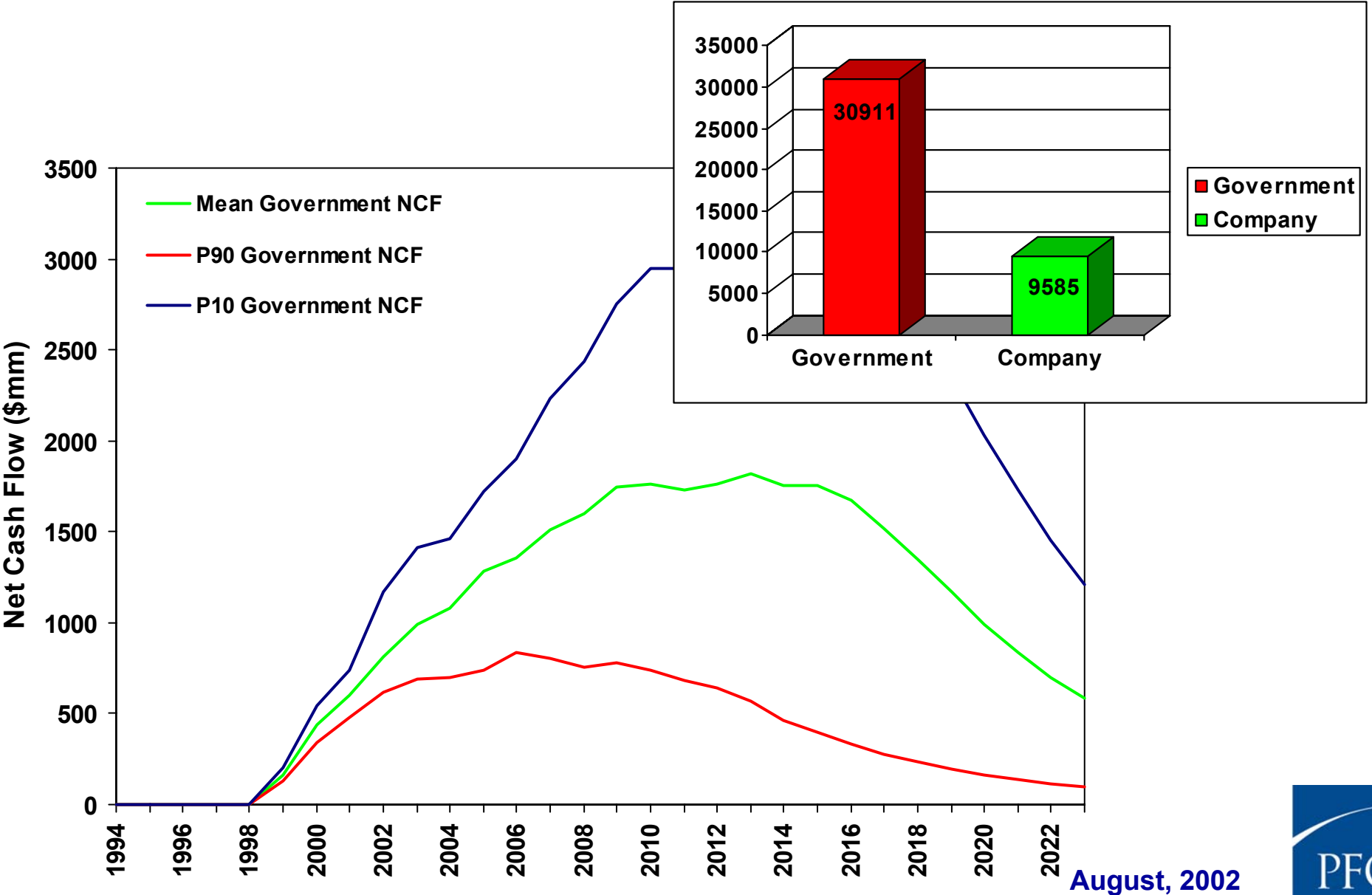


Southern Sudan – Modeled probabilistic production profile for existing producing fields, proven undeveloped fields and risked exploration potential in Blocks 1, 2, 4, 3, 7, 5A, 5B, and B (2.9 billion barrels)



This diagram summarizes the likely range of production probabilities if operations were possible throughout the entire basin – geologists would argue that based on what is known today it would be reasonable to expect about 2.9 billion barrels of reserves to be proven by the early part of the next decade

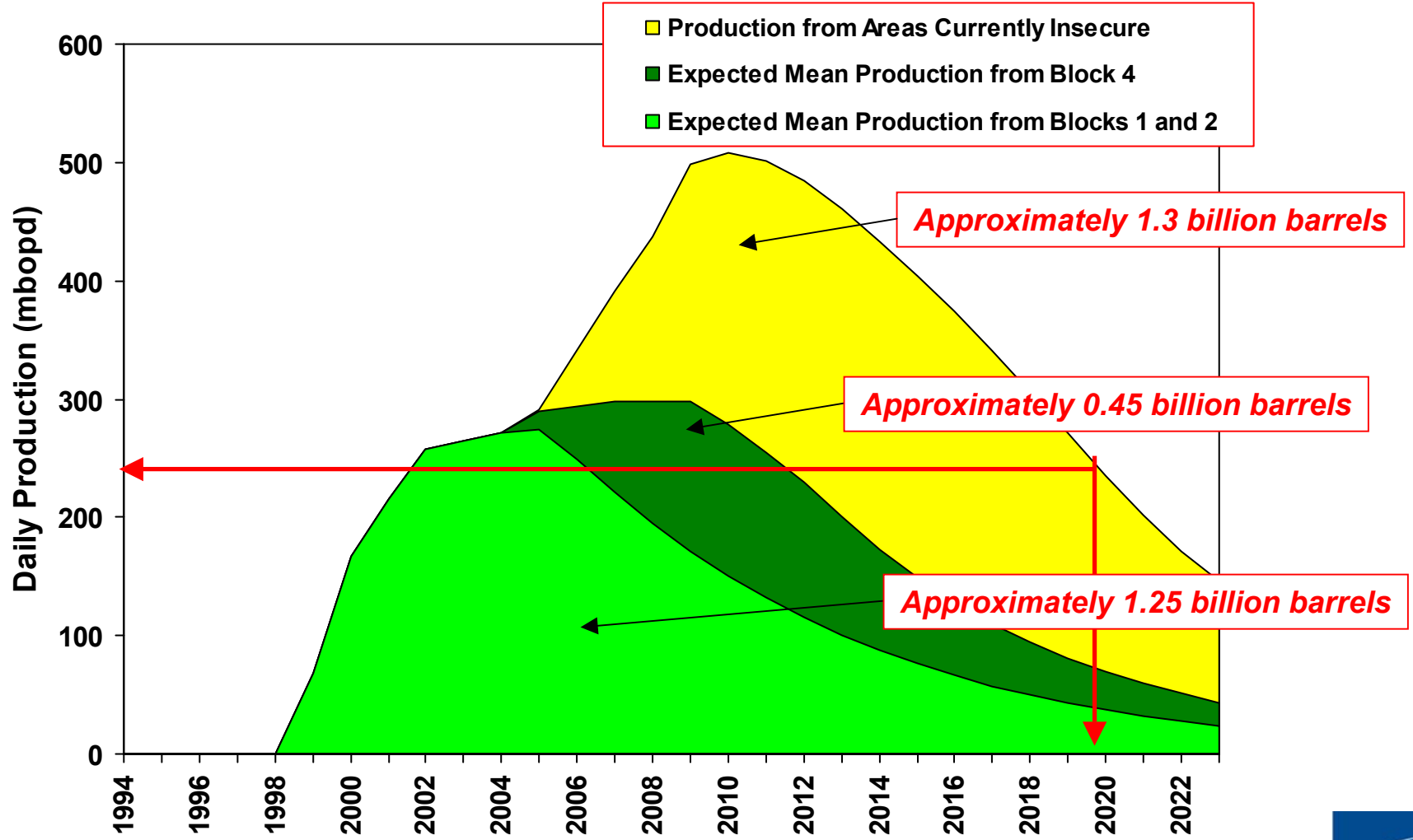
Southern Sudan – Modeled probabilistic government net cash flow profile for existing producing fields, proven undeveloped fields and risked exploration potential in Blocks 1, 2, 4, 3, 7, 5A, 5B, and B



