# The Hutton, NW Hutton, Q-West and Darwin Field, Blocks 211/27 and 211/28, UK North Sea

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## Abstract

Hutton (discovered 1973) and NW Hutton (discovered 1975), together with Q-West (discovered in 1994) and Darwin (discovered 1983, undeveloped), are part of a single petroleum system. The main fields were defined as two separate legal entities. Although Q‑West covered multiple blocks, it was wholly developed via the Hutton platform.

Together, Hutton and NW Hutton produced 328 Mmbo of oil and a small quantity of associated gas from Middle Jurassic, Brent Group sandstones. The trap is a complex series of tilted fault blocks sealed by Mid-Upper Jurassic Heather and Kimmeridge Clay Formation mudstones. Oil was sourced from the Kimmeridge Clay, which is mature for oil generation in the hanging walls to the field bounding faults and deep on the footwall flanks.

NW Hutton underperformed relative to Hutton. In part this was due to the poorer reservoir quality encountered at depth compared with the shallower Hutton Field but a significant component of the underperformance was due to the way in which the field was developed and then operated. Both fields contain areas of unproduced and unswept oil with the NW Hutton portion having the largest remaining oil in place.

Keywords: Hutton, NW Hutton, Q-West, Darwin, Galapagos, Brent sandstones

Conoco operated the Hutton Field and Amoco operated the NW Hutton Field. Q‑West production was allocated to Hutton. Hutton ceased production in 2001 (193 MMbo produced) and NW Hutton (124 MMbo produced) in 2002. The fields were abandoned and platforms removed. Fairfield Energy acquired the abandoned NW Hutton Field and adjacent acreage in 2009 and, with TAQA, drilled 3 wells into the southern extension of NW Hutton (named Darwin). Two wells encountered partial oil columns but were considered sub-commercial. The licenses were relinquished in 2016.

## History of Exploration and Appraisal

Hutton and NW Hutton are named after the Scottish geologist James Hutton (1726-1797) and Darwin (the undeveloped southern extension of NE Hutton) after the English naturalist Charles Darwin (1802-1882). Current operators Bridge Petroleum refer to the whole area as Greater Galapagos (Figure 1).

**Figure** 1 Here

### Exploration

The Hutton Field was discovered in July 1973 by well 211/28-1a drilled by a Conoco led partnership (Haig, 1991). Subsequent exploration wells 211/28-5, 211/28-6 and 211/28a-7 were all drilled in the hanging wall to the main Hutton bounding fault in Block 211/28.

The NW Hutton discovery well 211/27-3 reached the Brent Group sandstone target in April 1975 (Johnes and Gauer, 1991). From the original well records, it is not clear whether the well was regarded as a target distinct from Hutton or simply a bold appraisal step-out from the first two wells drilled on 211/27. Seven wells were used to appraise NW Hutton. Well 211/27-7 (drilled 1976) is an exploration well drilled between what is now Hutton and NW Hutton (Q‑West, Figure 1).

In 2013, two exploration wells were drilled by Fairfield Energy (211/27e-13, 211/27e-13z) and designed to evaluate previously untested segments of the southernmost extension of NW Hutton (Darwin) south of 211/27c-12. The easternmost of these wells (211/27e‑13) was drilled first but penetrated water bearing Brent Group sandstones. However, a sidetrack to the west (211/27e-13Z) encountered a 154 ft oil column in the Tarbert and Upper Ness reservoirs (Figure 2).

**Figure 2** Here

### Appraisal

Hutton field was appraised from 1974, with five wells (211/27-1a, 2, 211/28-2, 3 and 4) variously ranging from full oil columns in the Brent reservoir to completely water-wet. NW Hutton was appraised from 1978, with all appraisal wells encountering a full oil column in the Brent reservoir. After placement of the well template, appraisal continued in 1983 with well 211/27-11, which encountered but did not test, oil in the Brent Group. This well effectively discovered the Darwin accumulation but was beyond the drilling radius of the platform.

Q-West was discovered by well 211/28a-H35 which encountered a 400 ft oil column when drilled into Block 211/27b from the Hutton platform. The well proved that Hutton and NW Hutton are part of a single, large, oil bearing geological structure although the discovery did not alter the legal definition of the established fields. All production from Q-West was assigned to Hutton.

