Report on Hydrogeological Investigation at the Bog of the Ring.

North County Dublin Groundwater Project.

by

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June 1994

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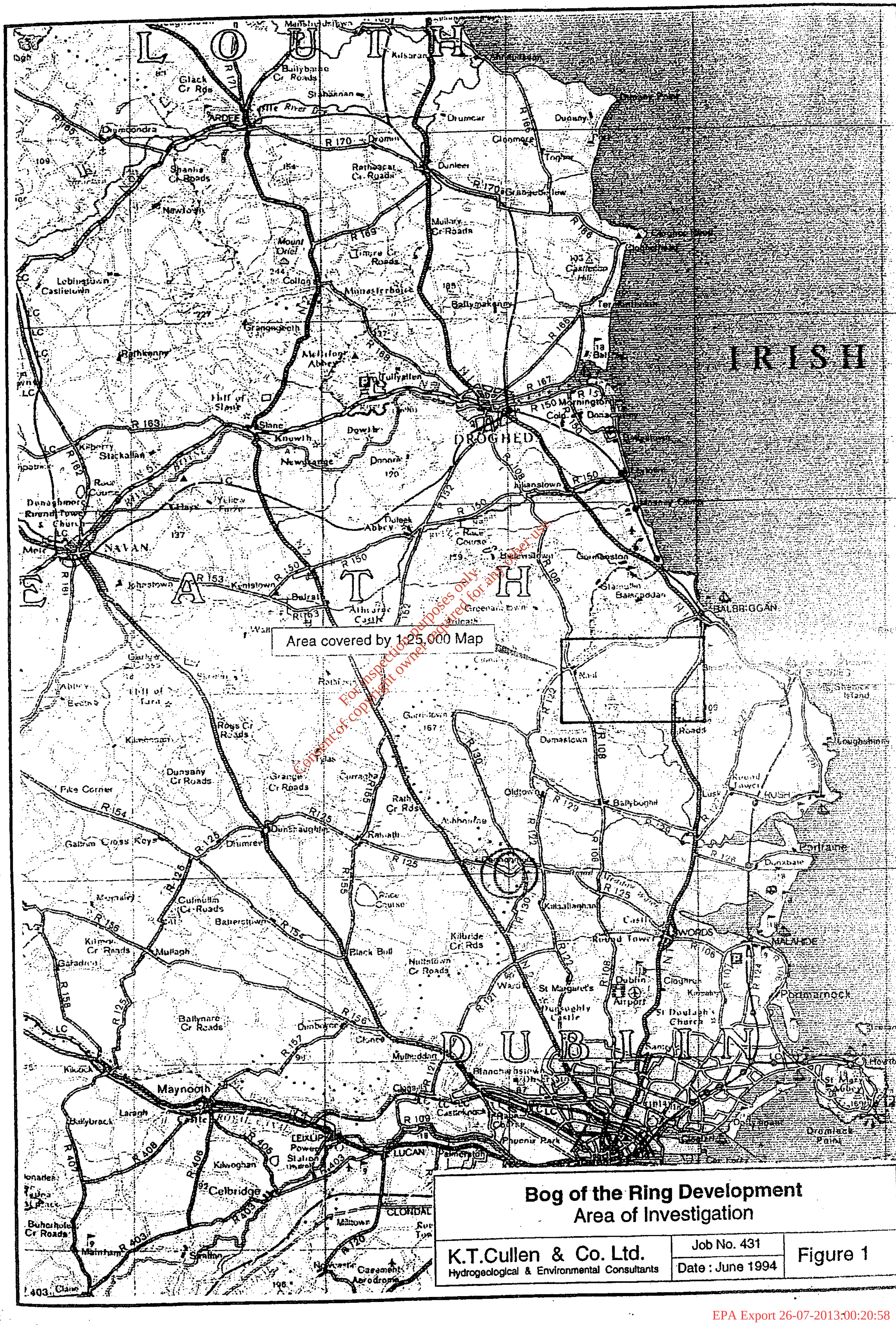
Hydrogeological Investigation of the Bog of the Ring. North County Dublin Groundwater Project.

1. Introduction.

This report dated 17rd June 1994 describes the works and studies carried out as part of a groundwater exploration project that was undertaken at the Bog of the Ring, North County Dublin. The report was commissioned by P.H. McCarthy & Partners, Consulting Engineers to Fingal County Council.

This report forms part of an ongoing study directed at locating and developing a major groundwater supply scheme to replace the existing local authority water supply to this area of North County Dublin (Figure No.1). The Naul Balbriggan Skerries area presently receives its potable water from the surface water abstraction at Leixlip. The treated water is pumped a considerable distance to a series of service reservoirs. A groundwater supply scheme developed in the area could be pumped directly to the service reservoir at Jordanstown.



Bog of the Ring Development
Area of Investigation

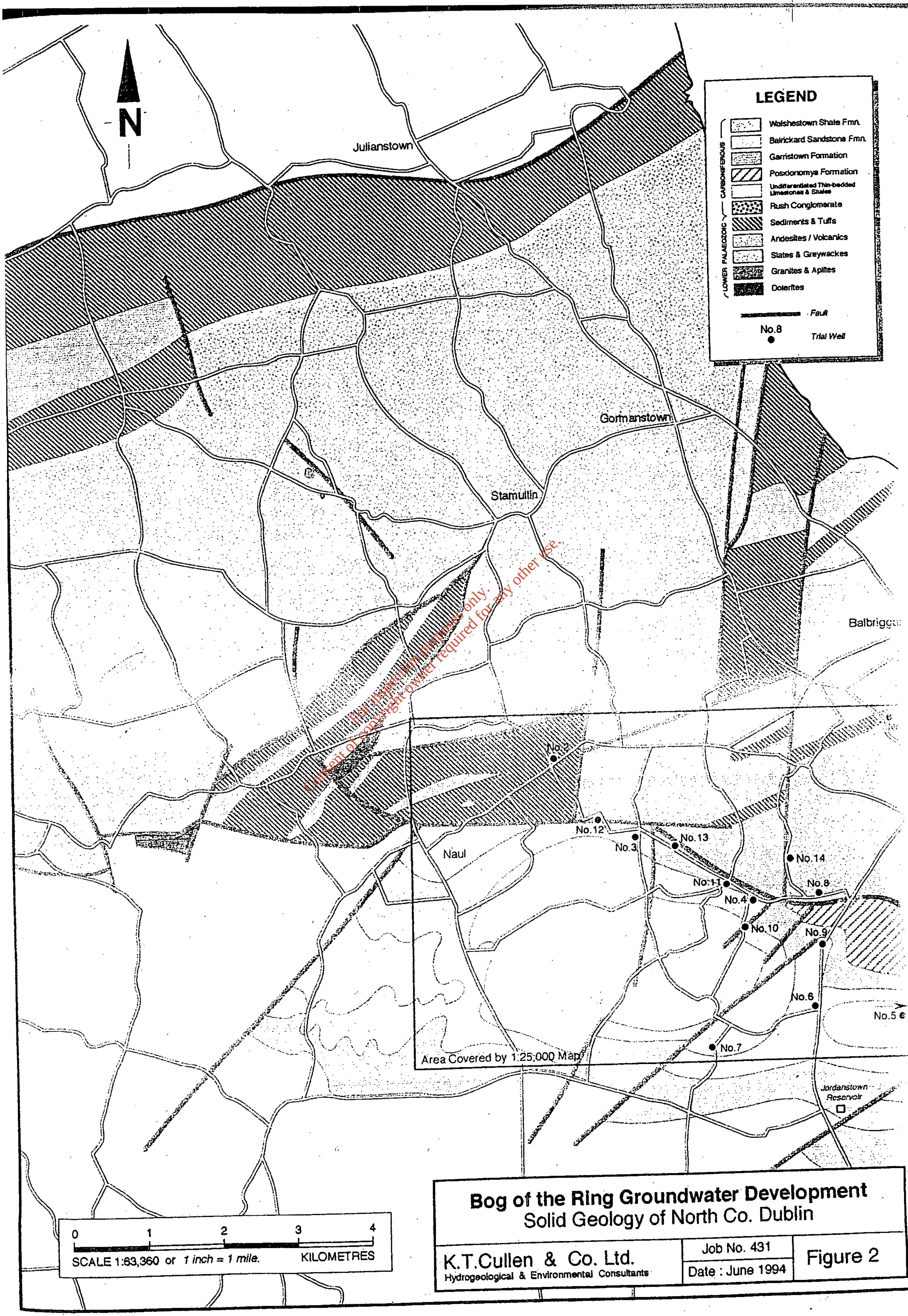
K.T.Cullen & Co. Ltd. Hydrogeological & Environmental Consultants	Job No. 431 / Date : June 1994	Figure 1

2. Situation To Date.

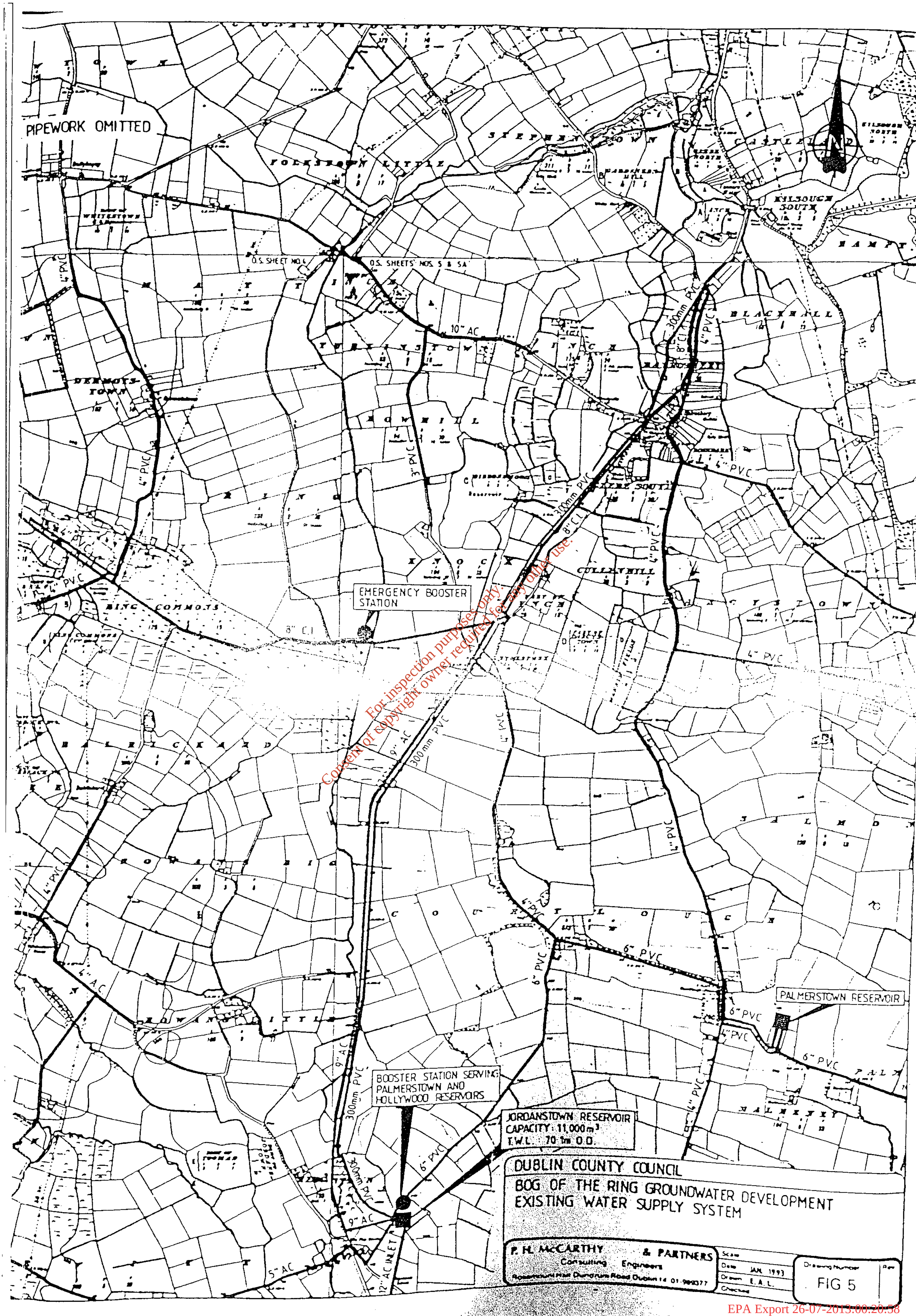
The first phase of the drilling and testing programme was carried out in 1984 and is described in a report entitled "Report on the Drilling and Testing of Trial Water Wells at Balbriggan, County Dublin." dated 14th March 1985. This work followed on from a preliminary desk study entitled "Preliminary Hydrogeological Report on North County Dublin." dated December 20th 1983.