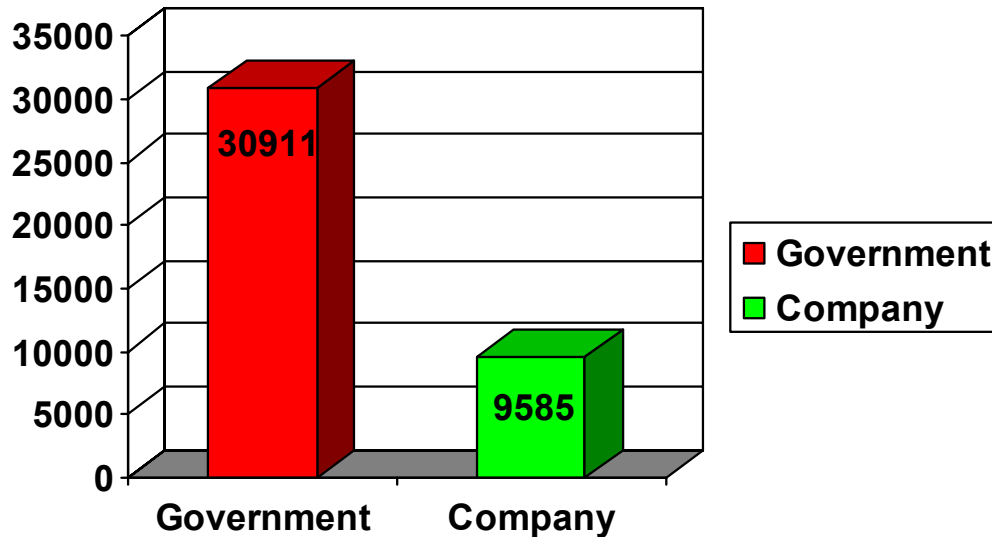
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Southern Sudan – Modeled expected mean production profile for existing producing fields, proven undeveloped fields and risked exploration potential (not total exploration potential but what a reasonable exploration program might find by the end of the decade)

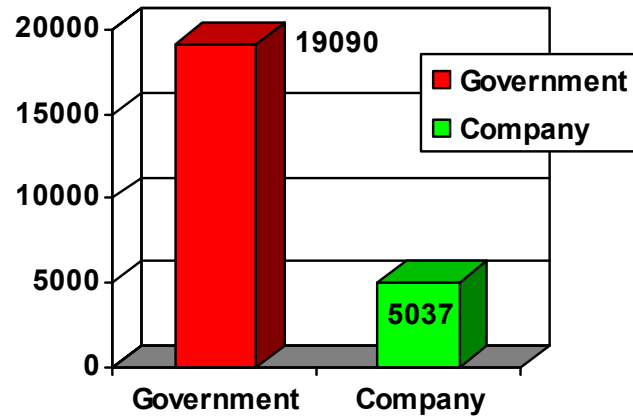


Southern Sudan – Modeled probabilistic government net cash flow versus company net cash flow for mean reserves in producing fields, proven undeveloped discoveries and risked mean exploration potential for all blocks (1, 2, 4, 3, 7, 5A, 5B, and B – total mean reserves of 2.9 billion barrels)



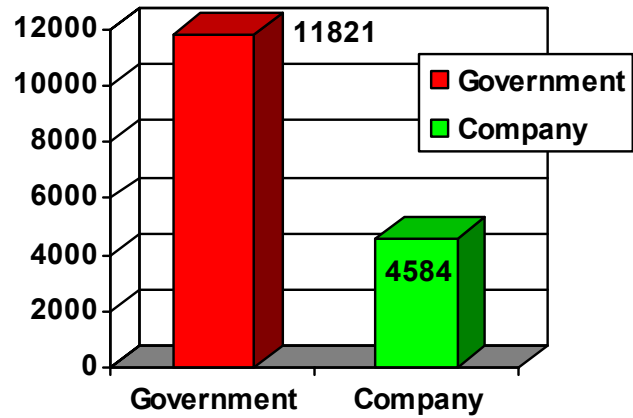
PFC's analysis of the after tax cash flow for a long term exploration/development program in southern Sudan suggests that in the Upstream sector the estimated government take is 76% of upstream net cash flow.

