



# **ASSESSMENT OF ERROR DUE TO ORIFICE DIAMETER MIS-MEASUREMENT AT ROUDHAM HEATH**

A Report for

**National Grid  
Brick Kiln Street  
HINCKLEY  
Leicestershire  
LE10 0NA**

PROJECT NO: NGR010

REPORT NO: 2010/234

DATE: 16 JUNE 2010



**This report is issued as part of the contract under which the work has been carried out for the client.**

## **NOTES**

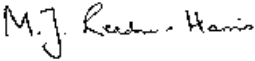
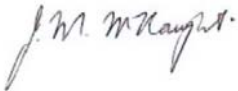
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## Assessment of Error Due to Orifice Diameter Mis-Measurement at Roudham Heath

A Report for

**National Grid  
Brick Kiln Street  
HINCKLEY  
Leicestershire  
LE10 0NA**

<b>Prepared by:</b>  	<b>Approved by:</b>  
<b>Dr M J Reader-Harris</b>	<b>J M McNaught</b>

for  
Michael Valente  
Managing Director

Date: 16 June 2010

## **EXECUTIVE SUMMARY**

Owing to a mis-measurement of orifice diameters flows have been mis-measured at affected offtakes connected to the National Transmission System. This project has been undertaken to resolve these errors.

At Roudham Heath a correction factor of 1.002177 should be applied during the period of mis-measurement.

Over the period 23/07/2007 to 27/03/2008 inclusive the flow was 322.37060 mscm and the corrected flow should be 323.07000 mscm.

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## 1 INTRODUCTION

Owing to a mis-measurement of orifice diameters flows have been mis-measured at affected offtakes connected to the National Transmission System. This project has been undertaken to resolve these errors. This report covers the flows through Roudham Heath in the period of the error. The Joint Office Error Code is EA005.

## 2 ORIFICE DIAMETERS

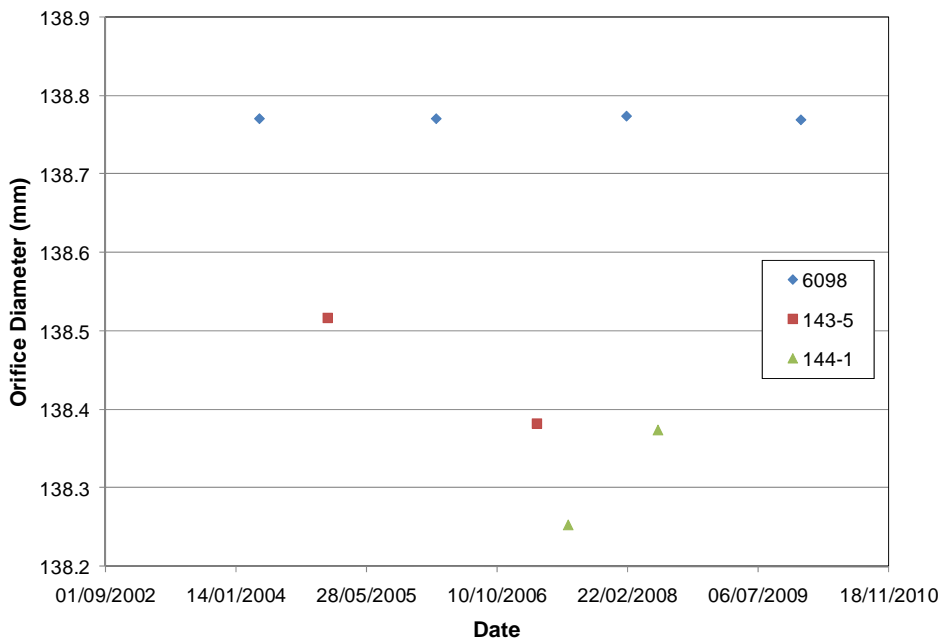
The calibrations of the orifice plates in question gave the measured diameters shown in Table 1. The diameters at 20 °C have been calculated.