TAQA drilled the 211/27a-14 well in order to appraise a distinct and previously untested structural high at the southernmost end of the developed field area. 211/27a-14 encountered a 190 ft oil column in the Tarbert and Upper Ness reservoirs but the interval was not tested.

### Development

Oil production from the Hutton Field began on 6 August 1984 using a new design tension leg platform, installed in 148 m (485 ft) of water. At production start-up 10 production wells had already been drilled and completed, the remainder were drilled after production start-up (Figure 3). Ultimately 20 production wells and 12 injection wells were drilled on the Hutton Field including Q‑West.

**Figure 3** Here

Development of NW Hutton began in October 1979 with the installation of a seabed template with 20 well slots. Production capacity for the platform was set at 100,000 bopd but with very low produced-water handling limits (20,000 bwpd). After just four years of production, the low produced water handling limit was identified as a bottleneck and the operator attempted to upgrade the produced water limits to 90,000 bwpd; only 43,000 bwpd was achieved. This had the effect of limiting the maximum potential field recovery since wells were shut in at modest water‑cuts.

NW Hutton had 52 development well penetrations (both production and water injection wells, Figure 3) drilled during three phases. No wells were drilled as planned water injectors and all injectors were initially oil production wells converted as and when required.

## Regional Context

### Stratigraphy

The Hutton area fields lie within the East Shetland Basin, a broad terrace within the western part of the Viking Graben (Johnes and Gauer, 1991). The stratigraphy has been extensively reported by a number of authors (e.g. Deegan and Scull, 1977; Lee and Hwang, 1993). The oldest strata penetrated in Blocks 211/27 and 211/28 are Triassic sandstones and mudstones (Cormorant Formation) at the crest of Hutton, although Permian and Devonian strata are known regionally to be present on Pre-Cambrian basement (Lee and Hwang, 1993; Evans et al 2003; Stewart and Faulkner, 1991; Kay, 2003).

The Triassic comprises a thick sequence of terrestrial sandstones and mudstones, penetrated by one well on the Hutton Field. Elsewhere in the Viking Graben these sandstones together with the basal Jurassic Statfjord Formation form major oil reservoirs, e.g. in the Tampen Spur area (Nystuen and Fält, 1995). Lower Jurassic, Dunlin Group, mudstones and minor sandstones have been penetrated by many wells (examples include 211/27c-12, 211/27-A35, 211/28-2, 211/28‑6).

Middle Jurassic, Brent Group sandstones form the reservoir in the Hutton, NW Hutton and Q-West fields (Figure 2), with subsidiary siltstones, mudstones and coals. This reservoir section is overlain by Upper Jurassic mudstones belonging to the Heather and Kimmeridge Clay Formations. The Upper Jurassic syn-rift interval also contains shallow and deep-water sandstones derived from the erosion of the Brent Group sandstones on the crests of the tilted fault blocks which now form the Brent Province traps (McLeod and Underhill, 1999). The sandstones are present in the hanging wall lows (Partington *et al*, 1993; Qin, 2014).

Cretaceous, Tertiary and Quaternary strata in the Hutton area are dominated by mudstone around 10,000 feet thick. Sandstones are developed in the Palaeocene and Eocene although they are not petroleum bearing.

### Petroleum system

The geological history and structural development of the East Shetland Basin and its control on development of the Brent Province are well established (Yielding et al, 1992). Major crustal extension took place in the early part of the Triassic, causing tilting of basement fault blocks. By the mid-Triassic, post-rift thermal subsidence began. While the Triassic rifting generated the basin into which the Lower and Middle Jurassic sediments were deposited, it only had a minor, local fault control on Brent Group deposition (Yielding et al, 1992).

Much of the present day structural pattern is a result of the Mid-Upper Jurassic E-W crustal extension, which culminated in the formation of the Viking Graben and the re-activation of basement-rooted, pre-existing Caledonide (NE-SW) and Variscan (NW-SE) fault trends. Regional mapping in the East Shetland Basin clearly shows the dominance of the two basement trends (Figure 4) indicating that the prevailing stress direction during extension favoured reactivation and oblique slip on these older fault sets.

Thermal subsidence began in the Lower Cretaceous and continued throughout the Tertiary. Two periods of rapid burial, one in the Palaeocene and a second continuing today have resulted in generation of overpressure (Swarbrick, 1994).