Southern Sudan – Modeled probabilistic government net cash flow versus company net cash flow for mean reserves in producing fields, proven undeveloped discoveries and risked mean exploration potential for all blocks



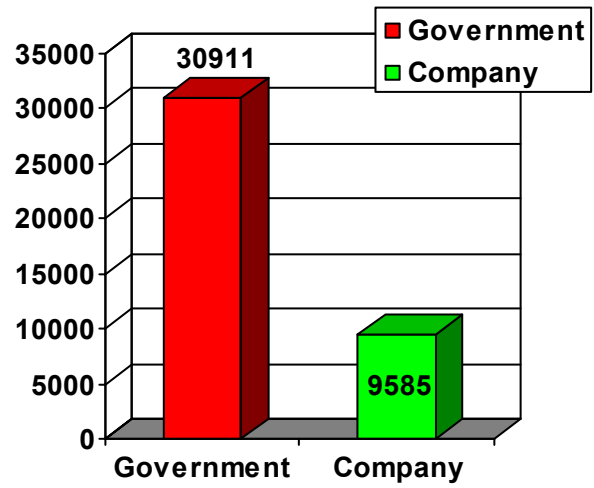
Secure Areas

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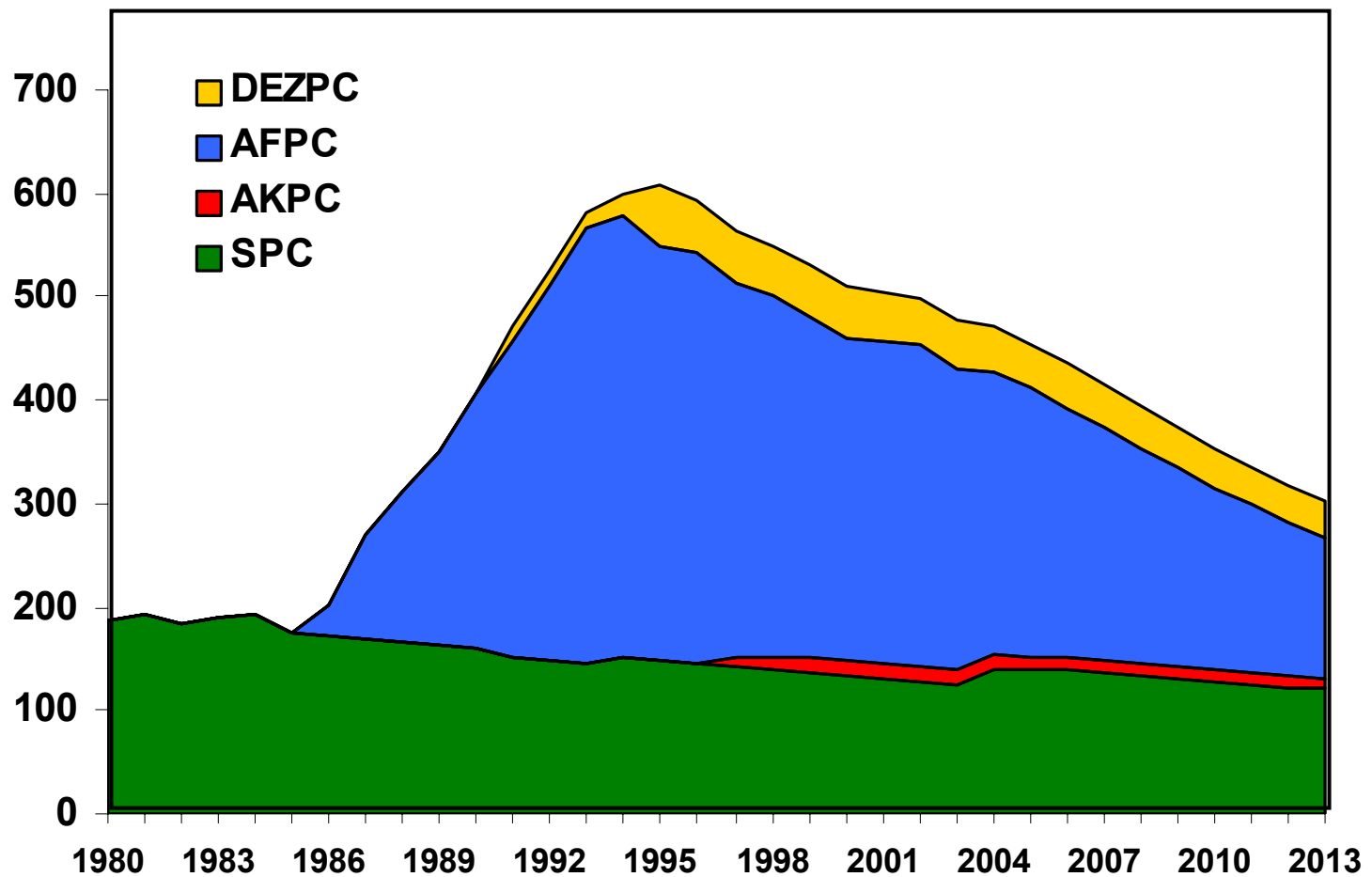
Insecure Areas

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Southern Sudan – *The Euphrates Graben in Syria is a good analogue for what Southern Sudan could look like*

The discovered reserve base is approximately 3 billion barrels – production was ramped up over 6 years and peaked at 400,000 bopd or 5% of total reserves.