**TABLE 1**  
**ORIFICE DIAMETERS**

Calibration Reference	Plate serial no	Declared certificate date	Orifice bore (mm)	Temperature	Value at 20 °C Orifice bore (mm)
OP4039	6098	14/04/2004	138.7730	21	138.7708
OP4241	143-5	31/12/2004	138.5190	21	138.5168
OP60025	6098	20/02/2006	138.7730	21	138.7708
OP70026	143-5	13/03/2007	138.3845	21	138.3823
OP70076	144-1	11/07/2007	138.2535	20	138.2535
OP80003	6098	19/02/2008	138.7740	20	138.7740
OP80029	144-1	19/06/2008	138.3735	20	138.3735
OP90057	6098	18/12/2009	138.7700	20.3	138.7693

Figure 1 shows the data from Table 1 for the orifice bores at 20°C. This figure shows that for plate 143-5 there is a high measurement followed by a low measurement of diameter and for plate 144-1 there is a low measurement followed by a high measurement of diameter. The deduction from this graph is that plates were mis-measured. From the experience of other sets of measurements it is the low measurements that are in error.

The calibration certificates for the orifice plates are given as Appendix A.



**Figure 1 Orifice Diameters at 20 °C**

The plates actually used in the meter tube are given in Table 2.

**TABLE 2**  
**PLATES USED IN EACH LINE AS CONFIGURED BY THE FLOW COMPUTER**

Configuration	omnM0502.cfg	omnM0723.cfg	omnN0128.cfg	omnN0327.cfg
	02/05/2007 23:01	23/07/2007 23:01	29/01/2008 00:01	28/03/2008 00:01
Orifice plate bore diameter (mm)	138.773	138.2535	138.2535	138.774
Expansion coefficient of the plate (°C)	0.000016	0.000016	0.000016	0.000016
Orifice plate calibration temperature	21	20	20	20
Meter tube diameter (mm)	202.7269	202.7269	202.7269	202.7269
Expansion coefficient of the meter tube (°C)	0.000011	0.000011	0.000011	0.000011
Meter tube calibration temperature	20	20	20	20
Isentropic Exponent	1.3592	1.3592	1.3589	1.3589
Dynamic Viscosity (Pa.s)	0.000012	0.000012	0.0000121	0.0000121
Orifice plate certificate number	OP60025	OP70076	OP70076	OP80003
Orifice plate serial number	6098	144-1	144-1	6098
Error in orifice diameter?	No	Yes	Yes	No

### 3 CORRECTING THE FLOWRATE

To correct the measured flowrate by replacing an incorrect diameter with the correct diameter might appear to be fairly straightforward. However, the data supplied only give time to the nearest minute and at four-minute intervals. This is inadequate for very accurate calculation. It is possible to calculate the flow over each time interval and to add the values over a day; this method can be used to check that the calculations are being done correctly, but the differences between the summed figures and the ones already given in the spreadsheet are too large to enable the correction to be calculated in this way. An alternative method has therefore been used.

The mass flowrate  $q_m$  is given by

$$q_m = \frac{\pi d^2 C \varepsilon \sqrt{2 \rho \Delta p}}{4 \sqrt{1 - \beta^4}}$$

where  $d$  is the orifice diameter,  $C$  is the discharge coefficient,  $\varepsilon$  is the expansibility,  $\rho$  is the density,  $\Delta p$  is the differential pressure, and  $\beta$  is the diameter ratio.

If the corrected and original data are described with subscripts  $c$  and  $o$ , then the following correction factor is obtained:

$$\frac{q_{m,c}}{q_{m,o}} = \left( \frac{d_c}{d_o} \right)^2 \frac{C_c \varepsilon_c \sqrt{1 - \beta_o^4}}{C_o \varepsilon_o \sqrt{1 - \beta_c^4}}$$

The correct effective diameter is taken as the average of the measurements shown in Table 1 for that plate excluding the erroneous measurement. It is then necessary to calculate  $C$  and  $\varepsilon$  in each case, and they were determined from the equations in ISO 5167-1:1991.  $C$  is a function of  $\beta$  and  $Re_D$ ; so there is a change in  $C$  due to  $\beta$ , but the change varies with Reynolds number. Throughout the calculations the upstream pressure  $p_1$  is taken as 61 bar a; the change in  $q_{m,c}/q_{m,o}$  due to changing the static pressure by 10 bar is around 0.00003% at maximum.