3. Geology.

The faulted boundary between the Carboniferous rocks of the Dublin basin and the Lower Palaeozoic sediments and meta-sediments of the Balbriggan inlier runs in an east west direction through the Bog of the Ring (Figure No.2). The boundary is not exposed and is generally believed to be faulted. The Carboniferous rocks form a syncline south of the unconformity. The oldest of these rocks within the area of investigation are thin bedded grey limestones and shales with chert bands and interspersed with reef knolls. These in turn are overlain by the Garristown formation which outcrops in the south and north east of the syncline. This formation consists of thin bedded black argillaceous limestones with occasional shale bands. Some of the limestone beds are reported to be cavernous. The Garristown formation is overlain by the Balrickard Sandstone, a dark grey micaceous calcareous sandstone. interspersed with dark limestones and shales. In the Balrickard quarry the sandstone beds vary in thickness from 0.5 to 1.8 metres. In rare exposures the sandstone passes upwards into argillaceous limestone through to thin ironstones and siltstones separated by thick black shale layers followed by shales with thin mudstones and siltstones scattered through them. This series of mainly argillaceous rocks is known as the Walshestown Shales. They are estimated to be at least 100 metres thick and two limestone bands are recognised within this series.



N
LEGEND
Walshestown Shale Fmn.
Balrickard Sandstone Fmn.
Garristown Formation
Posidonomya Formation
Undifferentiated Thin-bedded Limestones & Shales
Rush Conglomerate
Sediments & Tuffs
Andesites / Volcanics
Slates & Greywackes
Granites & Aplites
Dolerites
CARBONIFEROUS
LOWER PALAEOZOIC
Fault
No.8
Trial Well
Julianstown
Gormanstown
Stamullin
Balbriggan
Naul
No.2
No.12
No.3
No.13
No.14
No.11
No.4
No.8
No.10
No.9
No.6
No.5
No.7
Area Covered by 1:25,000 Map
Jordanstown Reservoir
0
1
2
3
4
SCALE 1:63,360 or 1 inch = 1 mile.
KILOMETRES
Bog of the Ring Groundwater Development
Solid Geology of North Co. Dublin
K.T.Cullen & Co. Ltd.
Hydrogeological & Environmental Consultants
Job No. 431
Date : June 1994
Figure 2


PIPEWORK OMITTED
O.S. SHEET NO. 6
O.S. SHEETS' NOS. 5 & 5A
EMERGENCY BOOSTER STATION
BOOSTER STATION SERVING PALMERSTOWN AND HOLLYWOOD RESERVOIRS
JORDANSTOWN RESERVOIR CAPACITY: 11,000 m³ T.W.L. 70 m O.D.
PALMERSTOWN RESERVOIR
300mm PVC
8" C.I.
10" AC
9" AC
4" PVC
6" PVC
3" PVC
4" AC
5" AC
12" AC INLET
DUBLIN COUNTY COUNCIL
BOG OF THE RING GROUNDWATER DEVELOPMENT
EXISTING WATER SUPPLY SYSTEM
P. H. McCARTHY & PARTNERS
Consulting Engineers
Date JAN. 1993
Drawn E.A.L.
FIG 5

LEGEND
EX. MAIN
EX. RESERVOIR
EX. BOOSTER STATION
HYNESTOWN RESERVOIR (Decommissioned)
HOLLYWOOD RESERVOIR
COOLFORES
WINNINGS
REYNOLDSTOWN
HYNESTOWN
KNOCKBRACK
HOLLYWOOD
PRIORLAND
CURRACH EAST
LOUGHER
4" PVC
3" PVC
4" AC
5" AC
8" C.I.
Scale km
0 0.5 1 1.5 2

The Lower Palaeozoic volcanics and sediments of the Balbriggan inlier lie to the north of the main area of investigation. These Pre-Carboniferous rocks are bounded to the south by the North Dublin Fault. The volcanics are of Ordovician age and consist of a series of interdigitating Andesites, Lavas and Tuffs. These are overlain by Silurian Slates and Greywackes which form the major part of the inlier. Several isolated granite and aplite pods occur within the Silurian strata to the north west of the area of investigation. These are likely to have been intruded during the main phase of igneous activity at the end of the Caledonian Orogeny. Several intrusive dolerite sills / dykes also occur within the Lower Palaeozoic rocks. The dominant structural feature within the inlier is faulting of approximate north-south and northeast-southwest trends.

4. Hydrogeology.

There was very little available information on the well yields in the area prior to the initiation of this investigation in 1983. The only high yielding well of note was located in the volcanics to the south of Balbriggan town. This well had a safe yield of greater than 700 m3/day. The wells drilled in the carboniferous are all domestic supplies and are terminated as soon as an adequate water inflow is encountered. Therefore the selection of potential aquifers was based on geological information rather than actual drilling results.

The Carboniferous bedrock can be considered to have some groundwater potential. The Walshestown Shales which constitute the core of the syncline is considered to have poor groundwater potential as it is composed primarily of shales and mudstone which are not conducive to fissuring and weathering. The lack of calcium carbonate inhibits the development of solution channels which increase the transmissivity of the bedrock.

The shales are also relatively soft and deform rather than fracture when subjected to structural faulting. The Balrickard Sandstones and the Garristown Limestone formation have greater potential due to the fact that they are more competent and have a high calcium carbonate content.

The volcanics to the north have proven potential at Balbriggan. In Waterford and Wexford similar rocks are important aquifers. However as has been the experience in Wexford there is an element of hit and miss in locating wells in transmissive zones.

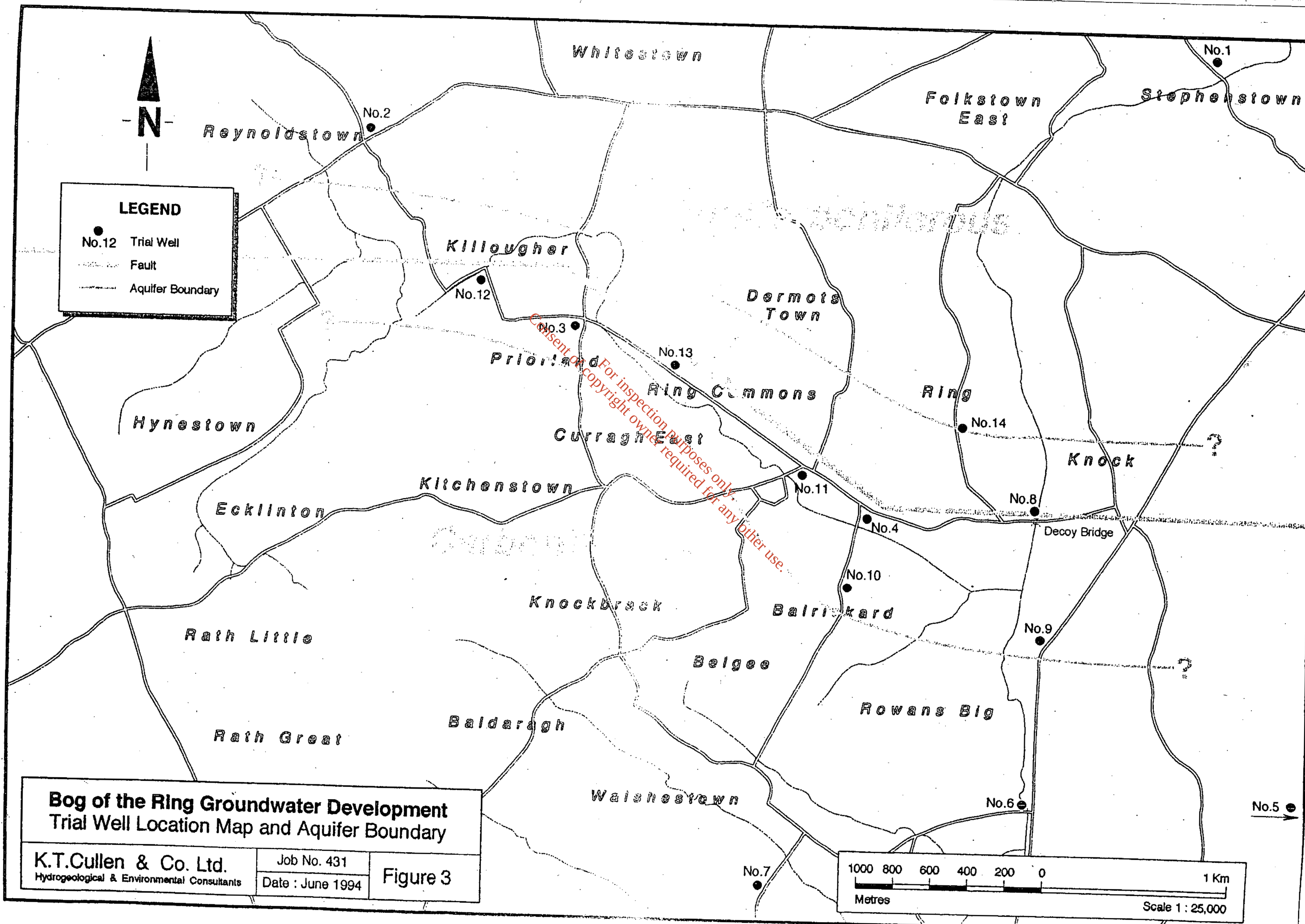
5. Schedule of Works

The drilling and testing programme commenced in 1984. Trial Well Nos. 1-5 were drilled at this stage. The drilling was carried out by Dunnes of Mallow and the pumping tests were undertaken by Seamus Kelly and Sons of Enniscorthy. The second phase of the drilling programme began in summer of 1993 and was completed in the spring of 1994. The wells were drilled by O'Donohoe Brothers of Gorey and the wells were tested by Seamus Kelly and Sons. Trial Well No.s 6-14 were drilled during this period (Figure No.2).

6. Trial Well Drilling and Testing Programme.

6.1 1984 Programme.

The works and studies carried out as part of this programme followed on from the preliminary desk study which collated the limited geological information available. 5 trial wells (Trial Well No.s 1 - 5) were drilled, of which three were subsequently test pumped. The drilling logs are shown in Appendix I. Trial Well No.1 tested the potential of the volcanics near Balbriggan. The well was pumped for a period of 72



Bog of the Ring Groundwater Development
Trial Well Location Map and Aquifer Boundary

K.T.Cullen & Co. Ltd. Hydrogeological & Environmental Consultants	Job No. 431	Figure 3
	Date : June 1994	

hours at a rate of 924 m3/day. Trial Well No.'s 3 and 4 were sited to investigate the potential of the Carboniferous bedrock in the vicinity of the east west fault that runs through the Bog of the Ring. Both trial wells encountered fissured limestone and were test pumped at rates of 273 and 1080 m3/d respectively. The pumping rate on Trial Well No.3 was limited due to the collapsing conditions encountered in the borehole, however, the drilling observations had indicated that the well was capable of yields in the order of 1000 m3/d. Trial Well No's 2 and 5 were not pump tested as the estimated yields did not warrant it.

This exercise identified two important aquifers namely, the volcanics at Balbriggan and the limestone at the Bog of the Ring. It provided no information on the extent and nature of the aquifers.

6.2 Trial Well Drilling and Testing Programme (Southern Limb) - Summer 1993.

This phase of the investigation was directed at delineating the extent and nature of the limestone aquifer in the area of the Bog of the Ring. It was directed at trying to establish if the transmissivity of the high yielding wells (TW 3 and 4) drilled in the limestones in 1984 were related to the major east west fault or the geology of the Carboniferous syncline. TW 6 and 7 were drilled on the southern limb of the syncline in the same formation as TW 3 and 4.

The completed well designs and drilling logs for all the wells are contained in Appendix I.

6.2.1 Trial Well No.6

Trial Well No.6 encountered 15 metres of overburden consisting of 9.0 metres of clay which was underlain by a clayey gravel from 9 to 15 metres. 250 mm steel casing was installed to 11 metres . The casing would not drive any further in the gravel . 200 mm steel casing was then installed to bedrock at 15 metres. The bedrock was composed of black shale with thin bands of mudstone. The well was drilled to a total depth of 91 metres at a diameter of 200 mm. The main inflow to the well was from the clayey gravel layer between 9 and 15 metres. There were no notable inflows recorded in the bedrock. The estimated yield of the well was low and estimated to be < 200 m3/d and consequently no pumping test was carried out on this well.

6.2.2 Trial Well No.7

TW No.7 was drilled to a depth of 91 metres and encountered a black shale bedrock at 33 metres. There was a thin layer of fissured brittle siltstone between 73 and 74 metres. The overburden was composed of 22 metres of black boulder clay. This was underlain by clayey weathered siltstone bedrock from 23 to 33 metres. There were two notable inflows into this well. The first was at 24 metres in the weathered layer and the second at 73 metres in the fissured siltstone. The drilling results indicated that the well was capable of yielding up to 1000 m3/day.

TW 7 was step tested on 11/5/93. The well was pumped at four increasing pumping rates for 90 minutes at each rate. The steps ranges from 530 to 1100 m3/day. The drawdown at the end of the final step was 37 metres. Steady state conditions had not been achieved at the end of any step. At this stage the well yield was estimated to be 900 - 1200 m3/day.

A 72 hour pumping test was carried out starting on the 12/5/93. The well was initially pumped at a rate of 1100 m3/day. This was reduced to 860 m3/day as the head against the pump increased. The pumping rate was cut back to 635 m3/day after 1680 minutes and to 575 m3/day after 1800 minutes. The final drawdown was 36.99 metres (48.39 metres below ground). The safe yield of this well is estimated at 500 m3/day. It would appear that the transmissive zone is of limited extent. The well was very slow to recover after pumping had stopped. 75 minutes after the test had finished the drawdown was 24 metres.

6.3 Summer 1993 - Southern Limb Conclusions.

These results indicated that the limestone aquifer identified in 1984 does not extend to the southern limb of the syncline and that the high transmissivity is related to structural deformation in the vicinity of the North Dublin Fault rather than the geological composition of the bedrock. It became important to shift the focus of the study and to investigate the geology in the region of the North Dublin Fault.