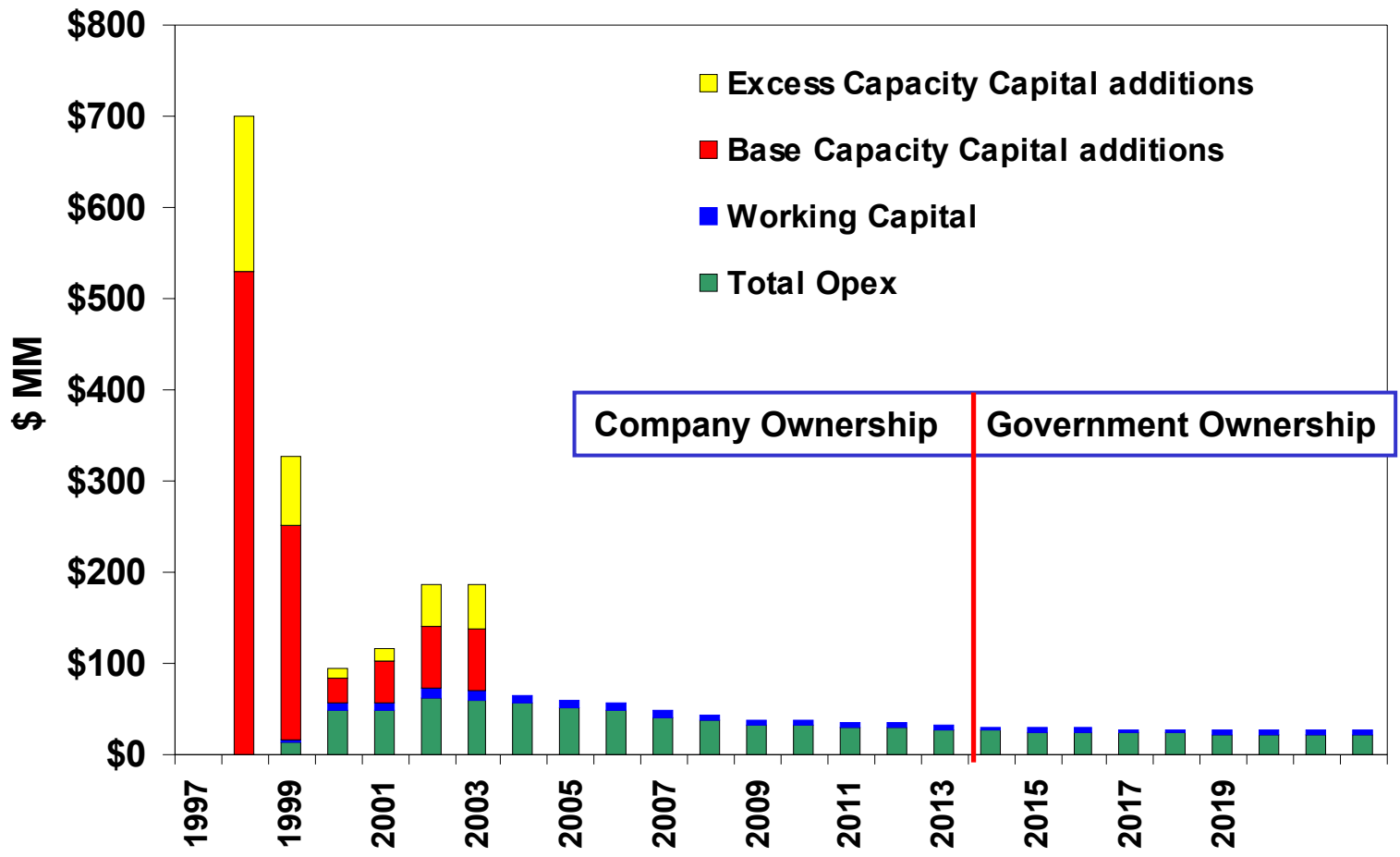
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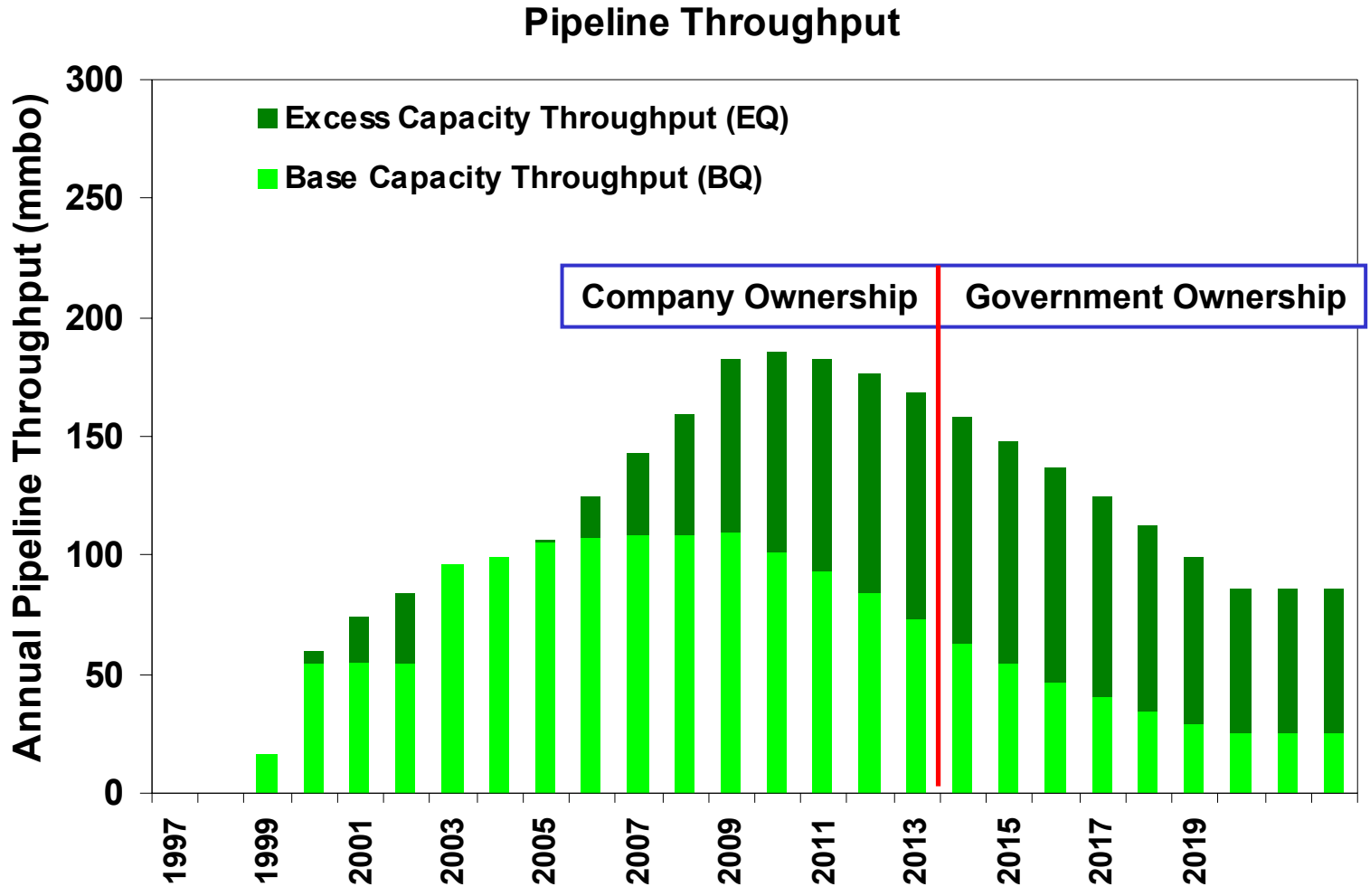