Over the period from 23/07/2007 to 28/01/2008 the correction can be calculated as in Table 3; throughout this calculation the meter tube diameter is 202.7269 mm, the isentropic exponent is 1.3592 and the dynamic viscosity 0.000012 Pa s.

**TABLE 3**  
**THE CORRECTION FROM 23/07/2007 TO 28/01/2008**

	$d$ mm	$\beta$	$\varepsilon$	$Re_D$	$C$	$\frac{q_{m,c}}{q_{m,o}}$
Original: $\Delta p=10$ mbar	138.2535	0.681969	0.999941	1772916	0.603755	
Corrected $\Delta p=10$ mbar	138.3735	0.682561	0.999941	1776778	0.603731	1.0021781
Original $\Delta p=500$ mbar	138.2535	0.681969	0.997071	12488871	0.603198	
Corrected $\Delta p=500$ mbar	138.3735	0.682561	0.997069	12516048	0.603174	1.0021760

So  $q_{m,c}/q_{m,o}$  is 1.002177.

Over the period from 28/01/2008 to 27/03/2008 the correction can be calculated as in Table 4; throughout this calculation the meter tube diameter is 202.7269 mm, the isentropic exponent is 1.3589 and the dynamic viscosity 0.0000121 Pa s.

**TABLE 4**  
**THE CORRECTION FROM 28/01/2008 TO 27/03/2008**

	$d$ mm	$\beta$	$\varepsilon$	$Re_D$	$C$	$\frac{q_{m,c}}{q_{m,o}}$
Original: $\Delta p=10$ mbar	138.2535	0.681969	0.999941	1758277	0.603759	
Corrected $\Delta p=10$ mbar	138.3735	0.682561	0.999941	1762107	0.603736	1.0021781
Original $\Delta p=500$ mbar	138.2535	0.681969	0.997071	12385671	0.603199	
Corrected $\Delta p=500$ mbar	138.3735	0.682561	0.997069	12412623	0.603175	1.0021760

So  $q_{m,c}/q_{m,o}$  is 1.002177.

#### 4 CORRECTIONS ON A DAILY BASIS

The volume flows for each day from 23/07/2007 to 27/03/2008 are given in Table B.1 of Appendix B together with the corrected values. It has been assumed that the plates were changed at 11:15 on 23/07/2007 and at 10:20 on 27/03/2008; therefore 77.9% of the flow for 23/07/2007 has to be corrected and 20.6% of the flow for 27/03/2008 has to be corrected based on the flow before and after the times at which the plates were changed. Summing the data gives the figures in Table 5.



**TABLE 5****THE FLOW OVER THE PERIOD 23/07/2007 TO 27/03/2008 INCLUSIVE**

Flow (mscm)	322.37060
Correction (mscm)	0.69940
Corrected flow (mscm)	323.07000
% change	0.2170

**5 CONCLUSIONS**

A correction factor of 1.002177 should be applied during the period of mis-measurement.

**APPENDIX A  
ORIFICE PLATE CALIBRATION CERTIFICATES**

**TRANSCO ORIFICE PLATE CALIBRATION**

**DATE:** 14-04-04

**REF NO:** OP4039

**TEMPERATURE:** 21 degsC

**MEASURED ORIFICE BORE:** 138.773mm

**PLATE DETAILS**

PLATE SERIAL:	6098	PLATE O.D:	214.099mm		
MANUFACTURER:		PIPE I.D:	202.742mm	SITE:	ROUDHAM HEATH
MATERIAL CERT.No		DESIGN BORE:	138.528mm	FLOW:	2496000 M <sup>3</sup> /day

**TEST EQUIPMENT**

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 3858 NEXT CAL DUB:- 17/10/04

**UPSTREAM FACE INSPECTION RESULTS (ISO 5167)**

STATIONS:	1	2	3	4	5	6	7	8
FLATNESS $\mu$	0.085	0.209	0.064	0.187	0.329	0.115	0.157	0.188
E mm	3.164	3.198	3.170	3.142	3.130	3.131	3.166	3
$t_e$ mm								
EDGE SHARPNESS mm	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125

CONCENTRICITY: 0.101mm

SURFACE FINISH (Ra):