At this stage three options were considered.

1) Carry out an extensive resistivity survey over the area of investigation to pinpoint structural anomalies on the basis of which further trial well sites could be selected.

2) Drill a large diameter production well close to one of the high yielding wells on the northern limb. Drill two observation wells at 50 and 100 metres distance. Carry out a 14 day pumping test at as high a rate as possible.

3) Due to the limited budget, use the financial resources to drill up to 7 additional trial well sites. Where successful, these would provide the locations for potential production wells that would be incorporated into the production well field.

Option 1.

Due to the disappointing results obtained on the southern limb it was concluded that high yielding trial well sites cannot be confidently predicted without drilling trial wells. The large overburden thickness encountered in the trial wells limit the effectiveness of the resistivity surveying as it can mask the structural anomalies of the underlying bedrock. This option was discounted at this stage as it was felt that resistivity budget could be better utilised on one of the other options.

Option 2.

The execution of a large scale extended duration pumping test would be useful in determining the performance of the aquifer as a whole in response to extended pumping and would help evaluate the impact of geological boundaries and the nature of the east west fault (permeable or impermeable). A doubt remained as to whether the pumping rate that could be achieved would be great enough to impinge on these structures. If this option were successful it would still be necessary to locate potential production well sites.

Option 3.

The third option was aimed at locating high yielding production wells sites and at the same time delineating the extent of the transmissive zone of the area in the vicinity of the North Dublin Fault. It was felt that the portion of the budget that was allocated to the resistivity survey could be better spent in this manner. This option would allow individual well yields to be evaluated and provide an indication of the number of wells that would be required in the final production well field configuration.


LEGEND
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PIPEWORK OMITTED
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JORDANSTOWN RESERVOIR CAPACITY 11,000m³ T.W.L. 70m O.D.
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300mm PVC
8" C.I.
4" PVC
6" PVC
3" PVC
4" AC
5" AC
9" AC
10" AC
12" AC INLET
O.S. SHEET NO.6
O.S. SHEETS NOS. 5 & 5A
Scale
km
0
0.5
1
1.5
2
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FIG 5

After careful consideration the third option of drilling and testing of as many trial wells as the budget would permit was adopted.

6.4 Drilling and Testing in the Region of the North Dublin Fault. December '93 - March '94:

Drilling and testing commenced in December 1993 and was completed in March 1994 when the available budget was exhausted. A further 7 trial wells were drilled in order to investigate the transmissivity of the bedrock in the region of the North Dublin Fault. In the event of the drilling results being encouraging, a pumping test would be carried out. The stated safe yields of the trial wells are the yields that can be maintained by a single well pumping without interference from other pumping wells.

6.4.1 Trial Well No.8

TW No.8 is located at Decoy Bridge encountered 13.5 metres of silty stony clay. This was underlain by coarse sandy gravel from 13.5 to 20 metres. The bedrock consisted of a limestone conglomerate which was very broken in parts. A water bearing fissure was recorded at 30 metres. 250 mm steel casing was installed to 21 metres to prevent the gravel from falling into the well during drilling. The upper portion of the limestone conglomerate bedrock was very broken and also needed to be cased with 200 mm steel casing to 24 metres. The drilling continued at 200 mm open hole to 38 metres. The borehole was completed prematurely at this point as further drilling was not possible due to the unstable nature of the bedrock and the ingress of material from a fissure located at 30 metres. The main inflows were recorded from the gravels at 15 metres and from the broken rock at 20 metres. A further major inflow was recorded from the fissure at 30 metres. The well was artesian and was overflowing at a rate of approximately 50 m3/day.

A 72 hour pumping test was carried out between the 5/1/94 and 8/1/94. The pumping test consisted of three steps. The first two steps were 90 minutes and the final step was extended for 72 hours. The well was overflowing prior to pumping. The average pumping rate for the first 90 minutes was 492 m3/day. The drawdown at the end of 90 minutes was 7.64 metres. The average pumping rate for the second step was 871 m3/day. The drawdown at the end of Step 2 was 17.62. The final step was extended to continue to the end of 72 hours. The pumping rate was 1080 m3/day but this reduced as the head increased. The final pumping rate was 979 m3/day. The drawdown after 90 minutes of this final step was 24.7 and the average pumping rate was 1050 m3/day. The final drawdown was 27.74 metres. This well exhibited some unusual characteristics. The time drawdown data reaches almost steady state conditions early in the third step when the drawdown is 19.74 metres. This coincides with the base of the gravel layer. The shape of the graph would indicate that the gravel lens is finite. The water is taken out of storage and when the gravel layer has been dewatered the drawdown resumes at an increased rate. The safe yield of this well is estimated to be 1000 m3/day. However the well did not achieve its target depth and the yield may increase if a production well were to be drilled on the site as more water bearing fissures may be intercepted.

6.4.2 Trial Well No.9

TW No.9 was drilled along the Belfast Road in the townland of Courtlough. This trial well was located some 750 metres south of the North Dublin Fault. The well encountered 19.5 metres of silty stony clay which was underlain by a very hard boulder clay from 19.5 to 32.5 metres. Very coarse water bearing gravels were intercepted at 32.5 metres. The well was lined with 250 mm steel casing to 15 metres and drilling continued open hole until the gravels at 32.5 metres. The collapsing of the gravel necessitated the installation of 38 metres of 150 mm steel casing. The gravel was actually drilled to 40 metres but the casing could not be driven beyond 38 metres due to the presence of large boulders. The standing water level was 0.04 metres below ground.

A step test was carried out on 12 /1/94. This test consisted of three steps of 90 minute duration. The initial pumping rate was 518 m3/day which dropped to 475 m3/day as the head against the pump increased. The drawdown at the end of Step 1 was 7.9 metres. In Step 2 the output was increased to 856 m3/day and the drawdown was 16.5 metres. The third step consisted of two pumping rates. For the first 14 minutes the well was pumped at an average of 1120 m3/day. This was then increased and for the last 76 minutes of Step 3 the average pumping rate was 1195 m3/day. The drawdown at the end of Step 3 was 25.68 metres. A 90 hour pumping test was carried out commencing on 13/1/94. The initial pumping rate was set at 1368 m3/day however this proved to be too much and the pump was cut back to 1267 m3/day after 60 minutes. The pumping rate was cut back again after 180 minutes to 1188 m3/day. Near steady state conditions were achieved 3600 minutes. The drawdown at the end of 90 hours was 28.45 metres. This water level is still above the gravel layer. A production well drilled at this location would have an individual safe yield of 1200 m3/day. The yield of a production well may even be greater as the water bearing gravel layer has not been fully penetrated and there may also be additional water reserves in the bedrock.

6.4.3 Trial Well No.10

TW 10 was drilled in a disused quarry in the townland of Balrickard. The site is located on elevated ground to the south of the North Dublin Fault. Bedrock was encountered at 1.5 metres and was overlain by made ground. The bedrock consisted of a black shaley limestone. There were no significant inflows before 89 metres. It had originally been intended to terminate drilling at 91 metres. However a slight change was noted at 89 metres and drilling was continued to 121 metres. There were weathered bands throughout the final 30 metres. 6 metres of 200 mm steel casing was installed and the bedrock was drilled at 200 mm open hole. The main inflows occurred in the weathered bands below 89 metres.

A 72 hour pumping test was carried out between the 23/2/94 and 26/2/94. The standing water level was 14.42 metres below ground level. The pumping test consisted of three steps. The first two steps were 90 minutes and the final step was extended for 72 hours. The pumping rate for the Step 1 averaged 508 m3/day and the drawdown after 90 minutes was 7.28 metres. The pumping rate was then increased for Step 2 and the pumping rate at the end of the step was 785 m3/day. The drawdown at the end of Step 2 was 14.42 metres. The pumping rate was again stepped up and the well pumped at an average of 1152 m3/day until the end of the test. The drawdown after 90 minutes of this phase was 27.68 metres. The drawdown at the end of the test was 30.85 metres (a water level of 45.55 metres below ground). This water level is still above the main water bearing zone and consequently no dewatering of fissures has taken place. Near steady state conditions had been achieved by the end of the test. TW 11 was monitored during the pumping test and is located 650 metres away. TW 11 was artesian prior to pumping TW 10. The water level dropped by 1.89 metres by the end of the test. The individual safe yield of TW 10 is estimated to be 1100 m3/day.

6.4.4 Trial Well 11

TW 11 was drilled in the Ring Commons. Some 10 metres of peat and grey clay were encountered. The site was located on made ground within the Bog itself. This clay was underlain by sand and gravel from 10 to 17 metres. The gravel got coarser with depth and contained large cobbles and boulders between 13 and 17 metres. There were very large inflows of water recorded from these gravels. The bedrock was intercepted at 17 metres and was a black shaley limestone. 250 mm steel casing was installed to bedrock at 17 metres. The installation of this casing did not reduce the inflow of water from the gravel. The bedrock was drilled at 250 mm open hole to 22 metres. The diameter of the hole was reduced to 200 mm at this stage due to large quantities of water entering the hole. The well was completed to a depth of 60 metres. The target depth of 90 metres was not achieved as the compressor could not cope with the large volumes of water. The well was artesian.

No test was carried out on this well due to budgetary considerations. It was clear that the yield of the well was very large and it was felt that the budget would be better utilised testing wells whose yields were not apparent from the drilling operation. The drilling results indicate that the safe individual yield of TW 11 is approximately 2000 m3/day.

6.4.5 Trial Well No.12

TW 12 was drilled in the townland of Killougher. This well encountered 19 metres of black boulder clay overlying a very weathered black limestone from 19 to 31 metres. The bedrock was very broken and cavernous between 31 and 37 metres and was unstable. A coarse gravel filled zone was met between 37 and 43 metres. There were very large inflows of groundwater from this zone. Solid blue/black limestone was encountered between 43 and 54 metres. There was a large fissure at 54 metres with further inflows of groundwater. The quantity of water became so great at this stage that drilling was abandoned as no further progress could be made. The well was lined to 6 metres with 250 mm steel casing. Drilling continued at 250 mm to 37 metres at which stage the well continued to collapse and 43 metres of 200 mm steel was required. The remainder of the well was 200 mm open hole to 55 metres.

TW 12 was tested for a period of 48 hours between 2/3/94 and 4/3/94. The duration of the pumping test was limited to budget for testing of other wells. No step test was carried out on this well as it was clear from the drilling that the yield of the well would be greater than the largest pump that could be in the well. The standing water level was 8.9 metres. The pumping rate was set at 2468 m3/day initially and fluctuated from 2400 to 2541m3/day in the course of the test. Near steady state conditions were reached after 1440 minutes. The drawdown was varying between 8.5 and 8.6 metres. The pumping rate was increased marginally before the end of the test to 2541 m3/day and the drawdown increased to 10.01 metres. TW 3 was used as an observation well during this test. TW 3 which is artesian is located 600 metres from TW 12. The drawdown in TW 3 at the end of the test was 2.19 metres. This was the highest yielding well of those tested. The individual safe yield of this well is 2500 m3/day.

6.4.6 Trial Well No.13

TW 13 was drilled in the Ring Commons townland. The drilling conditions in all the previous trial wells were extremely difficult and most wells failed to achieve their target depths. An alternative method of drilling was adopted for this well. The well was drilled using the Odex method which drills and cases the hole at the same time. Unstable and collapsing conditions are overcome by casing and drilling simultaneously. TW 13 encountered 36 metres of overburden consisting of gravelly clay with a clayey gravel lens from 24 to 27 metres. The bedrock was composed of cavernous limestone.

The colour of the limestone became lighter with depth. The composition of the bedrock was complex. The broken rock and debris in the cavities has the appearance of gravel. 175 mm steel casing was installed to 68 metres. The bedrock became more competent after 60 metres and at 68 metres it was decided to drill on at 150 mm open hole. The well was completed after 80 metres. The main groundwater inflows were intercepted at 42, 45, 60, and 69 metres.

A step test was carried out on TW 13 on 7/3/94. The standing water level in TW 13 was 0.87 metres below ground level. The step test consisted of three 90 minute steps of increasing pumping rate. The pumping rate at the end of the first step was 524 m3/day and the drawdown was 7.84 metres. The pumping rate was increased to 884 m3/day at the start of the 2nd step. This was increased again after 2 minutes to 1015 m3/day. The pumping rate decreased slowly throughout the step. The pumping rate at the end of Step 2 was 969 m3/day. The drawdown was 18.68 metres. The rate was increased to 1322 m3/day for the 3rd step. This had decreased to 1283 m3/day by the end of the step. The drawdown was 30.09 metres at the end of the step. A 48 hour pumping test was carried out between 8/3/94 and 10/3/94. The pumping rate was set as high as possible for the 48 hour test at 1603 m3/day. This proved to be too great and this was reduced to 1375 after 5 minutes. The water was very dirty at the start and the flow meter was blocked with small pebbles several times. The small step increase after 20 minutes was as a result of the flow meter becoming blocked and being opened to clear it. The flow was greater with the meter open. After 300 minutes the pump began to get blocked with pebbles and stopped several times. This problem had cleared up 450 minutes. The well was pumped at a lower pumping rate of 969 m3/day. The drawdown at the end of the test was 39.08 metres. The water level in the nearby trial wells was monitored during the test. TW 11 which was artesian prior to the pumping test was drawn down by 0.38 metres as a result of pumping TW 13. TW 11 is located 900 metres from TW 13.