Current burial depth for the Middle Jurassic Brent Group sediments ranges from about 1.7 km (Gullfaks, Norwegian North Sea) to greater than 5.5 km (UKCS 3/10b-1). Most of the topography at top Brent was created during the syn-rift rather than post-rift period. In the Hutton area the highest elevated Brent interval occurs in Fault Block C at 9180 ft TVDss and the deepest is at about 14,000 ft TVDss on the western flank of NW Hutton.

**Figure 4** Here

The regional oil source rock is the Upper Jurassic Kimmeridge Clay Formation (KCF), reported by Johnes and Gauer (1991) to be in excess of 1200 ft thick in the region of NW Hutton and with total organic carbon content of 4.5% - 6.5%. The KCF became mature for oil between about 62 Ma and 50 Ma while the NW Hutton Field filled with oil later, between about 49 Ma and 33 Ma (Swarbrick, 1994). NW Hutton was charged from the west, evident through the presence of abundant hydrocarbon inclusions, with varying API gravity, in quartz cements on the western side of the field with a decreasing presence/API range toward the eastern side of the field.

## Database

### Geophysics

Both Hutton and NW Hutton Fields were discovered following identification of a closed structure on a reconnaissance 2D seismic dataset. The first Hutton 3D seismic survey, covering 50 km2 was shot in 1980 (Haig, 1991). Several more surveys were shot between 1975 and 1978 and NW Hutton 3D seismic surveys acquired in 1979 (Johnes and Gauer, 1991) and 1984. The former was only the second 3D survey shot in the North Sea. Both the Hutton and NW Hutton 3D seismic surveys were reprocessed in the mid-1980s.

Operator Oryx commissioned a second 3D seismic survey over 211/28a in 1995/1996 to enable better imaging of the crestal degradation complex to the east of the main bounding faults to Hutton. The survey was aimed mainly at the non-unitised parts of the block but the opportunity was taken to reprocess and merge with the original 3D seismic survey.

The original Amoco development of NW Hutton was carried out using the 1979 and 1984 data. The 1979 survey delivered a significant improvement in imaging relative to the 2D seismic data but did not allow confident mapping of any seismic reflectors below the Base Cretaceous Unconformity (BCU). Imaging of faults was also inadequate. In the absence of a decent seismic image, the poor production performance of the field was used to infer structural complexity and field segmentation, backed up by some early attempts at estimating the abundance of sub-seismic faults using scale-independent fractal modeling (pers. Comm. J Walsh, 2010). No further seismic data were acquired before cessation of production from NW Hutton in 2002.

Reprocessing during 2007 for Fairfield Energy used up-to-date processing techniques such as bin expansion, together with multiple attenuation (specifically surface-related multiple elimination, SRME) and Kirchoff pre-stack time migration. Imaging of the top Brent reflector, deeper horizons and faults were all much improved and, considering its vintage, the quality of final result was remarkably good (Figure 5).

**Figure 5** Here

Although the reprocessed data were significantly better than the original data, the preserved field data were incomplete and, given the vintage of the survey, the accuracy of the positioning data was also a concern. Therefore, in February 2009, Fairfield and operators of the adjacent fields to the northwest acquired a high density, high resolution 3D seismic survey in the East Shetland Basin – ESB09 (Figure 1). That survey was processed to pre-stack depth migration and was also inverted, resulting in a dataset which was, for the first time, capable of imaging the base Brent Group horizon in addition to the top Brent Group reflector. Clarity over fault terminations also assisted in defining and refining the existing field structural model.

### Wells

A full database of wireline logs (gamma, sonic, resistivity) was available for most of the 32 Hutton and 52 NW Hutton wells as well as all 3 new wells drilled by TAQA. Core coverage is extensive as is conventional core analysis data. All of the core data for Hutton were donated to the British Geological Survey in 2002 and are stored by them.

### Trap

The Hutton area fields comprise a series of south-westerly dipping fault blocks. Seal is provided by a combination of the Upper Jurassic Heather Formation and Kimmeridge Clay Formation. The bounding faults between blocks are sealing and the Hutton area has many different oil water contacts and oil-down-to levels (Table 1, Figure 6).