DOWNSTREAM FACE/EDGE VISUAL INSPECTION :- PASS

ROUNDNESS: 0.017mm TAPER: 0 degs

BEVEL ANGLE: DEGS

COMMENTS:

INSPECTED BY: *G. Wardle* G. WARDLE

VERIFIED BY: *P. Kennerson* P. KENNERSON

**TRANSCO ORIFICE PLATE CALIBRATION**

**DATE:** 31-12-04  
**REF NO:** OP4241  
**TEMPERATURE:** 21 degsC

**MEASURED ORIFICE BORE:** 138.519mm

**PLATE DETAILS**

PLATE SERIAL.	143-5	PLATE O.D	214.074mm	SITE	ROUDHAM HEATH
MANUFACTURER:		PIPE I.D:	mm	FLOW	
MATERIAL CERT.No	M7121	DESIGN BORE	mm		

**TEST EQUIPMENT**

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 4820 NEXT CAL DUE:- 15/10/05

**UPSTREAM FACE INSPECTION RESULTS (ISO 5167)**

STATIONS	1	2	3	4	5	6	7	8
FLATNESS $\mu$	0.128	0.150	0.094	0.370	0.025	0.280	0.013	0.230
DIAMETER mm	3.370	3.370	3.347	3.357	3.359	3.342	3.363	3.363
EDGE SHARPNESS mm	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0250
BEVEL ANGLE:	DEGS							
CONCENTRICITY	0.158mm							
SURFACE FINISH (Ra)	1.4 microns							
DOWNSTREAM FACE/EDGE VISUAL INSPECTION	PASS							
ROUNDNESS 0.020mm	TAPER 0 degs							

COMMENTS

INSPECTED BY:  G. WARDLE

VERIFIED BY:  P. KENNERSON

## NATIONAL GRID ORIFICE PLATE CALIBRATION

**DATE:** 20-02-06  
**REF NO:** OP60025  
**TEMPERATURE:** 21 degsC

**MEASURED ORIFICE BORE:** 138.773mm

### PLATE DETAILS

PLATE SERIAL.	6098	PLATE O.D.	214.110mm	SITE:	ROUDHAM HEATH
MANUFACTURER:		PIPE I.D.:	mm	FLOW:	
MATERIAL CERT.No.		DESIGN BORE	mm		

### TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 4820 NEXT CAL DUE:- 14/10/06

### UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS:-	1	2	3	4	5	6	7	8
FLATNESS $\mu$	0.096	0.247	0.040	0.095	0.344	0.244	0.117	0.185
'E' mm	3.152	3.163	3.161	3.127	3.050	3.137	3.158	3.172
'a' mm								
EDGE SHARPNESS mm	0.0125	0.0125	SQUARE	0.0125	0.0125	SQUARE	0.0125	0.0125
BEVEL ANGLE								
CONCENTRICITY	0.112mm							
SURFACE FINISH (Ra)	0.9 microns							
DOWNSTREAM FACE/EDGE VISUAL INSPECTION :-	PASS							
ROUNDNESS	0.021mm	TAPER: 0 degs						

### COMMENTS:

INSPECTED BY



P. KENNERSON

NATIONAL GRID ORIFICE PLATE CALIBRATION

DATE: 13-03-07  
 REF NO: OP70026  
 TEMPERATURE: 21 degsC

MEASURED ORIFICE BORE: 138.3845mm

PLATE DETAILS

PLATE SERIAL. 143-5 PLATE O.D. 213.911mm  
 MANUFACTURER: PIPE I.D.: mm SITE: ROUDHAM HEATH  
 MATERIAL CERT.No DESIGN BORE: mm FLOW:

TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 4820 NEXT CAL DUE:- 13/10/07

UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS	1	2	3	4	5	6	7	8
FLATNESS %	0.137	0.032	0.077	0.404	0.029	0.271	0.017	0.252
Ø mm	3.414	3.407	3.333	3.348	3.415	3.419	3.342	3.336
EDGE SHARPNESS mm	0.0125	0.0125	0.0125	0.0125	0.025	0.0125	0.0125	0.0125
BEVEL ANGLE	DEGS							
CONCENTRICITY	0.156mm							
SURFACE FINISH (Ra)	1.0 microns							
DOWNSTREAM FACE/EDGE VISUAL INSPECTION	PASS							
ROUNDNESS	0.129mm	TAPER: 0 degs						