Sudan Crude Oil Pipeline Agreement (COPA) - *Cost to build and operate pipeline*

Pipeline Costs

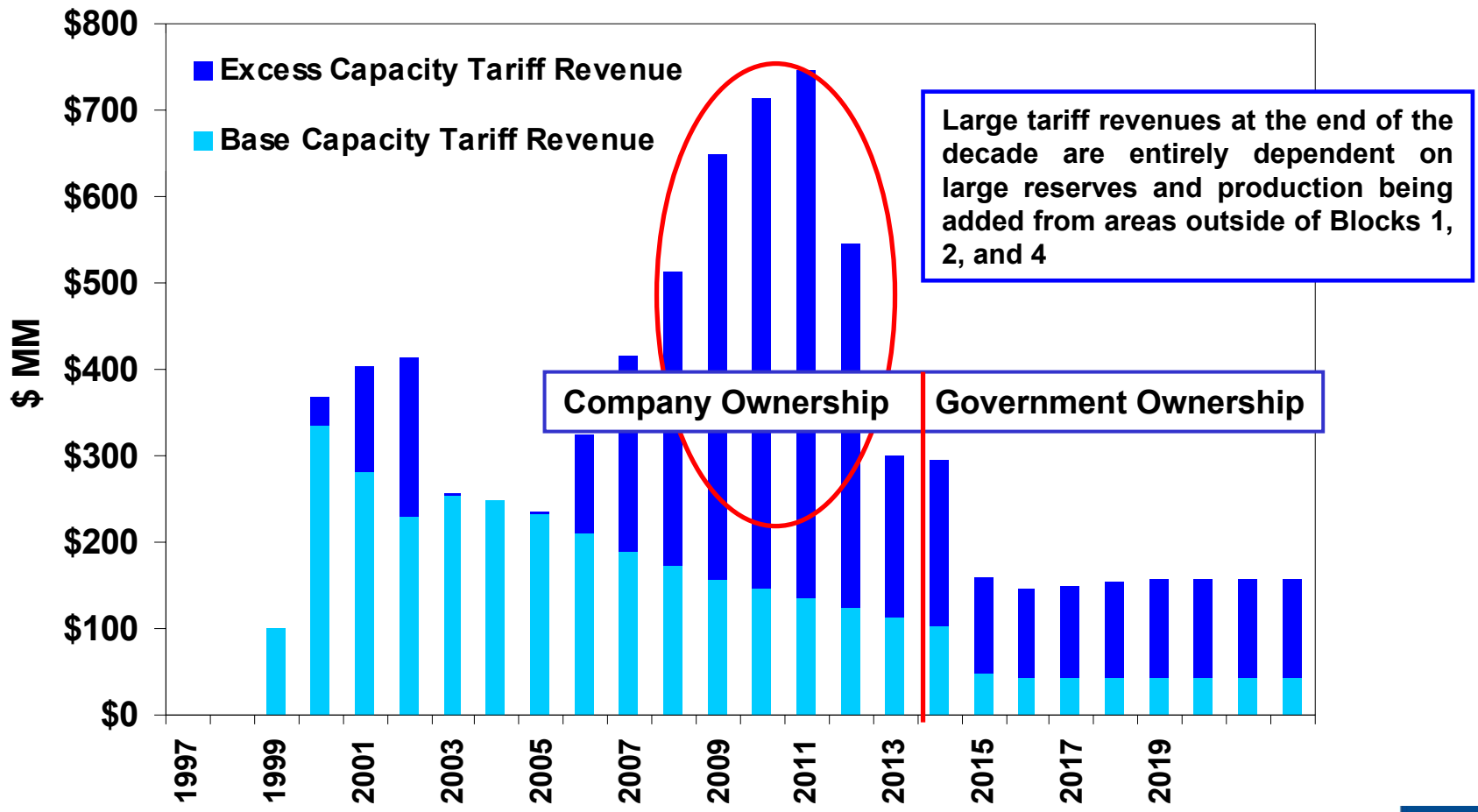


Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline throughput for a mean expected reserve/production projection of 2.9 billion barrels



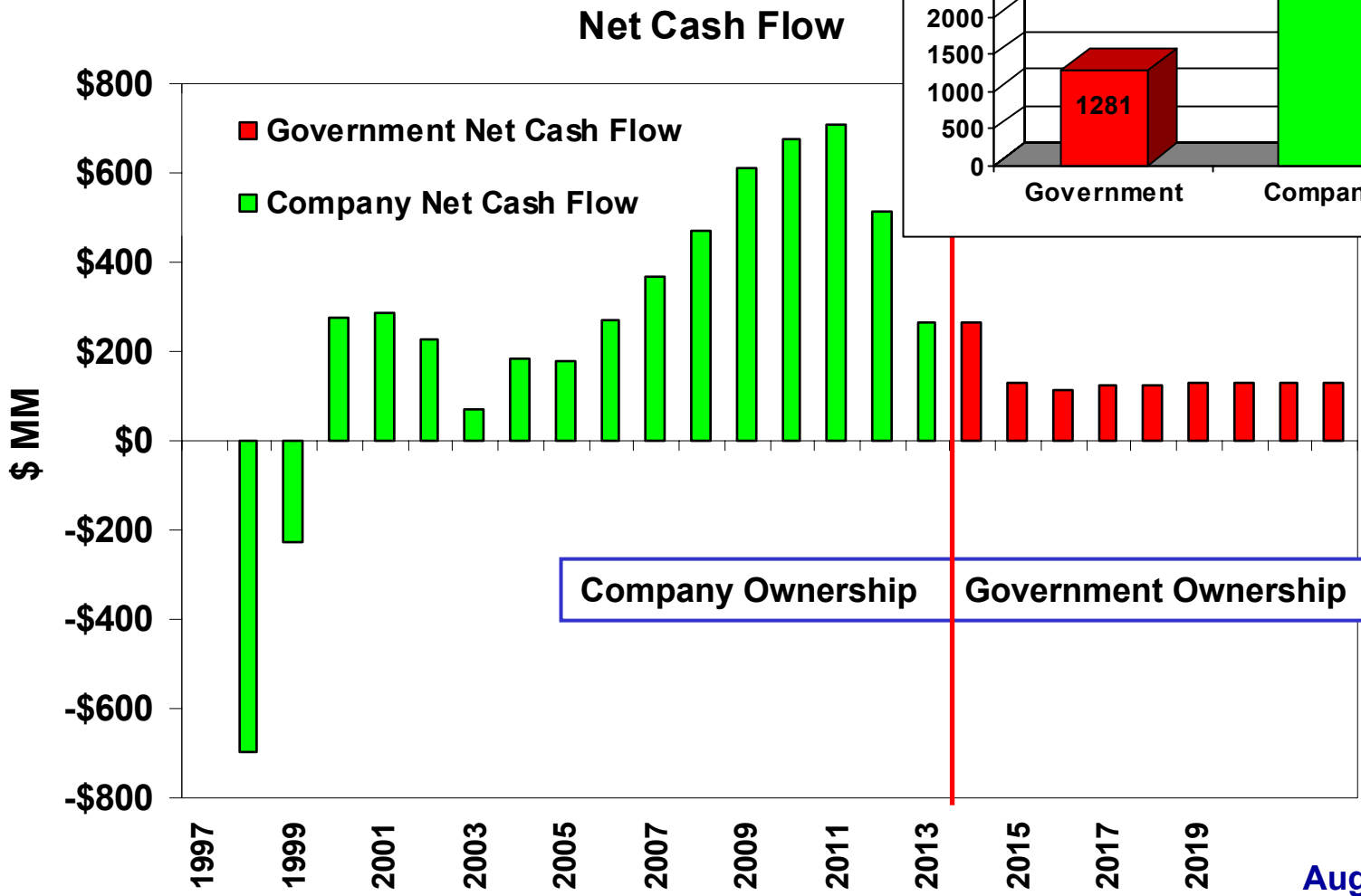
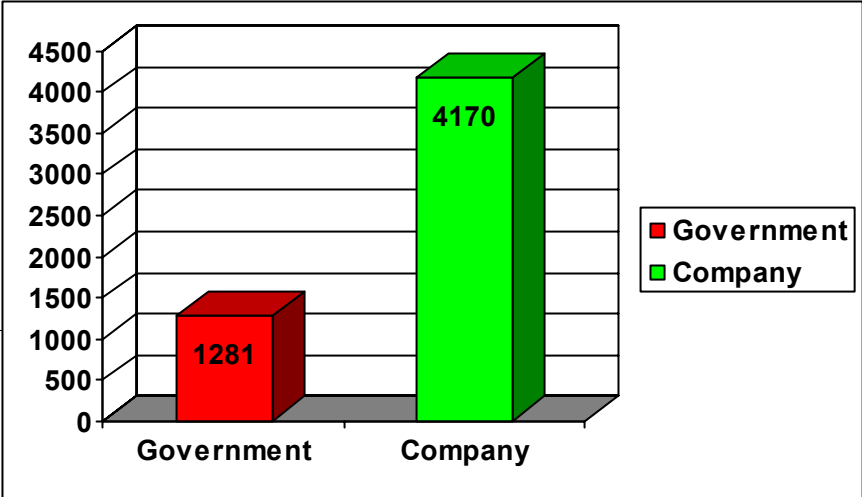
Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline tariff revenues (estimated) for a mean expected reserve/production projection of 2.9 billion barrels