**Figure 6** here

Table 1 Hutton area oil-water contact depths

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Well | Depth (ft TVD SS) | | Reservoir interval | Fault block |
| 211/28a-H21 | 10020 | | Tarbert Fm | Hutton C |
| 211/28a-H13 | 10020 | | L. Ness Mbr | Hutton B |
| 211/28a-H12 | 10090 | | L. Ness Mbr | Hutton A |
| 211/28a-H35  211/27-7 | ODT  Est  WUT | 10816  10850  10893 | Tarbert Fm | Hutton Q-West |
| 211/27a-A08z | ODT 11812 | | Rannoch Fm | NWH Eastern Lobe |
| 211/27-A44 | ODT 11594 | | L. Ness Mbr | NWH East Lobe South |
| 211/27-A25 | ODT 11829 | | Rannoch Fm | NWH Central Lobe |
| 211/27-A36 | ODT 12084 | | Broom Fm | NWH Inner West Lobe |
| 211/27-A50 | ODT 12384 | | Broom Fm | NWH Inner West Lobe S |
| 211/27-A28 | ODT 12795 | | Etive Fm | NWH Outer West Lobe |
| 211/27-A47 | ODT 12399 | | L. Ness Mbr | NWH Outer West Lobe S |
| 211/27-A41 | ODT | 11872 | Etive Fm | 211/27a-A41 Block |
| 211/27-8st-A | 13151 | | U. Ness Mbr | 211/27a-8z Block |
| 211/27-11 | ODT 12432  WUT 12439 | | L. Ness Mbr | 211/27a-11 Block |
|  |  | |  |  |
| 211/27-11z | ODT 12018 | | Tarbert Fm | 211/27a-11z Block |
| 211/27c-12 | ODT 11446 | | Etive Fm | Darwin 211/27c-12 Block |
| 211/27e-13z | ODT | 12235 | U. Ness Mbr | Darwin 211/27e-13z Block |
| 211/27a-14 | ODT 12046 | | L. Ness Mbr | Darwin 211/27a-14 Block |

### Reservoir

The Middle Jurassic, Brent Group reservoir sandstones of the Hutton area were deposited in paralic settings (Flint et al, 1998). The reservoir sandstones are interbedded with mudstones and coals. The Brent Group is divided into five formations. Figure 2 contains descriptions of each formation and the interpretation of the environment of deposition based on work by Flint et al (1998).

The Brent reservoir sequence is attenuated at the crests of both the Hutton and NW Hutton. This was due rifting which led to rotation and uplift of fault blocks. Most of the rifting occurred in the Late Jurassic but dramatic thickness changes in the Tarbert Formation in the Brent Province suggests that incipient rotation of the fault blocks may have occurred earlier in the Bathonian (Gluyas and Underhill, 2003). This caused both non-deposition of the youngest part of the Brent Group & overlying Heather Formation as well as erosion of some older Brent Group strata. The Tarbert Formation is stratigraphically thin on NW Hutton and is only seen off-crest in Hutton, where part of the Ness Formation can also be missing.

Lower Ness sandstones can be correlated over broad distances indicating sea level control on sediment deposition. The Upper Ness Sandstones are more channelized and the interval can be further subdivided into a lower (sand-prone) and upper (shale-prone) zone (Liviera 1989). Statistically, the significantly higher net to gross of the lower sand-prone zone (60+%) implies a significant degree of lateral connectivity, as was proven through the field production performance.

Net to gross varies between formations and across the field. The Mid-Ness Shale provides a lateral seal horizon that limits vertical flow, although many of the thin mudstone intervals within the Upper and Lower Ness formations also show sealing potential as evidenced by the differential pressures of individual Ness Formation channel sandstones in NW Hutton development wells. A combination of compaction and cementation in the fine-grained, micaceous Rannoch Formation resulted in it developing the rock properties of a non-reservoir seal horizon in the deeper parts of the fields.

The reservoir quality of the Brent sandstone reservoirs in the Hutton area is an important control on production performance. Both the porosity and permeability of the best quality sandstones diminishes with increased burial depth. The Hutton Field occupies the shallowest part of the whole structure with a crest at about 9180 ft TVDSS. The most promising quality Ness and Etive Formation sandstones have porosities of 25-31% and permeabilities from 100 mD to in excess of 10 D whereas the structurally lower crest of NW Hutton is at 11,000 ft TVDSS and the corresponding values for porosity and permeability are 15-25% and 10mD to about 3D (Figure 7). The decline both in porosity and permeability from the crest of Hutton Block C to the deepest parts of Darwin South is relatively uniform at the rate of about 5% porosity units and a little over an order of magnitude permeability loss per 1000 ft.