COMMENTS

INSPECTED BY



P. KENNERSON



NATIONAL GRID ORIFICE PLATE CALIBRATION

DATE: 11-07-2007

REF NO: OP70076

TEMPERATURE: 20 degsC

MEASURED ORIFICE BORE: 138.2535mm

PLATE DETAILS

PLATE SERIAL. 144-1 PLATE O.D. 213.870mm  
 MANUFACTURER: ANTOOLS PIPE I.D: mm SITE: ROUDHAM HEATH  
 MATERIAL CERT.No. 316 DESIGN BORE mm FLOW:

TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 4820 NEXT CAL DUE:- 13/10/07


UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS:	1	2	3	4	5	6	7	
FLATNESS %	0.063	0.077	0.042	0.109	0.122	0.123	0.188	0.101
E' mm	3.472	3.496	3.435	3.433	3.475	3.487	3.427	3.403
e' mm								
EDGE SHARPNESS mm	1	1	1	1	1	1	1	1
BEVEL ANGLE:	DEGS							
CONCENTRICITY	0.043mm							
SURFACE FINISH (Ra)	0.27 microns							

DOWNSTREAM FACE/EDGE VISUAL INSPECTION :- PASS

ROUNDNESS 0.120mm TAPER: 02 degs

COMMENTS:

INSPECTED BY:  M LIVINGSTONE

NATIONAL GRID ORIFICE PLATE CALIBRATION

DATE: 19-FEB-2008

REF NO: OP80003

TEMPERATURE: 20 degsC

MEASURED ORIFICE BORE: 138.774mm

PLATE DETAILS

PLATE SERIAL. 6098 PLATE O.D 214.096mm  
 MANUFACTURER: PIPE I.D: 202.7269mm SITE: ROUDHAM HEATH  
 MATERIAL CERT.No. DESIGN BORE: mm FLOW: M<sup>3</sup>/DAY

TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 6292 NEXT CAL DUE:- 05-OCTOBER-2008

UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS:-	1	2	3	4	5	7	8
FLATNESS %	0.026	0.004	0.003	0.092	0.179	0.093	0.109
'E' mm	3.149	3.178	3.161	3.129	3.119	3.134	3.147
mm							
EDGE SHARPNESS mm	SQUARE	0.0125	SQUARE	SQUARE	SQUARE	SQUARE	SQUARE
BEVEL ANGLE	DEGS						
CONCENTRICITY	0.109mm						
SURFACE FINISH (Ra)	0.8 microns						

DOWNSTREAM FACE/EDGE VISUAL INSPECTION :- PASS

ROUNDNESS : 0.017mm TAPER: 0 degs

COMMENTS: LIGHT PITTING TO BOTH FACES.

INSPECTED BY:  M Livingstone.

NATIONAL GRID ORIFICE PLATE CALIBRATION

DATE: 19-JUNE-2008

REF NO: OP80029

TEMPERATURE: 20 degsC

MEASURED ORIFICE BORE: 138.3735mm

PLATE DETAILS

PLATE SERIAL. 144-1 PLATE O.D. 214.038mm  
 MANUFACTURER: PIPE I.D.: 202.7269mm SITE: ROUDHAM HEATH  
 MATERIAL CERT.No. DESIGN BORE: mm FLOW: M<sup>3</sup>/DAY

TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE -ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, CERT:- 6292 NEXT CAL DUE:- 05-OCTOBER-2008

UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS:-	1	2	3	4	5	6	7
FLATNESS %	0.071	0.079	0.047	0.092	0.116	0.128	0.146
'E' mm	3.418	3.451	3.441	3.440	3.412	3.425	3.432
'e'							
EDGE SHARPNESS mm	0.025	0.025	0.025	0.025	0.025	0.025	0.025
BEVEL ANGLE:	DEGS						
CONCENTRICITY	0.032mm						
SURFACE FINISH (Ra)	0.35 microns						

DOWNSTREAM FACE/EDGE VISUAL INSPECTION PASS

ROUNDNESS : 0.007mm TAPER:

DRAINHOLE PRESENT ? (YES/NO): No

COMMENTS: LIGHT DEPOSIT ON PLATE.