The individual safe yield of TW 13 is estimated at 900 m3/day.

PARAMETERS	UNIT	TW No.1	TW No.3	TW No.4	TW No.6	TW No.7	TW No.8	TW No.9	TW No.10	TW No.12	TW No.13	POTABLE WATER M.A.C.
pH	units	7.4	7.6	7.2	7	7.2	7.4	7.2	7.2	7.3	7.6	6.0 - 9.0
Colour	Hazen	5	5	10	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5	< 5	20
Turbidity	NTU	0.6	4.4	3.2	0.25	38	44	8.7	25	16	25	4
Conductivity	µS/cm 20°C	496	582	698	720	670	490	735	670	690	565	1500
Total Hardness	CaCO3 mg/l	242	312	328	417	403	265	370	320	378	306	-
Alkalinity	CaCO3 mg/l	216	324	290	338	346	203	256	260	344	282	-
N.C. Hardness	CaCO3 mg/l	-	-	-	79	57	62	114	60	34	24	-
Calcium	Ca mg/l	75	101	112	134	140	83	107	95	115	93	200
Magnesium	Mg mg/l	13	19.5	23.3	20	13	14	25	20	22	18	50
Sodium	Na mg/l	25	32.8	28.8	22	13	16	33	22	31	21	150
Potassium	K mg/l	2	2.31	7	4.9	4.1	1.6	3.1	3.9	1.7	2.3	12
Iron	Fe mg/l	0.07	0.17	0.28	2.3	2.6	1.6	0.62	1.7	0.61	0.39	0.2
Manganese	Mn mg/l	0.19	1.79	0.48	0.28	0.13	0.19	0.16	0.07	1.2	0.08	0.05
Copper	Cu mg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.5
Aluminium	Al mg/l	-	-	-	< 0.05	< 0.05	0.38	< 0.05	0.07	< 0.05	0.26	0.2
Nitrate	NO3 mg/l	2.04	-	2.7	< 0.5	< 0.5	2.8	0.9	< 0.5	< 0.5	< 0.5	50
Nitrite	NO2 mg/l	-	< 0.001	< 0.001	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.1
Chloride	Cl mg/l	37	29.5	30	29	23	29	17	31	31	27	250
Sulphate	SO4 mg/l	2.6	43.6	68	82	40	43	63	61	41	25	250
Ammonia	NH4 mg/l	0.11	0.2	-	0.23	0.15	< 0.05	0.1	0.24	0.24	< 0.05	0.3
T.O.C	C mg/l	-	-	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-
Plate Count (22°C)	T.C.C./ml	-	-	-	-	11	109	83	87	> 300	> 300	No significant increase above background level
Plate Count (37°C)	T.C.C./ml	-	-	-	-	Nil	Nil	8	11	1	Nil	
Coliforms	count/100ml	Nil	-	Nil	-	Nil	Nil	Nil	Nil	Nil	Nil	Nil
E. Coli	count/100ml	Nil	-	Nil	-	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Faecal Streptococci	count/100ml	-	-	-	-	-	Nil	-	Nil	Nil	Nil	Nil

Table No.2: Chemical and Bacteriological Analyses from Trial Wells at the Bog of the Ring.

6.4.7 Trial Well No.14

TW 14 is located in the townland of Ring to the north of the assumed location of the North Dublin Fault. The bedrock was overlain by 16 metres of overburden. Coarse water bearing gravels were encountered between 12 and 16 metres. The well was collapsing continually making identification of the different strata very difficult. The bedrock was a green greywacke from 16 to 20 metres and this was underlain by a very broken limestone. 200 mm steel casing was installed to 12 metres. No more 200 mm casing could be installed because of the very coarse nature of the gravels. 150 mm steel casing was installed into solid bedrock. This bedrock gave way to fractured limestone which collapsed. The unstable nature of this limestone made further drilling impossible. No pumping test was carried out on TW 14. On the basis of the drilling observations the yield of TW 14 is estimated to be approximately 300 m3/day.

7. Hydrochemistry.

Water samples were collected at the end of each of the pumping tests. These samples were forwarded for chemical and bacteriological analyses. The results of these analyses and the analyses carried out as part of the previous programme are shown in Table No.2. All the wells show elevated levels of iron and manganese. The concentration of iron in TW 1 and TW 3 is less than the E.U. maximum admissible concentration for potable water. The elevated turbidity values are related to the concentrations of iron and manganese. The iron and manganese precipitate as the water becomes oxygenated and causes a cloudy appearance. TW 8 and TW 13 have concentrations of aluminium greater than the E.U. M.A.C. Blending with groundwater from other wells will bring these concentrations within acceptable limits. The

WELL NO.	BOREHOLE DEPTH (m)	AQUIFER	DEPTH TO ROCK (m)	S.W.L. (m)	DRAWDOWN (m)	ESTIMATED SAFE YIELD (m3/day)
TW No.1	52	Volcanics	22	12	22.48	948
TW No.2	87	Red Sandstone	18	-	-	-
TW No.3	34	Black Limestone	28			1000
TW No.4	65	Black Limestone	14	Artesian		2000
TW No.5	35	Mudstone	18	-	-	-
TW No.6	91	Gravel	15		-	>300
TW No.7	91	Siltstone/shale	22.5	11.44	36.99	500
TW No. 8	38	Limestone Conglomerate	20	Artestian	27.86	1000
TW No. 9	40	Gravel	?	0.4	28.45	1200
TW No.10	122	Weathered Limestone	2	14.16	31.39	1100
TW No.11	61	Gravel/limestone	17	Artesian		2000
TW No.12	55	Gravel/limestone	42	8.9	10.01	2500
TW No.13	80	Limestone	36	0.87	39.08	900
TW No.14	24	Volcanics	16	-	-	300

Table No.1: Trial Well Details from Drilling Programme at Bog of the Ring.

bacteriological quality of the water is good with no coliforms or E.Coli in any of the samples. Iron and manganese removal will be a necessary requirement in any supply scheme that is developed. The water is naturally hard in contrast to the water from Leixlip that is presently supplying the needs of the area.

8. Drilling and Testing Programme - Summary and Conclusions.

The results of the recent drilling and testing exercise have shown that the aquifer associated with the original trial wells is related to the structural deformation associated with the fault. This fault runs in an east-west direction and is characterised by pre-Carboniferous on its northern side and Carboniferous bedrock on its southern side. The aquifer is conceived to be a corridor along the fault but it remains to be confirmed whether the pre-Carboniferous sedimentary succession provides any groundwater potential. The Carboniferous limestones which were deformed and fractured by the faulting have become cavernous with large weathered fissures. The individual well yields of the wells in this limestone aquifer range from 900 - 2500 m3/day. The drilling and testing details are summarised in Table No.1. This phase of the investigation has shown that high yielding wells can be drilled along the southern edge of the fault. These trial wells are now proven sites for production wells. This phase of the investigation also showed that there was a band of highly transmissive gravels overlying the bedrock. The drilling conditions were particularly difficult due to a combination of the amount of water and the collapsing nature of the bedrock. Only one of the trial wells reached the designated target depth. This resulted from the low cost drilling technique used. It is quite likely that the individual well yields from production wells drilled at particular sites will be greater than that recorded in the trial well. The eastern and western boundaries of the aquifer still remain unknown at this stage. The fault related nature of the aquifer combined with the large quantities that it is hoped to abstract make the regional response of the aquifer to a major groundwater abstraction and the long term sustainability of that abstraction impossible to predict with confidence based on the information currently available. There is a lack of quality geological and hydrogeological data on the regional scale. There is not sufficient observation well data to predict the interaction between pumping wells when several are pumping simultaneously. The yields of each well will decrease from that listed in Table No.1 when several wells are pumped at the same time. A large scale pumping test is required to overcome this information deficit. This abstraction should be sufficiently large to stress the aquifer on a regional scale and should extend for a sufficiently long period such that the effects of boundaries and storage may be determined. The influence of the single well tests may not have extended sufficiently far to allow these to be evaluated. Iron and manganese removal will be required if the wells are to be used as a source of public water supply. Almost all the trial wells had concentrations of iron and manganese that exceeded the maximum admissible concentrations.

9. Recommendations.

9.1 Extended Multiple Well Pumping Test.

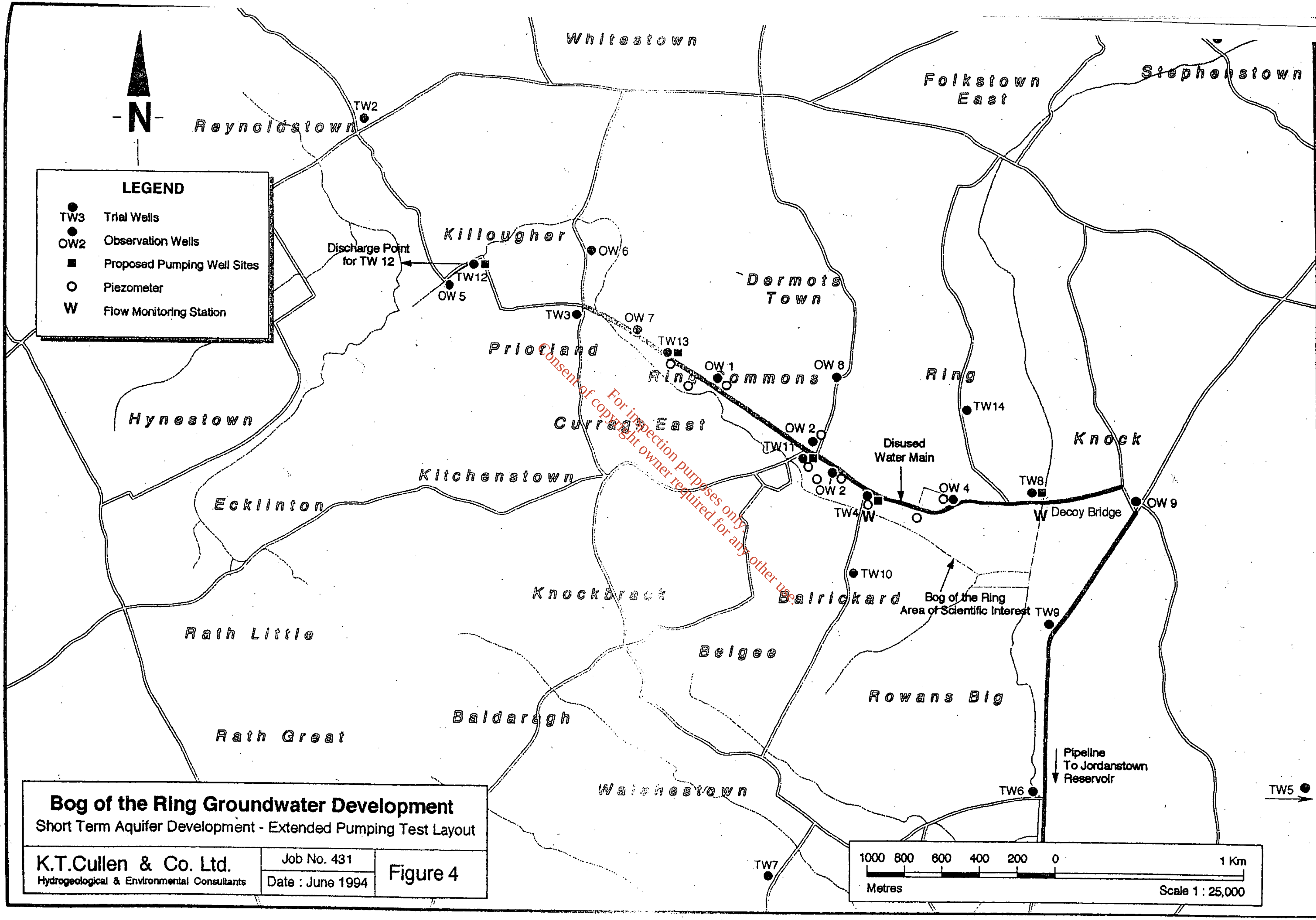
A multiple well pumping test carried out over an extended period of time is required in order to provide information on the response of the aquifer to the abstraction of large volumes of water. The ideal time for this exercise is when the regional water table is in recession between July and October. This test should be conducted in a manner that maximises the benefit to Fingal County Council. The test is designed to utilise the present infrastructure to the optimum. A pilot treatment plant is to be installed at Decoy Bridge beside TW 8. The discharged water can be fed from here directly into the rising main to Jordanstown reservoir.

It is recommended that the following measures be carried out in order that the pumping test can proceed and provide the required information:

i) It is proposed to abstract up to 5000 m3/day from the aquifer in the short term from wells located at TW 4, TW 8, TW 11, TW 12, and TW 13. There is a 200 mm CI main running through the Bog of the Ring. In undertaking this exercise it is important that the abstracted water is exported from the catchment to ensure that no recirculation of water occurs. The capacity of this main is estimated to be 3500 - 4000 m3/day. The discharge from the wells located at the sites of TW 4, TW 8, TW 11 and TW 13 will be pumped in to the existing 200 mm CI main. TW 12 will be pumped to waste to a water course that will carry the water out of the catchment.

ii) Construct new production wells at the sites of TW 8, TW 4, TW 11 and TW 13. These production wells will be drilled to a depth of 90 metres and will have a finished diameter of 250 mm. The difficult drilling conditions observed during the trial well drilling programme necessitate that the wells are lined throughout. TW 12 will be used as a pumping well. The locations of these new production wells and the other pumping wells are shown in Figure No.4

iii) As series of observation wells are required to provide distance drawdown data. These well will be finished at a diameter of 150 mm. They will be completed to varying depths of up to 60 metres. It is anticipated that 9 observation wells will be required the location of these is shown in Figure No.4.