**Figure 7** Here

This decrease in reservoir quality results from increased levels of mineral cements at the greater depths. The diagenesis of the Brent sandstones in the Hutton area (Scotchman *et al*, 1989; Harris, 1992) is directly comparable with that seen elsewhere in the Brent Province (Gluyas, 1985). Soon after deposition, concretionary calcite locally occluded porosity. Following compaction, feldspar dissolution was accompanied by quartz and clay cementation. The clays are typically kaolinite and illite, with illite replacing kaolinite in the more deeply buried areas. Porosity decrease is due largely to increased levels of quartz cement at depth. Clays are less abundant than quartz cement and have only modest effect on porosity but because of their morphology, being micron sized crystals in pore spaces, they have a disproportionately large impact on permeability.

There is evidence from fluid inclusions trapped at the margin of quartz grains and enveloped by quartz cement that oil migrated into the trap at the same time as cementation occurred (Scotchman et al, 1989) and that cementation progressed during a period of elevated heat flow (Swarbrick, 1994). Such simultaneous oil migration and cementation is common in North Sea Jurassic sandstones (Gluyas et al, 1993) and because the migrating oil displaces water progressively from crest to flank, cementation can be arrested, leaving the crests of fields with very high reservoir quality (Oxtoby *et al*, 1995).

The degree to which cementation has reduced the reservoir quality of the sandstones at any one location is heterogeneous. The variation from less than 1 mD to over 100mD is displayed in Figure 7. However, the depth relationship is subtle. A detailed analysis of NW Hutton/Darwin shows that despite an overall reduction in permeability with depth to levels at which oil production in the Darwin area should be difficult, below 1mD, the deterioration of permeability is notably less in the Ness and Tarbert Formation reservoirs, where high flow rates have still been achieved. For example the Ness and Etive Formations in NW Hutton well 211/27a-10 flowed almost 14,000 bopd at a depth of c. 11,600 ft TVDSS. Many examples, such as core data from 211/27‑11 and 211/27-A02, show that the Tarbert Formation and Upper Ness Formation retain permeabilities of several hundred mD at depths >12000 ft across the southern part of NW Hutton and Darwin and so could be considered potentially highly productive.

## Production history and reserves

### Oil in place and Reserves

Data on oil in place and reserves progression for the Hutton area have been compiled from published and released information (Table 2). We assume these figures represent deterministic, ‘most likely’ values for all assessments pre-2000 and the more recent oil in place and reserves figures are P90, P50 and P10 values.

Table 2 shows significant reductions over time for oil in place. Conversely, for Q‑West a minimum value of 57 MMbo was reported by Fraser (1997) while the oil in place calculated by Fairfield in 2006 yielded 97 MMbo, the most likely case 133 MMbo and the upside (water-up-to) case 146 MMbo. The reason for the large difference in stock tank oil initially in place (STOIIP) is not known. None of the historical documents cross reference to earlier studies. However, given that the Fairfield volumetric calculation for Hutton is 431 MMbo (Hutton total minus Q-West) it is possible that part of what had previously been considered Hutton Block A was assigned to Q-West.

NW Hutton was reported to contain 1157 MMbo in 1983. From this the anticipated reserves were 274 MMbo (Table 2). The oil in place was downgraded throughout the field’s production life. Amoco drafted the first cessation of production document in 1997 with only 576 MMbo. However, volumes are restricted to oil accessible from the platform and in rock above a poroperm cutoff, despite proven historical flow from field sandstones below those defined cutoffs. These restrictions have the effect of reducing the apparent field STOIIP to 124 MMbo and hence a recovery factor of 22% at the time of abandonment. A total STOIIP in excess of one billion barrels is still considered to be correct. Darwin oil in place was initially calculated at 198 MMbo but following the unsuccessful 211/27e-13 well and the partially successful 211/27e-13z and 211/27a-14 wells was downgraded to 46 MMbo (TAQA, 2016). No reserves have been reported for Darwin.