Pipeline Tariff Revenue



Sudan Crude Oil Pipeline Agreement (COPA) - Pipeline net cash flow (estimated) for a mean expected reserve/production projection of 2.9 billion barrels

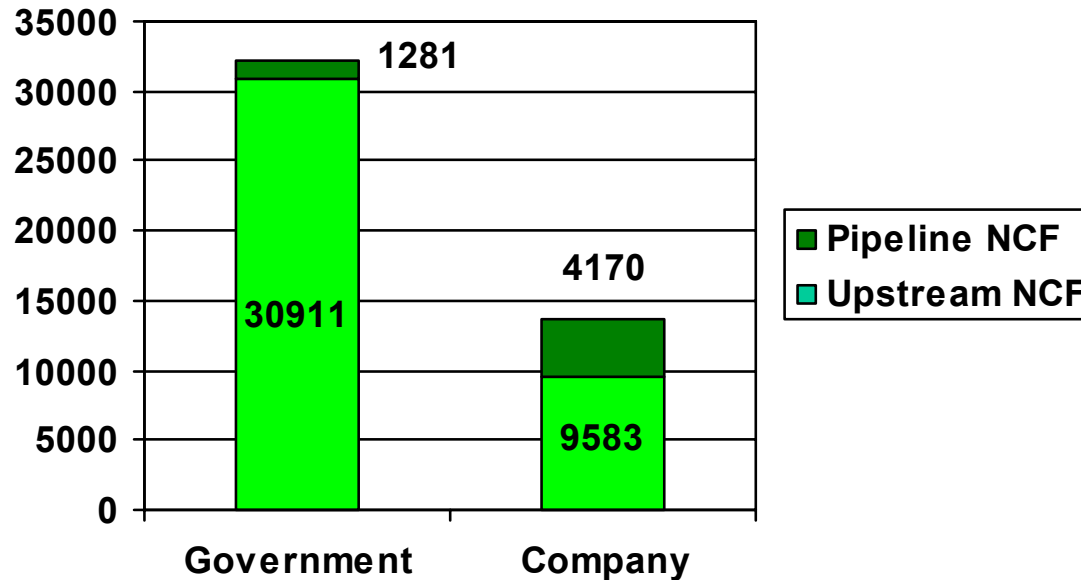
Large cash flows at the end of the decade are entirely dependent on large reserves and production being added from areas outside of Blocks 1, 2, and 4.



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Southern Sudan – Modeled probabilistic government net cash flow versus company net cash flow for pipeline and mean reserves in producing fields, proven undeveloped discoveries and risked mean exploration potential for all blocks (1, 2, 4, 3, 7, 5A, 5B, and B – total mean reserves of 2.9 billion barrels)



PFC's analysis of the after tax cash flow for a long term exploration/development program in southern Sudan suggests that in the combined upstream and midstream sector estimated government take is 70%