Bog of the Ring Groundwater Development

Short Term Aquifer Development - Extended Pumping Test Layout

K.T.Cullen & Co. Ltd. Hydrogeological & Environmental Consultants	Job No. 431 Date : June 1994	Figure 4

iv) It is envisaged that the pumping wells will be pumped to waste until the water quality meets potable water standards. The iron and manganese removal plant can be tuned in during this phase. The discharge can be pumped directly into the stream at Decoy Bridge (TW 8) after treatment. This phase will also permit the wells to be pumped continuously during the early stages. When the system is connected into the public supply the output will be controlled by the demand at Jordanstown Reservoir.

9.2 Regional Impacts and Monitoring Requirements.

The long term development of the aquifer may involve pumping volumes greater than 5000 m3/day. Developments of this size require an EIA. Regardless of this necessity there are a number measures which must be undertaken prior to pumping. A comprehensive monitoring programme must be put in place to provide base line data which will be used to assess the impact of pumping and to predict the yield of the aquifer as opposed to the yields of individual wells.

a) The water levels in the observation wells should be monitored as long as possible prior to the test in order that the natural fluctuations in the regional water table can be evaluated.

b) A well survey should be conducted to locate all the users of wells in the area that will be effected. These wells should be monitored on a twice monthly basis prior to the test. The vulnerability of domestic wells can be assessed. Contingency measures can be implemented in the event of water supplies drying up due the pumping of the wells.

c) Weirs should be installed in the main water course running through the Bog of the Ring. These will provide data on the flow into and out of the area. It is recommended that 2 weirs be installed. The locations of these are shown on Figure No.4. Additional stream flow measurements will be made using a stream velocity meter at times of high and low flows.

d) An area of the Ring Commons was designated an Area of Scientific Interest by An Foras Forbatha. The effect of the development on this area must be carefully assessed. This will necessitate the installation of both shallow and deep piezometers within the wetland area to determine the hydraulic connection between the shallow water regime and the aquifer below. The levels in these should be monitored twice monthly to provide a base line prior to pumping the aquifer.

f) The rainfall in the area must be monitored closely. This will provide data on the recharge characteristics of the aquifer.

The monitoring programmes outlined above should be implemented as soon as possible. A high level of monitoring will be required in the early stages. Where possible, automatic methods of monitoring will be implemented. The baseline data can be used to calibrate a computer model. The more detailed the pre-pumping monitoring, the easier it will be to differentiate between natural fluctuations and those induced by pumping. If this level of data is collected then the computer model will be a very useful prediction tool. Once the model is calibrated various scenarios can be investigated. The response of the regional water table to constant high volume abstraction may show the influences of geological boundaries and the sustainability of the aquifer can then be accurately assessed.

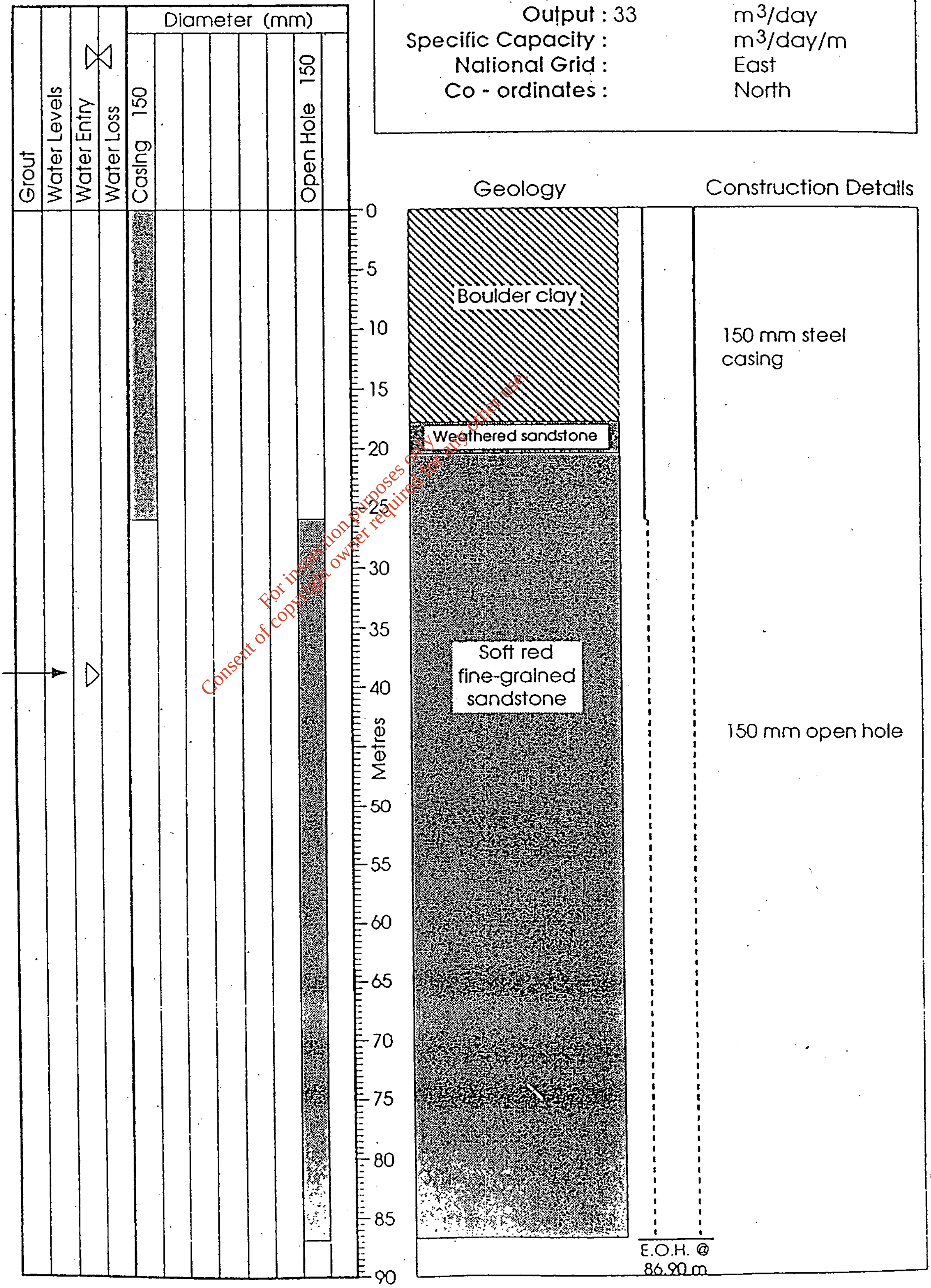
Completed Well Design

Trial Well No. 2

Client : Dublin County Council
Project : Groundwater Development
Location : Reynoldstown
County : Dublin
Date : November 1984.
Driller : Seamus Kelly
Aquifer : Red sandstone
Output : 33 m^3/day
Specific Capacity : m^3/day/m
National Grid : East
Co - ordinates : North

Remarks

Minor Inflow
Approx. 33 m3/d



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Completed Well Design

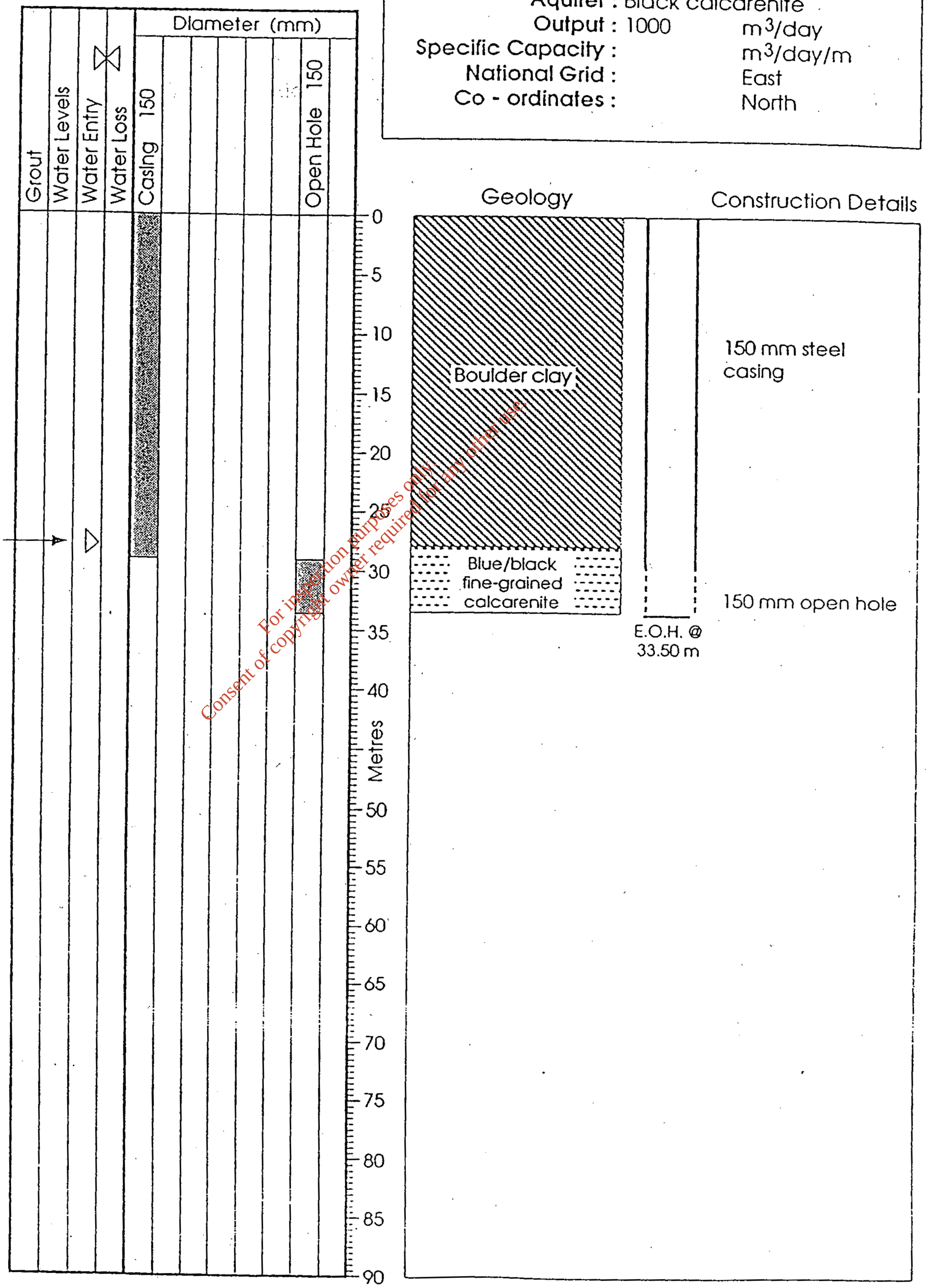
Trial Well No. 3

Client : Dublin County Council
Project : Groundwater Development
Location : Priorland
County : Dublin
Date : December 1984.
Driller : Seamus Kelly
Aquifer : Black calcarenite
Output : 1000 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North

Remarks

Well is artesian.