Table 2 Oil in place and reserves progression for Hutton area fields

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Field | Date | Oil in place (MMbo) | Reserves (MMbo) | Recovery factor | Data source and notes |
| Hutton | 1990 | 590 | 214 | 36% | Conoco long range development plan, Q-West listed as prospect |
| Hutton | 1991 | 559 | 190 | 34% | Haig (1991) Pre-dates Q-West |
| Hutton | 2001 | 527 | 195 | 37% | Kerr McGee (2001) cessation of production document |
| Hutton | 2006 | 564 | - |  | Fairfield, Petrel model based upon data release on cessation of production, includes 133 mm BBL in Q-West |
| Q-West | 1994 | 60 | 10 | 17% | Interra (1994) Q-West simulation study |
| Q-West | 1994 | 95 | - |  | Oryx 1994 mapping, reported in Hoy (1996) |
| Q-West | 1996 | 107 | 17 | 16% | Hoy (1996) |
| Q-West | 1997 | 57 | 16 | 28% | Fraser (1997) |
| Q-West | 2006 | 97-133-146 | - |  | Fairfield, Petrel model based upon data release on cessation of production |
| NW Hutton | 1977 | 1157 | 274 | 24% | Amoco Annex B, in BP (1999) Cessation of production document |
| NW Hutton | 1983 | - | 280 |  | Bartz et al 1997, refers to initial reserves hence presumed to be 1983 at field start-up |
| NW Hutton | 1983 | 995 | 259 | 26% | Amoco Annex B revision, in BP (1999) Cessation of production document |
| NW Hutton | 1984 | 955 | 130 | 14% | ERC evaluation for Enterprise Oil, in BP (1999) Cessation of production document |
| NW Hutton | 1989 | 673 | 120 | 18% | Amoco report, in BP (1999) Cessation of production document |
| NW Hutton | 1991 | 935 | 136 | 15% | Johnes and Gauer, 1991 |
| NW Hutton | 1997 | 576 | 108 | 19% | Amoco draft cessation of production document, in BP (1999) Cessation of production document |
| NW Hutton + Darwin | 2012 | 1225 | - |  | TAQA (2016) pre-drill wells 13, 13z and 14 |
| NW Hutton + Darwin | 2013 | 847 | - |  | TAQA (2016) post-drill wells 13, 13z and 14 |
| Darwin | 2012 | 198 | - |  | TAQA (2016) pre-drill wells 13, 13z and 14 |
| Darwin | 2013 | 46 | - |  | TAQA (2016) post-drill wells 13, 13z and 14 |

## Production

Production from NW Hutton began in April 1983 and from Hutton in August 1984 (Figure 8). Hutton was six months later than planned because of fabrication problems with the hull for the tension leg platform. However, it was NW Hutton which was to prove the most problematic of the two fields.

### NW Hutton

**Figure 8** Here

The production rate from NW Hutton built up quickly as the pre-drilled wells were brought on stream. The planned plateau rate was 100,000 bopd (barrels of oil per day) but the instantaneous daily rate peaked at 86,500 bopd production in May 1983. Peak monthly field production was 68,211 bopd in June 1983 but there was no natural plateau. Production rate fell rapidly to 50,000 bopd (September 1983) but was then maintained at above 40,000 bopd until the end of 1986. During this period the full-field production rate was unstable as the operators tried to maintain production levels while the field pressure declined rapidly. Many wells showed production profiles highly typical of wells draining limited rock volumes; a high initial rate (in excess of 20,000 bopd in a few wells) followed by rapid decline in both rate and well pressure while the gas-oil ratio of the produced fluid increased by a factor of two or three. Rarely was much water produced. The declining production prompted the operator to reconfigure wells from oil production to water injection and thus give pressure support. This was the case for well 211/27a-A5, one of the original pre-drilled production wells. It came on stream at field start-up and averaged 20,436 bopd in May 1983. Production had fallen to 6387 bopd with almost no co-produced water when in June 1984 it was converted to (sea) water injection. This pattern was repeated across the field.

Significant water breakthrough occurred in September 1984 and the water oil ratio rose steadily for two years. The field was shut-in at the end of 1986 and when production recommenced a month later, around 10,000 bopd production had been lost. By end 1986 the water oil ratio had increased to 0.3 and some of the more permeable sandstones had already watered out. This proved to be particularly problematic because when the field was shut-in, injection water flowed inside the wellbore, from the (now) higher pressure, high quality sandstones into the depleted but still unswept lower quality sandstones. Barium sulphate scale was caused by sea-water injection and detrimentally impacted near-wellbore permeability. Scale inhibitor was available but not used because the cost was considered too high (pers comm C. Laing, 2008). By mid 1991 production was at 10,000 bopd and declined to around 5000 bopd at the end of field life.