INSPECTED BY:  M Livingstone



NATIONAL GRID ORIFICE PLATE CALIBRATION

DATE: 18-DEC-2009

REF NO: OP90057

TEMPERATURE: 20.3 degsC

MEASURED ORIFICE BORE: 138.77mm

PLATE DETAILS

PLATE SERIAL: 6098 PLATE O.D: 214.110mm  
 MANUFACTURER: PIPE I.D: 202.7269mm SITE: ROUDHAM HEATH  
 MATERIAL CERT.No: DESIGN BORE: mm FLOW: M<sup>3</sup>/DAY

TEST EQUIPMENT

MANUFACTURER & TYPE: KEMCO 700 MANUAL 3-DIMENSIONAL MEASURING MACHINE ASSET NO OP-A02  
 CALIBRATED BY: QUALITY CONTROL TECHNOLOGY, UKAS TRACEABLE CERT:- 7325. NEXT CAL DUE:- 02-OCTOBER-2010

UPSTREAM FACE INSPECTION RESULTS (ISO 5167)

STATIONS:-	1	2	3	4	5			
FLATNESS %	0.031	0.135	0.035	0.084	0.131	0.133	0.081	0.173
'E' mm	3.116	3.181	3.174	3.135	3.113	3.119	3.163	
'e'								
EDGE SHARPNESS mm	0.0125	SQUARE	SQUARE	SQUARE	SQUARE	0.0125	SQUARE	SQUARE
BEVEL ANGLE:	DEGS							
CONCENTRICITY	0.099mm							
SURFACE FINISH (Ra)	0.85 microns							

DOWNSTREAM FACE/EDGE VISUAL INSPECTION :- PASS

ROUNDNESS : 0.021mm TAPER: 0 degs

DRAINHOLE PRESENT ? (YES/NO): No

COMMENTS: CLEAN PLATE

INSPECTED BY:  M Livingstone

## APPENDIX B CORRECTED DAILY VOLUME FLOWS

TABLE B.1

### FLOWS AT ROUDHAM HEATH DURING THE PERIOD OF THE MIS-MEASUREMENT

	Original Values (total)	Corrected values (total)	% increase
Date	Volume (mscm)	Volume (mscm)	Volume (mscm)
23-Jul-07	0.71440	<b>0.71561</b>	0.1697
24-Jul-07	0.68890	<b>0.69040</b>	0.2177
25-Jul-07	0.69720	<b>0.69872</b>	0.2177
26-Jul-07	0.71530	<b>0.71686</b>	0.2177
27-Jul-07	0.69850	<b>0.70002</b>	0.2177
28-Jul-07	0.66340	<b>0.66484</b>	0.2177
29-Jul-07	0.67120	<b>0.67266</b>	0.2177
30-Jul-07	0.72100	<b>0.72257</b>	0.2177
31-Jul-07	0.73130	<b>0.73289</b>	0.2177
01-Aug-07	0.71890	<b>0.72047</b>	0.2177
02-Aug-07	0.71640	<b>0.71796</b>	0.2177
03-Aug-07	0.70300	<b>0.70453</b>	0.2177
04-Aug-07	0.67040	<b>0.67186</b>	0.2177
05-Aug-07	0.65810	<b>0.65953</b>	0.2177
06-Aug-07	0.71020	<b>0.71175</b>	0.2177
07-Aug-07	0.72590	<b>0.72748</b>	0.2177
08-Aug-07	0.74120	<b>0.74281</b>	0.2177
09-Aug-07	0.76060	<b>0.76226</b>	0.2177
10-Aug-07	0.74870	<b>0.75033</b>	0.2177
11-Aug-07	0.71220	<b>0.71375</b>	0.2177
12-Aug-07	0.71660	<b>0.71816</b>	0.2177
13-Aug-07	0.76560	<b>0.76727</b>	0.2177
14-Aug-07	0.76340	<b>0.76506</b>	0.2177
15-Aug-07	0.75840	<b>0.76005</b>	0.2177
16-Aug-07	0.72620	<b>0.72778</b>	0.2177
17-Aug-07	0.51940	<b>0.52053</b>	0.2177
18-Aug-07	0.33210	<b>0.33282</b>	0.2177
19-Aug-07	0.34210	<b>0.34284</b>	0.2177
20-Aug-07	0.41880	<b>0.41971</b>	0.2177
21-Aug-07	0.40820	<b>0.40909</b>	0.2177
22-Aug-07	0.46000	<b>0.46100</b>	0.2177
23-Aug-07	0.54590	<b>0.54709</b>	0.2177
24-Aug-07	0.50740	<b>0.50850</b>	0.2177
25-Aug-07	0.56180	<b>0.56302</b>	0.2177
26-Aug-07	0.70940	<b>0.71094</b>	0.2177
27-Aug-07	0.66240	<b>0.66384</b>	0.2177
28-Aug-07	0.67810	<b>0.67958</b>	0.2177
29-Aug-07	0.77550	<b>0.77719</b>	0.2177
30-Aug-07	0.75850	<b>0.76015</b>	0.2177