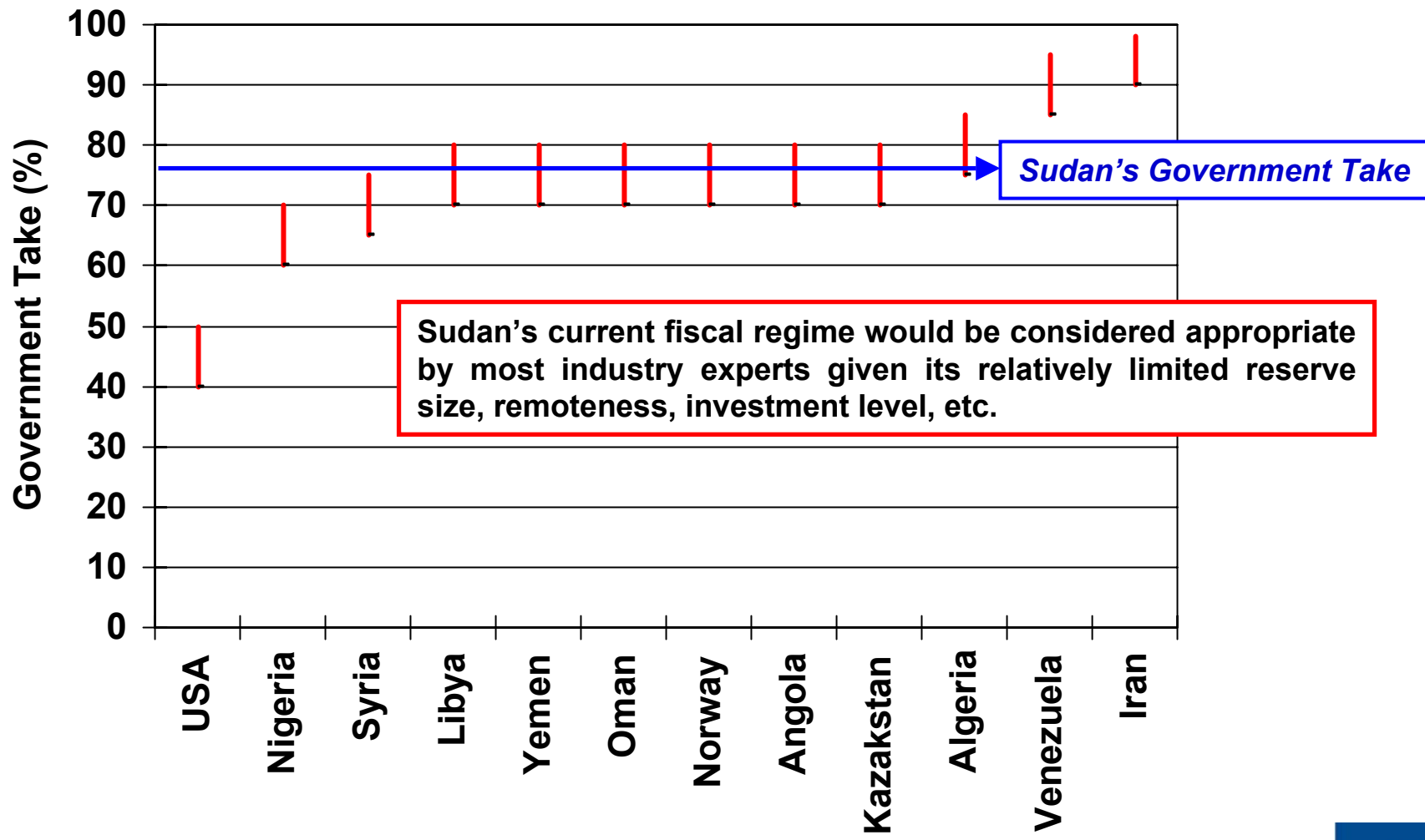
Southern Sudan – *Conclusions for what peace and security could provide from the oil sector*

- It is reasonable to expect that as much as 2.9 billion barrels could be found by the end of the decade from the entire area of southern Sudan and possibly quite a bit more if the field size distribution pattern changes through additional exploration
- Production levels at or near current levels (250 – 300 mbopd) could be sustainable for two decades from reserves found before the end of the decade – *this means that the profit oil share to the government of at least \$1 to \$1.2 billion per year should be sustainable over two decades and could be as high as \$1.5 billion for 10 years during peak production*
- The government will receive a profit share of the oil worth somewhere in the area of \$30 billion (assuming an oil price range of \$18 - \$25 per barrel) over the life of this production
- The companies will receive a profit share of the oil worth somewhere in the area of \$5.5 billion (assuming an oil price range of \$18 - \$25 per barrel) over the same period

Southern Sudan – *Other key issues to be considered*

- Peace alone would cause significant interest by foreign investors in Southern Sudan's oil sector
- However, a general rule of thumb is that every barrel of oil found and developed will require about \$2.50 per barrel – *1 billion barrels of new reserves developed will require pre-revenue investments of over \$2 billion*
- Companies (existing or new) will need some assurance of the contract terms under which they will produce the oil they find – *an agreement which does not also address fiscal terms to be applied after autonomy (if chosen), will cause concern among foreign investors who will worry that after they invest large sums of money a new government or institutions could impose more severe contract terms that would severely impact their return on investment*
- Uncertainty will cause delays in exploration that will in turn cause delays in development, production, and cash flow

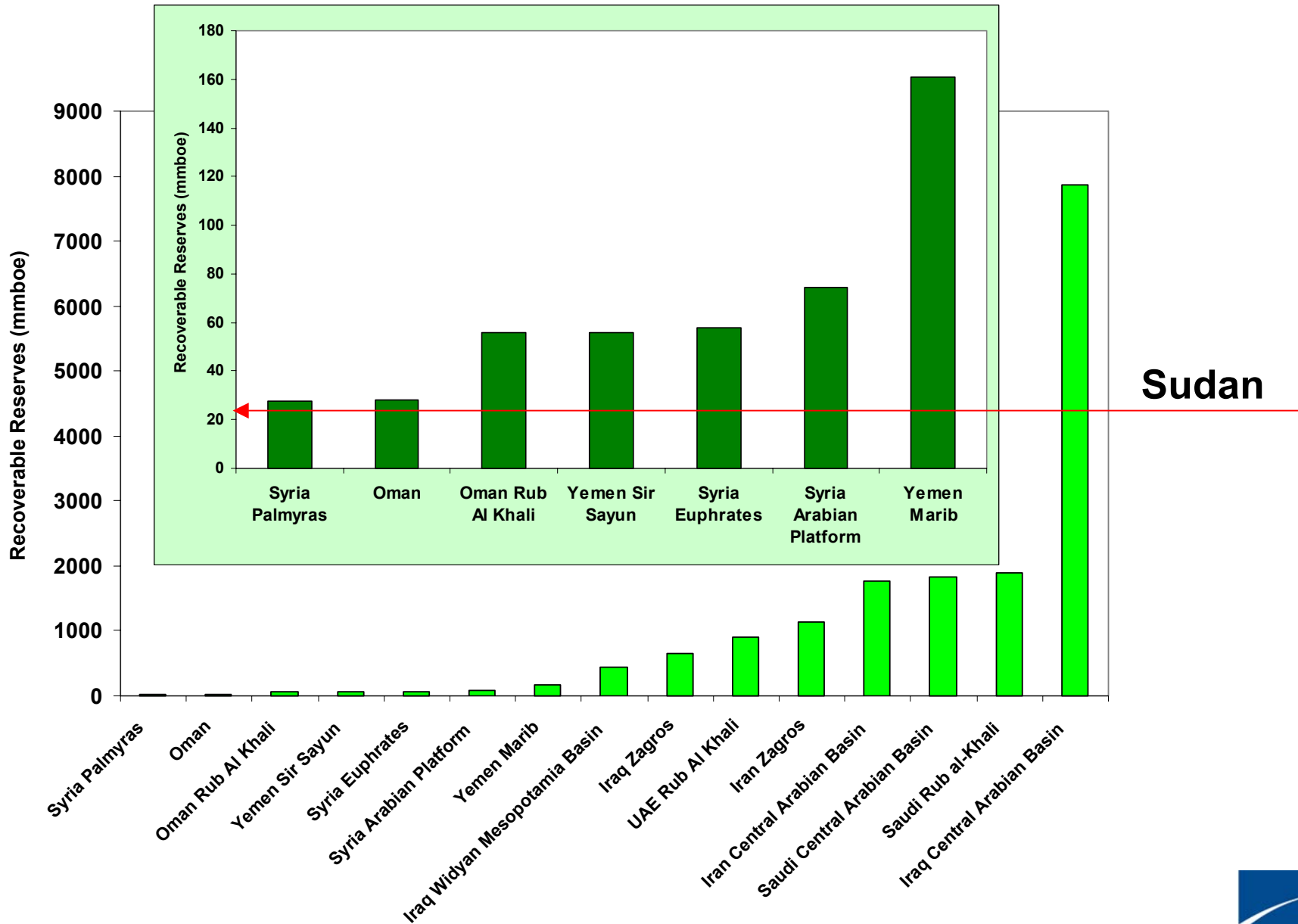
Sudan's Contract - Sudan's existing contract