Water inflow Approx. 1300 m3/day



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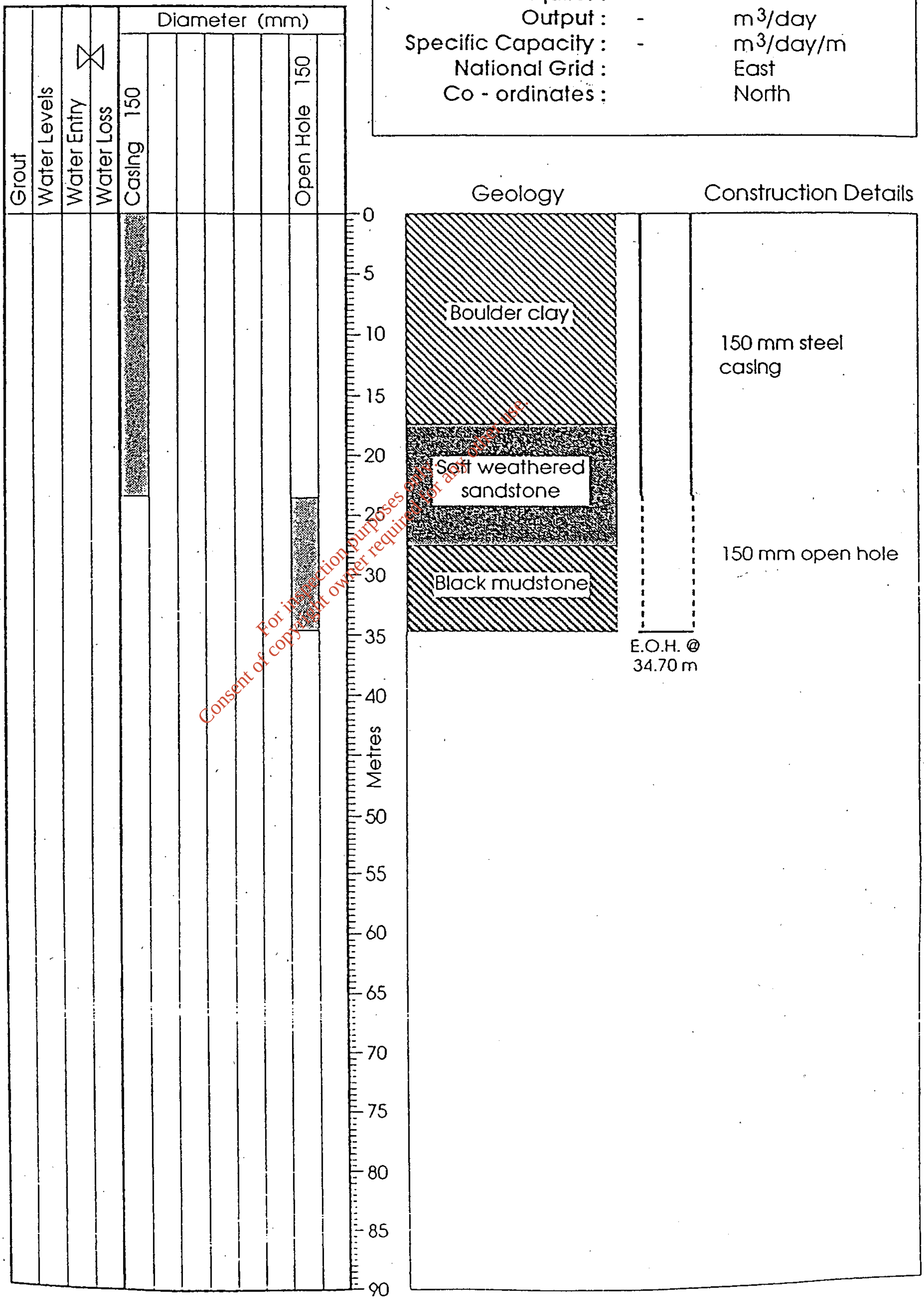
Completed Well Design

Trial Well No. 5

Client : Dublin County Council
Project : Groundwater Development
Location : Piercetown
County : Dublin
Date : December 1984.
Driller : Seamus Kelly
Aquifer : -
Output : - m³/day
Specific Capacity : - m³/day/m
National Grid : East
Co - ordinates : North

Remarks



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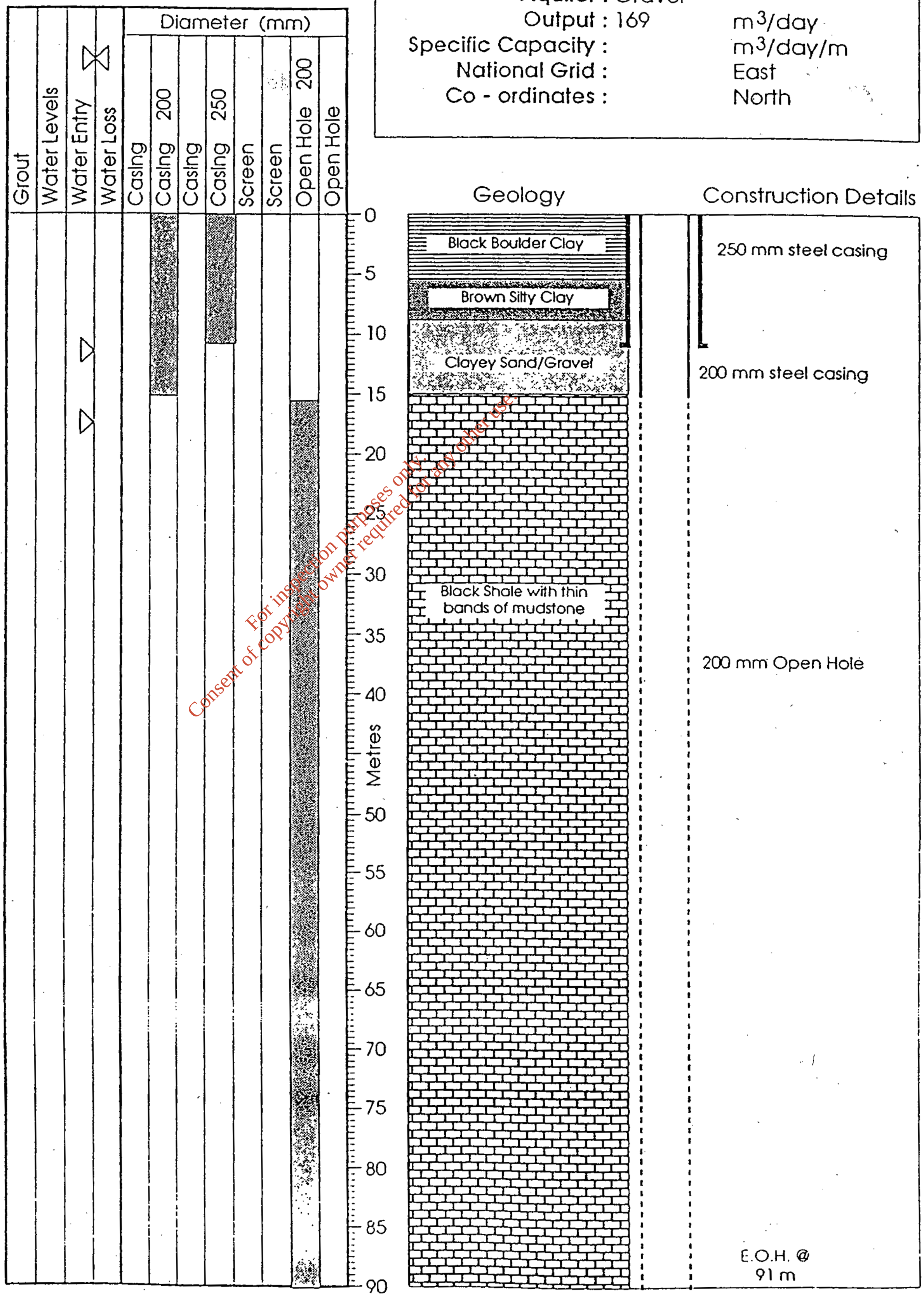
Completed Well Design

Trial Well No.6

Client : Dublin Co.Co
Project : Groundwater Development
Location : Rowans Little
County : North County Dublin
Date : April 1993
Driller : O'Donohoe Bros.
Aquifer : Gravel
Output : 169 m³/day
Specific Capacity : m³/day/m
National Grid : East
Co - ordinates : North

Remarks

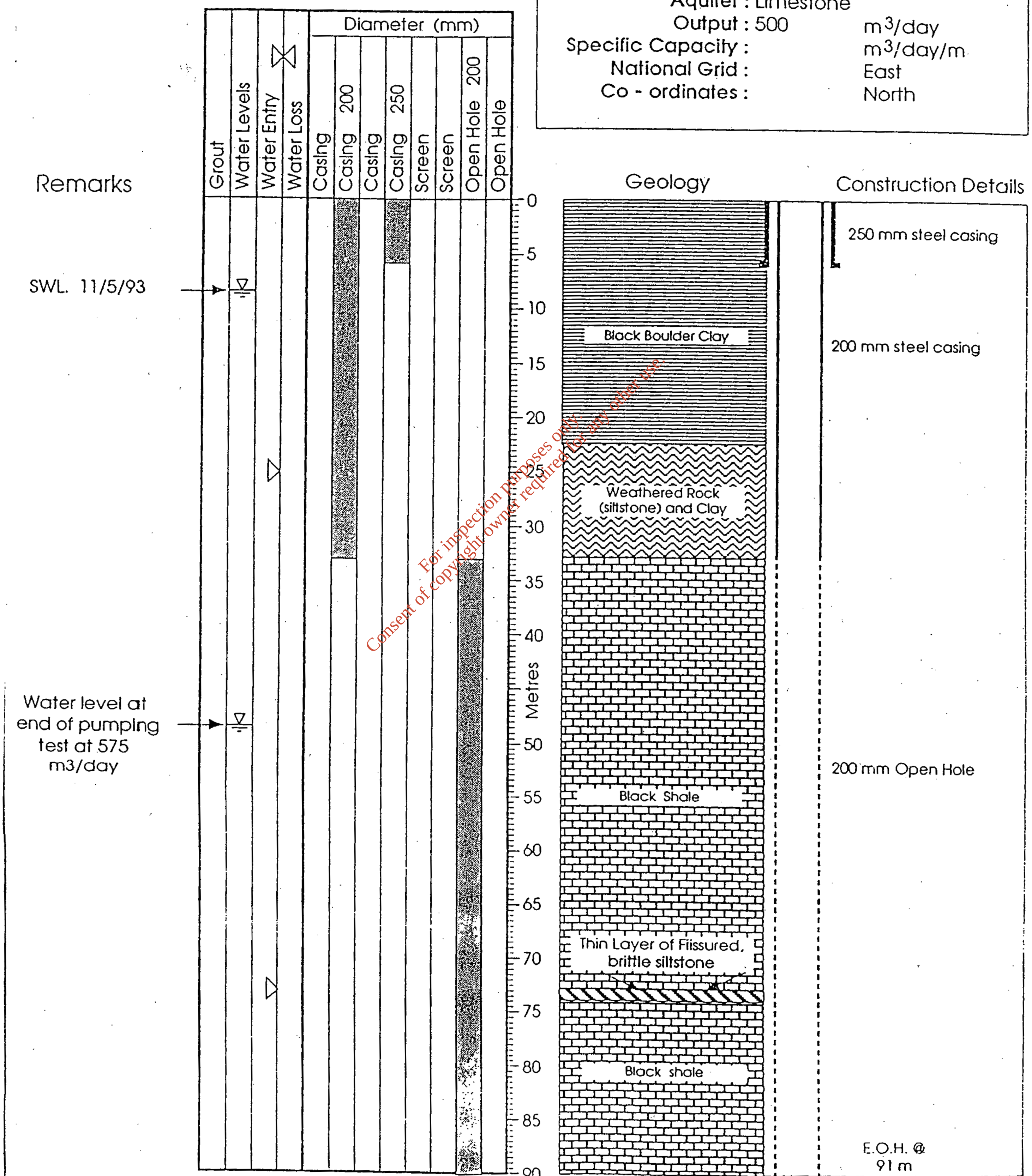
Well is flowing under artesian pressure.



Completed Well Design

Trial Well No.7

Client : Dublin Co.Co
Project : Groundwater Development
Location : Walshestown
County : North County Dublin
Date : May 1993
Driller : O'Donohoe Bros.
Aquifer : Limestone
Output : 500 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North



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Completed Well Design

TRIAL WELL NO.8

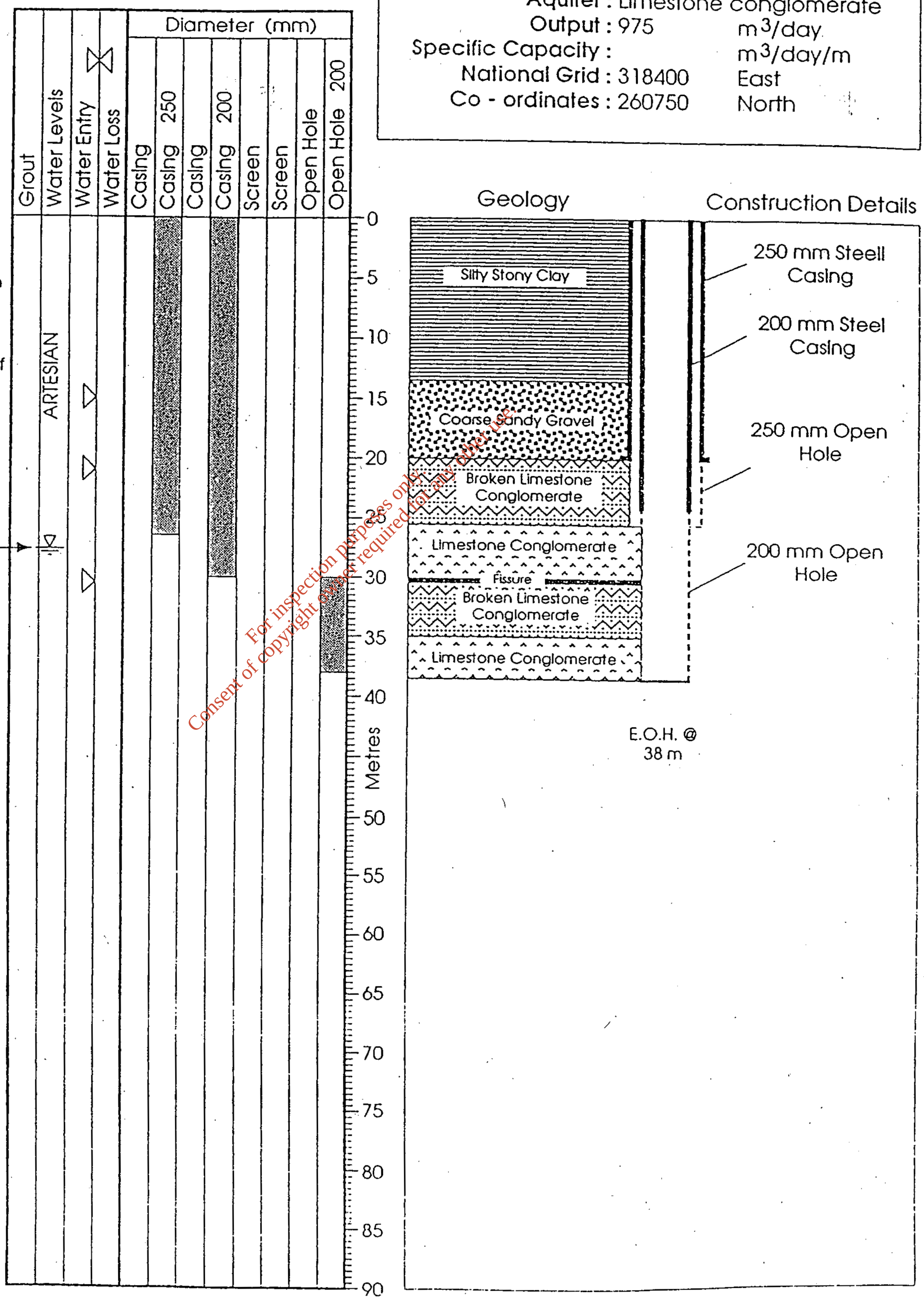
Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Decoy Bridge
County : Dublin
Date : December 1993
Driller : O'Donohoe Bros
Aquifer : Limestone conglomerate
Output : 975 m3/day
Specific Capacity : m3/day/m
National Grid Co - ordinates : 318400 East
260750 North