### Hutton

Production from the Hutton Field was less problematic than NW Hutton. ‘First oil’ was August 1984 from 10 pre-drilled wells and within a month production volume reached 75,000 bopd but pressure declined quickly and the average production in 1985 was 57,000 bopd against a forecast of 90,000 bopd. Deployment of water injection on Hutton was successful and production levels of about 50,000 bopd were maintained for four years until September 1988 when it began to fall. By 1991 production levels were around 20,000 bopd. Thereafter water injection was increased substantially allowing an oil rate of 10,000 to 25,000 bopd to be maintained until near end of field life.

## End of field life and beyond

The Hutton Field decommissioning plan was submitted to government in 2001 (Beckman, 2004). The wells were abandoned, and then the tension leg platform, sea bed foundation and well templates removed, as were the two pipelines (gas import and oil export).

Decommissioning of the fixed NW Hutton platform was completed in 2009 from a plan submitted in 2005 (BP, 2005). All that now remain are the cuttings pile (Nixon, 2013) and 49 m of footings extending from the sea-bed at 140 m below sea-level..

The initiative from Fairfield and TAQA to redevelop the southern part of NW Hutton and its extension southwards into Darwin was unsuccessful despite finding oil in two of the three wells drilled in 2012-2013. The poor reservoir quality encountered and likely high degree of compartmentalisation in the area were both cited as reasons not to progress to development (TAQA, 2016).

Figure 9 is a plot of recovery factor for Brent Province fields against depth to crest of field. Depth to crest is a proxy for reservoir quality. In broad terms relative to a linear regression fit of recovery factor to burial depth, Hutton produced the expected volume of oil given its oil volume and NW Hutton significantly underperformed. Further evidence of the same comes from a plot of cumulative oil production against water/oil ratio (Figure 10). The progression of Hutton and NW Hutton was almost identical except that Hutton was produced to a water oil ratio of >10 while NW Hutton was only produced to a water oil ratio of about 4. The implication is that had NW Hutton continued to produce oil with the existing well stock it could have produced about 190 MMbo (55 MMbo more than at abandonment) with a water oil ratio of 10 to 20.

**Figure 9** Here

**Figure 10** here

TAQA (2016) identified the remaining potential of Darwin following the 211/27e-13, 13z and 211/27a-14 wells (Figure 4). An additional portfolio of opportunities in the Hutton area, derived from analysis of information collated from cessation of production documents for the fields, is shown in Figure 12.

The Hutton area fields may have been an early casualty of portfolio management decisions amid a period of competitive exploration and development. Later, the industry downturn and subsequent harsh economic climate undermined a period of new interest and investment. However, there remains significant potential in the area.

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Figure 1 – Location map – license block with field outlines and inset regional map. Area coverage of the PGS/TGS East Shetland Basin ESB09 3D seismic survey outlined in red. The exploration and appraisal wells drilled in the Hutton area are also shown.

Figure 2 – Reservoir stratigraphy with subdivisions and reservoir properties. Typical gamma-ray log profile for Brent Group shown on left.

Figure 3 Hutton, NW Hutton and Q-West Field location of exploration, appraisal and development wells on top reservoir depth map.

Figure 4 Regional two-way-time map on the Base Cretaceous Unconformity, showing pre-existing structural grain, both NE-SW and NW-SE .

Figure 5 Comparison of seismic line from 1979 3D acquisition with original processing (a) and 2007 reprocessing (b).

Figure 6 NW to SE cross section across NW Hutton, Q-West and Hutton showing distribution of oil-water contacts

Figure 7 Crossplots of depth versus porosity (a) and permeability (b) for cored wells in Hutton (black square), NW Hutton (red triangle), Q-West (green diamond), Darwin (grey square) and 211/28-7 (blue circle).

Figure 8 Oil and water production profiles for Hutton and NW Hutton. The anomalous trough (end 1990) and peak (end 2001) identified on the NW Hutton plot are probably data errors in the released production data from the UK Oil and Gas Authority.

Figure 9 Brent Province recovery factors, data from Abbots, 1991 and Gluyas and Hichens, 2003.

Figure 10 water oil ratio progression for Hutton and NW Hutton (low WOR) at 100 mmbbl for NW Hutton is a data error

Table 1 Hutton area oil-water contact depths

Table 2 Oil in place and reserves progression for Hutton area fields