Southern Sudan – Countries with contract government takes exceeding 80 – 85%

- Iran (50 – 90 billion barrels of oil and daily rates of 3.6 million)
- UAE (60 - 100 billion barrels of oil and daily rates of 2.2 million)
- Iraq (100+ billion barrels of oil and potential rates of 3+ million)
- Venezuela (daily rates of 2.9 million)
- Indonesia (daily rates of 1.4 million)
- Other countries where some contracts have government takes reaching as high as 85% (Libya, Nigeria, Russia, Qatar, Azerbaijan)
- Deepwater Exploration Areas (Angola 60-75%, Nigeria 50-60%, Brazil 60-70%, United States 40-50%, Indonesia 70-80%)

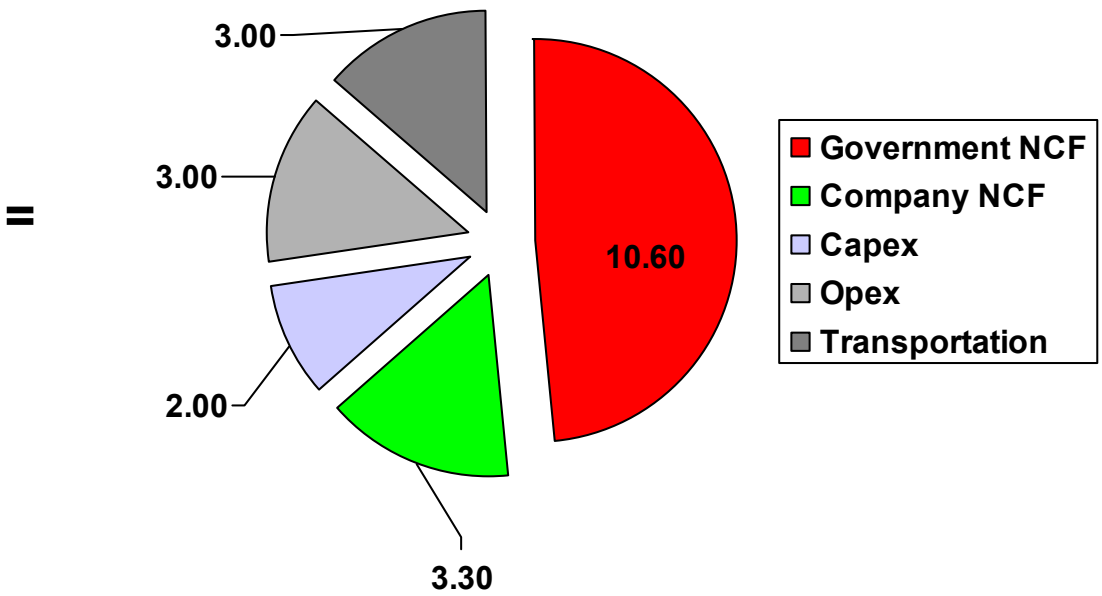
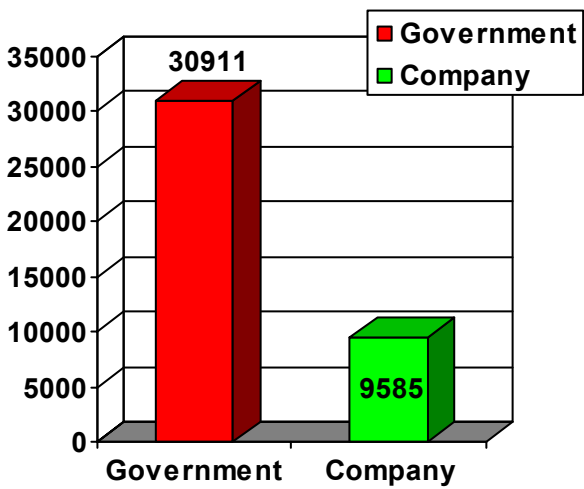
Sub Caucus Basins – Mean field sizes in the Middle East



Southern Sudan – Considerations for contract term changes

- Talk of changing contract terms (regardless of validity) will cause an emotional response by existing contract holders – will cause delays
- The oil industry is willing to pay higher government takes in countries where the reserve base will support a business life cycle measured in decades – *companies will accept 90% government take levels in places like Iran, UAE, Kuwait, etc because they know that once they are an established operator they will be well placed to participate in business opportunities until there is no more oil industry (they make up for lower cash flow per barrel with larger volumes over a longer period of time)*
- Ultimately it is Sudan's oil and Contracts – Carefully consider the trade off of changing terms which at most could improve the governments net cash flow per barrel by maybe 10% but in return could cause companies to delay work programs because of the initial emotional response, arbitration, reevaluate commerciality and returns to their shareholders, they will have to compare Sudanese opportunities with opportunities in countries with much larger reserve potential

Southern Sudan – Considerations for contract term changes



Changing terms to improve the government's take (cash flow per barrel) by 10% in the upstream sector take means that the foreign investors net cash flow deteriorates by at least 30%

Southern Sudan – Final and Very Important Message

- In areas outside of producing blocks 1 and 2, proven reserves are limited (less than 250 mmbo) – *potential for a lot more is clearly there but by no means guaranteed*
- The oil industry has had high expectations dashed more often than realized – *exploration is a science but of limited precision in rank wildcat areas like Southern Sudan*
- *In planning the future of Southern Sudan huge oil wealth should not be considered as guaranteed*
- *The oil industry can bring more than just oil wealth – it can bring social develop funds, scholarship funds, infrastructure, employment, maybe added corruption, an economy that becomes addicted to a resource that depletes very rapidly*