Remarks

Drilling was completed prematurely due to ingress of material from fissure

The well was test pumped for a period of 72 hours and the drawdown at the end of the test was 27.86 metres. The pumping rate at the end of the test was 979 m3/d

Water level at end of pumping test



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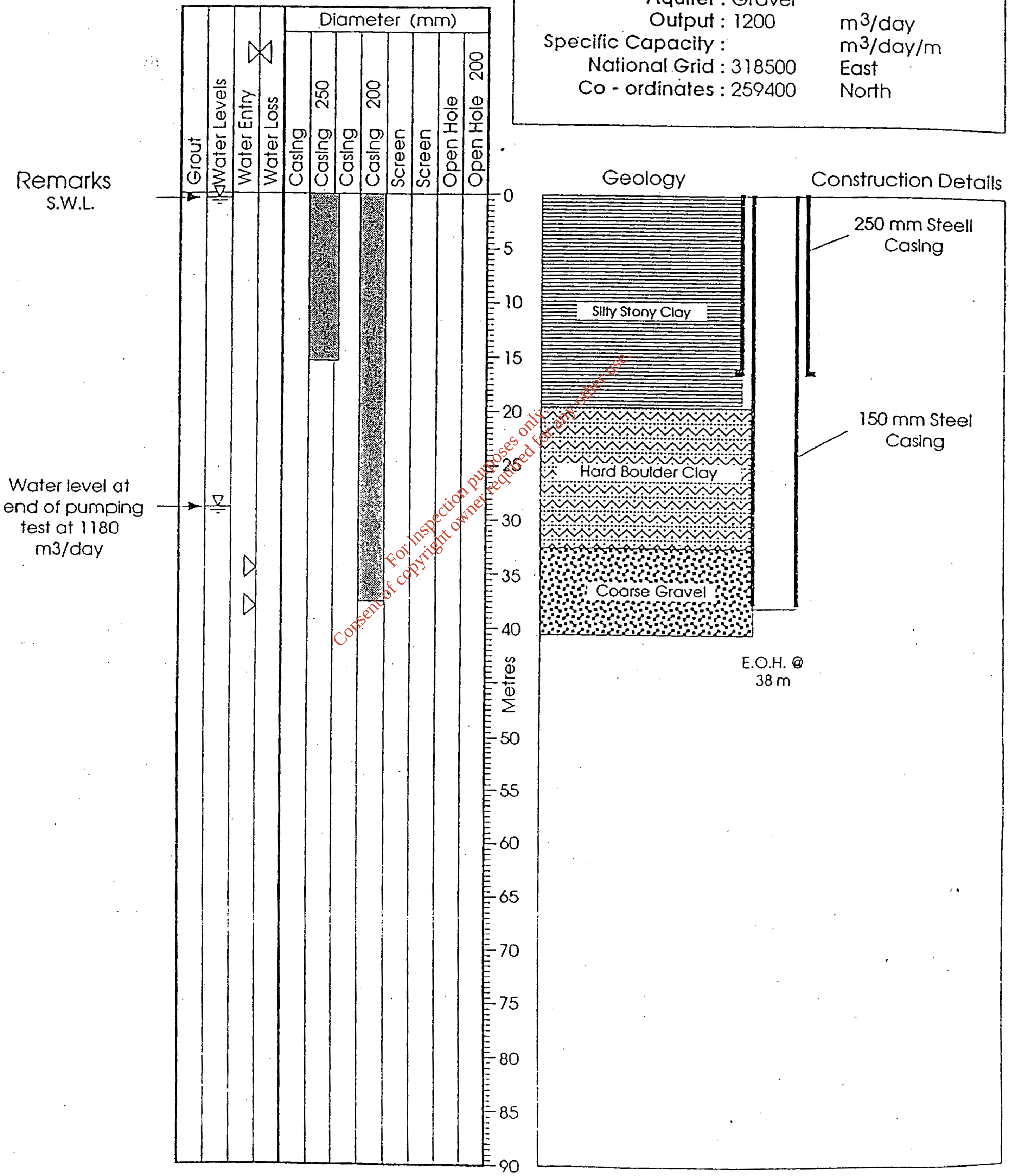
Completed Well Design

TRIAL WELL NO.9

Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Belfast Road
County : Dublin
Date : December 1993
Driller : O'Donohoe Bros
Aquifer : Gravel
Output : 1200 m3/day
Specific Capacity : m3/day/m
National Grid : 318500 East
Co - ordinates : 259400 North



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Completed Well Design

TRIAL WELL NO.10

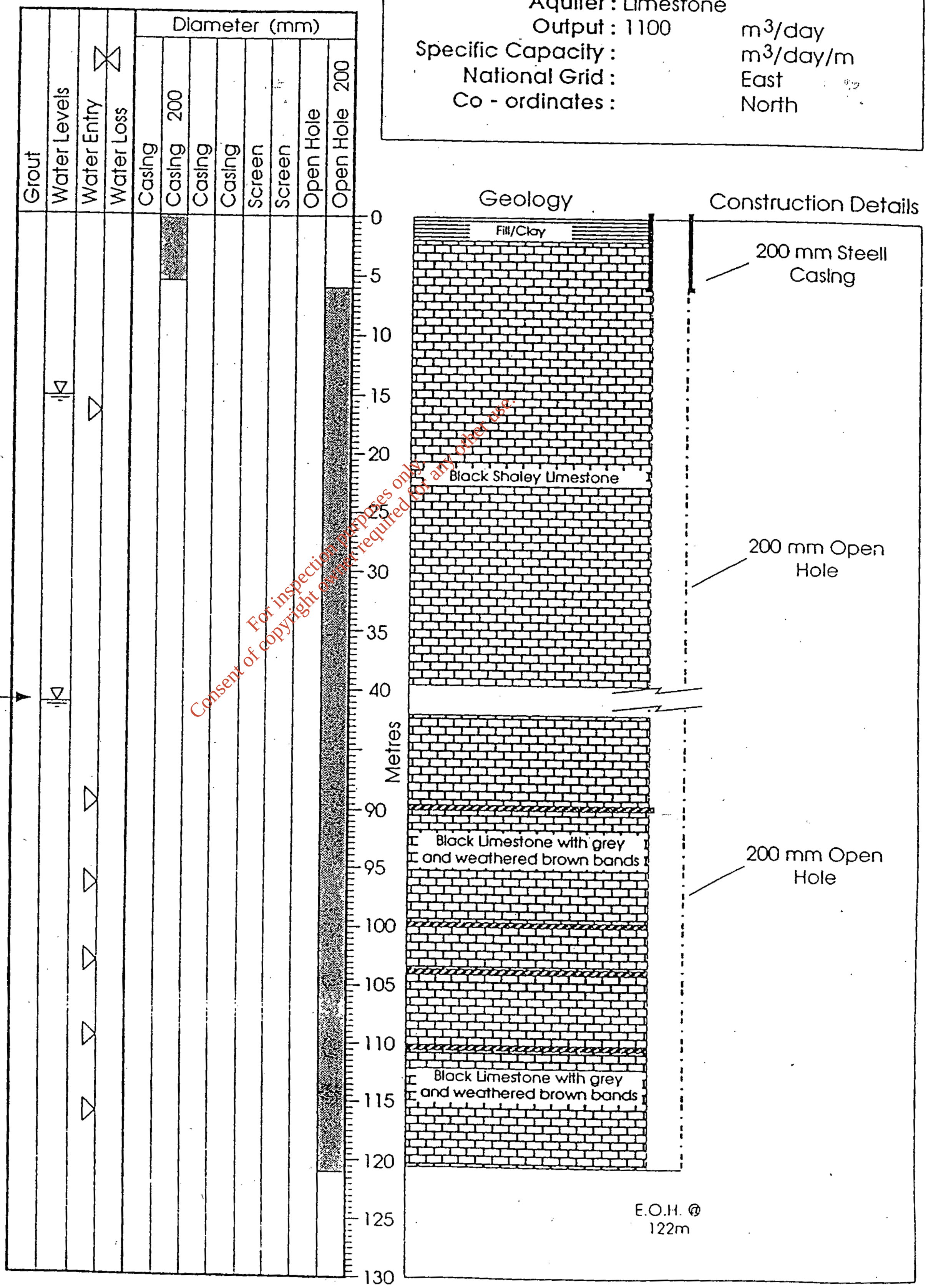
Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Balrickard
County : Dublin
Date : January 1994
Driller : O'Donohoe Bros
Aquifer : Limestone
Output : 1100 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North

Remarks

The depth of this borehole extended to 122 m due to its elevation

The yield of the well was estimated to be 20 m3/day at 85 metres. All the water entered in the last 30 metres which had bands of weathered limestone.

Water level at end of PumpingTest
Q = 1149 m3/day



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Completed Well Design

TRIAL WELL NO.11

Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Ring Commons.
County : Dublin
Date : January 1994
Driller : O'Donohoe Bros
Aquifer : Gravel/Limestone
Output : 2000 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North

Remarks

Very large inflows were recorded from the gravel at 14 metres. There was so much water it became difficult to notice further inflows

No Pumping Test was carried out on this well due to budgetry Considierations

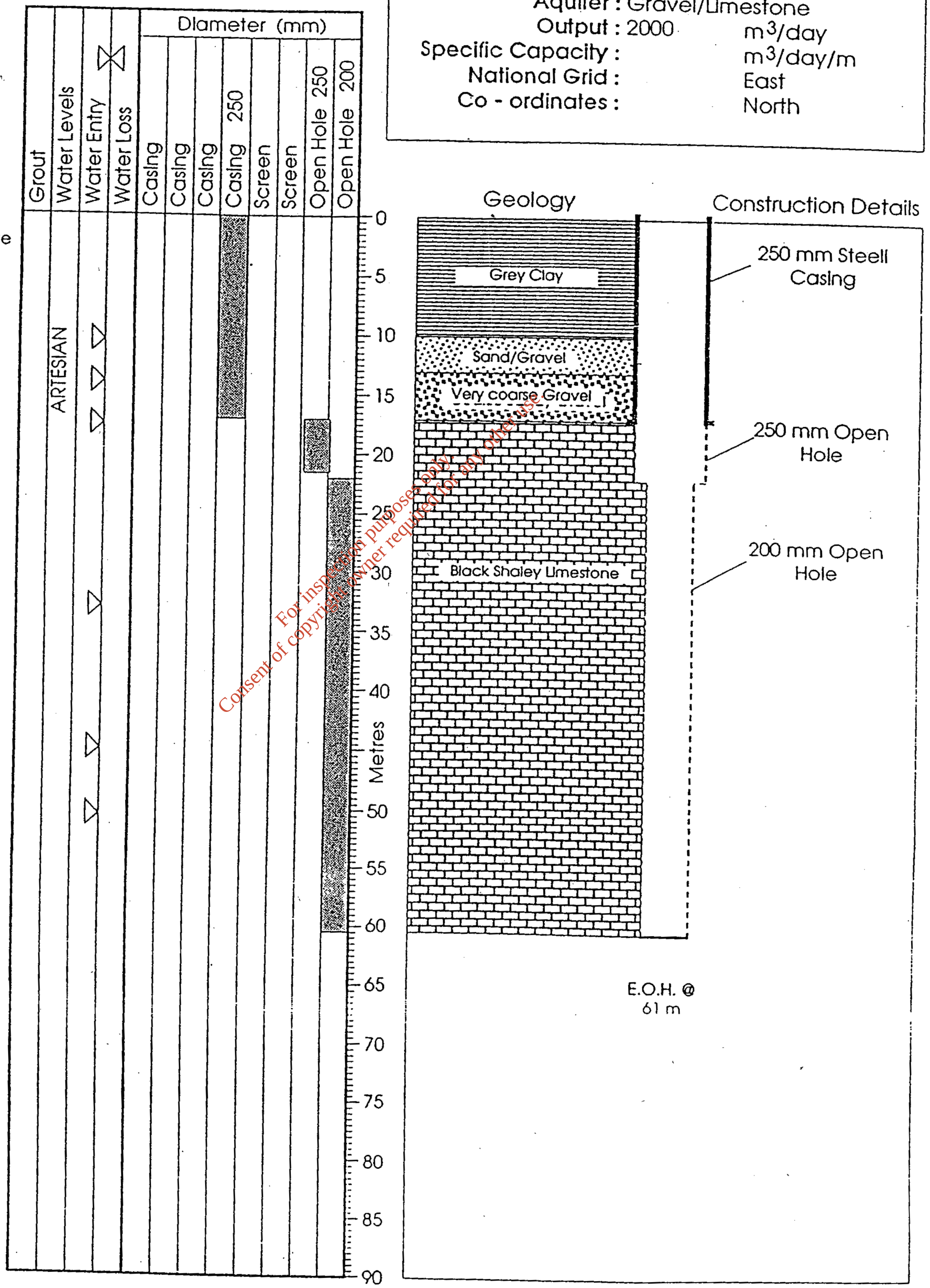

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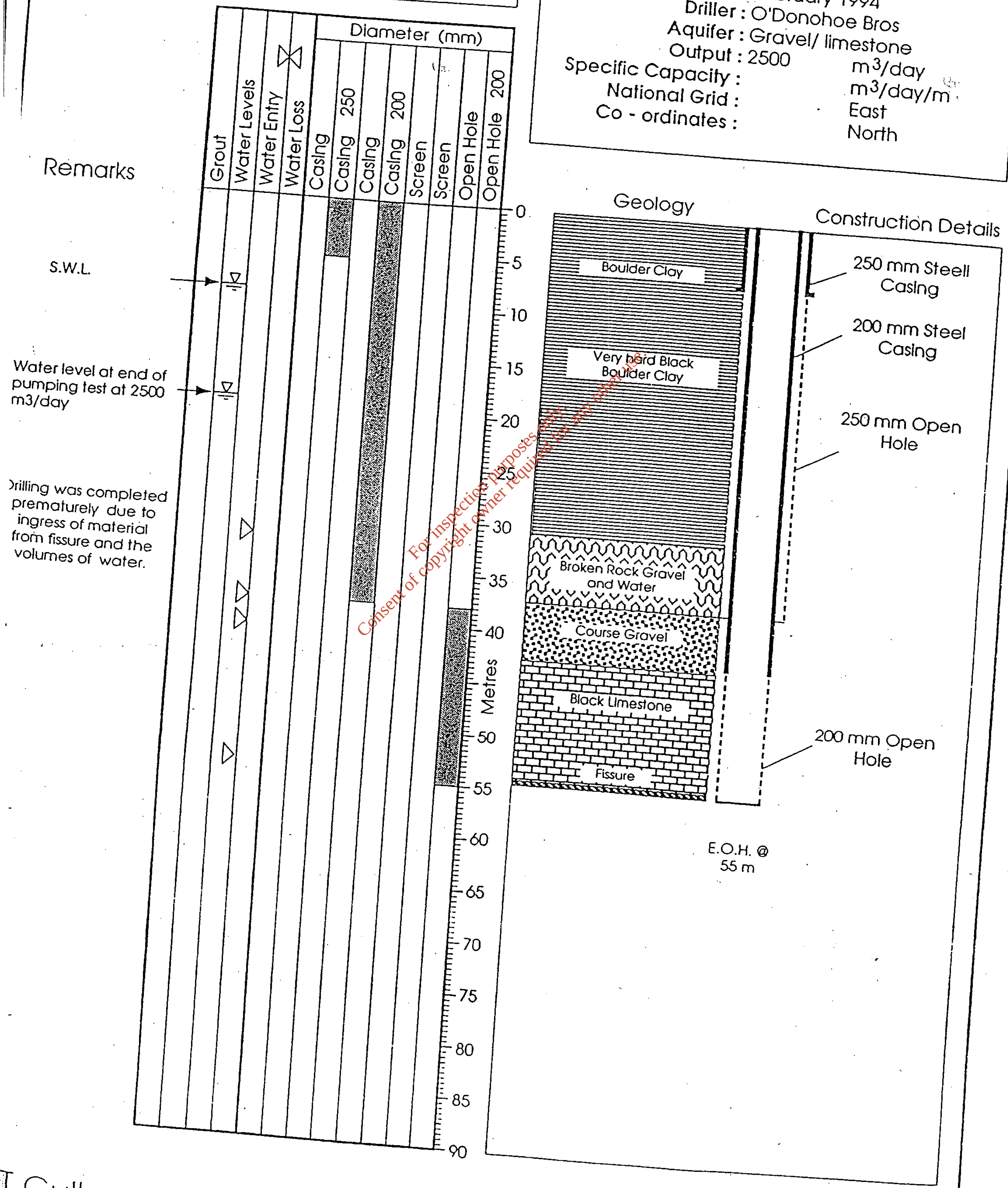
Figure No

Completed Well Design

TRIAL WELL NO.12

Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Killougher
County : Dublin
Date : February 1994
Driller : O'Donohoe Bros
Aquifer : Gravel/ limestone
Output : 2500 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North



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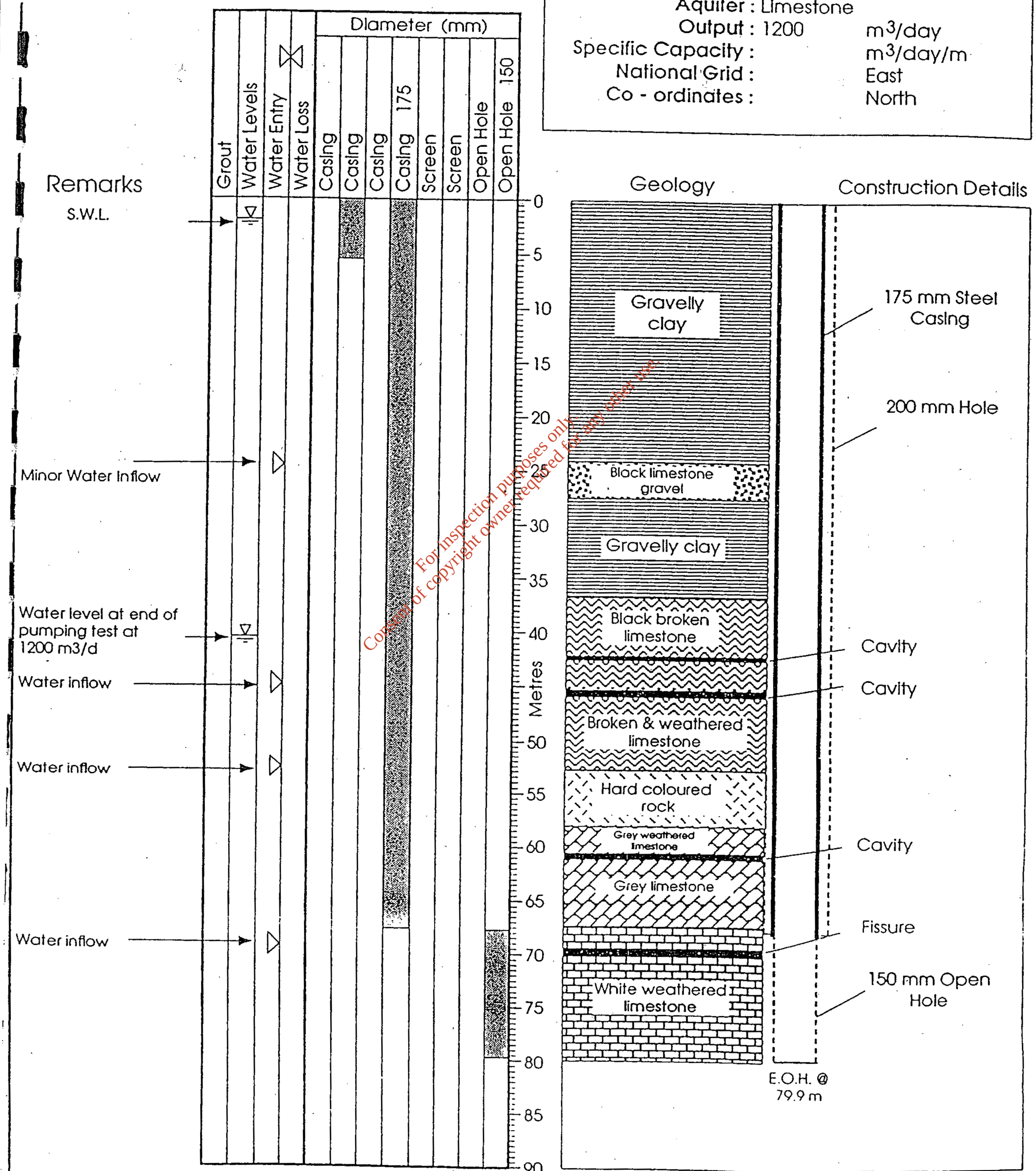
Completed Well Design

TRIAL WELL NO.13

Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Commons
County : Dublin
Date : March 1994
Driller : O'Donohoe Bros
Aquifer : Limestone
Output : 1200 m3/day
Specific Capacity : m3/day/m
National Grid : East
Co - ordinates : North



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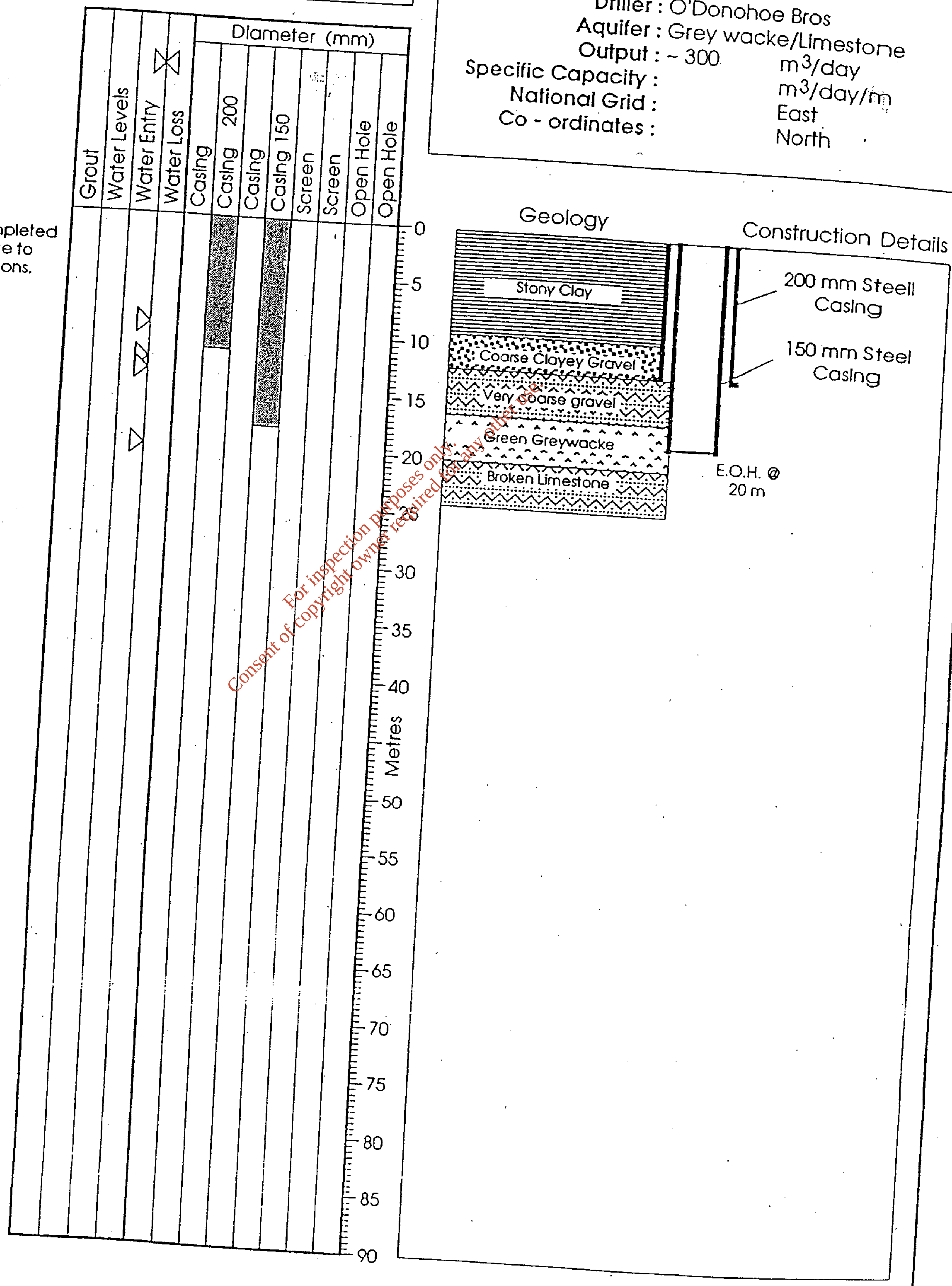
Completed Well Design

TRIAL WELL NO.14

Client : P.H. McCarthy & Ptnrs
Project : Bog of the Ring RWSS
Location : Matt Lane, Ring.
County : Dublin
Date : March 1994
Driller : O'Donohoe Bros
Aquifer : Grey wacke/Limestone
Output : ~ 300 m3/day
Specific Capacity : m3/day/m
National Grid Co - ordinates : East North

Remarks

Drilling was completed prematurely due to unstable conditions.



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