31-Aug-07	0.78600	<b>0.78771</b>	0.2177
01-Sep-07	0.63650	<b>0.63789</b>	0.2177
02-Sep-07	0.60260	<b>0.60391</b>	0.2177
03-Sep-07	0.69030	<b>0.69180</b>	0.2177
04-Sep-07	0.78100	<b>0.78270</b>	0.2177
05-Sep-07	0.78200	<b>0.78370</b>	0.2177
06-Sep-07	0.78700	<b>0.78871</b>	0.2177
07-Sep-07	0.78740	<b>0.78911</b>	0.2177
08-Sep-07	0.74970	<b>0.75133</b>	0.2177
09-Sep-07	0.75030	<b>0.75193</b>	0.2177
10-Sep-07	0.79720	<b>0.79894</b>	0.2177
11-Sep-07	0.89250	<b>0.89444</b>	0.2177
12-Sep-07	0.87760	<b>0.87951</b>	0.2177
13-Sep-07	0.86560	<b>0.86748</b>	0.2177
14-Sep-07	0.91560	<b>0.91759</b>	0.2177
15-Sep-07	0.91150	<b>0.91348</b>	0.2177
16-Sep-07	0.93130	<b>0.93333</b>	0.2177
17-Sep-07	0.99260	<b>0.99476</b>	0.2177
18-Sep-07	1.09420	<b>1.09658</b>	0.2177
19-Sep-07	1.34000	<b>1.34292</b>	0.2177
20-Sep-07	1.35290	<b>1.35585</b>	0.2177
21-Sep-07	1.33540	<b>1.33831</b>	0.2177
22-Sep-07	1.31770	<b>1.32057</b>	0.2177
23-Sep-07	1.30000	<b>1.30283</b>	0.2177
24-Sep-07	1.38320	<b>1.38621</b>	0.2177
25-Sep-07	1.42340	<b>1.42650</b>	0.2177
26-Sep-07	1.42080	<b>1.42389</b>	0.2177
27-Sep-07	1.41980	<b>1.42289</b>	0.2177
28-Sep-07	1.39740	<b>1.40044</b>	0.2177
29-Sep-07	1.29050	<b>1.29331</b>	0.2177
30-Sep-07	1.32320	<b>1.32608</b>	0.2177
01-Oct-07	1.37820	<b>1.38120</b>	0.2177
02-Oct-07	1.36500	<b>1.36797</b>	0.2177
03-Oct-07	1.37300	<b>1.37599</b>	0.2177
04-Oct-07	1.35100	<b>1.35394</b>	0.2177
05-Oct-07	1.42110	<b>1.42419</b>	0.2177
06-Oct-07	1.36539	<b>1.36836</b>	0.2177
07-Oct-07	1.37930	<b>1.38230</b>	0.2177
08-Oct-07	1.41670	<b>1.41978</b>	0.2177
09-Oct-07	1.52760	<b>1.53093</b>	0.2177
10-Oct-07	1.43470	<b>1.43782</b>	0.2177
11-Oct-07	1.49010	<b>1.49334</b>	0.2177
12-Oct-07	1.39660	<b>1.39964</b>	0.2177
13-Oct-07	1.36170	<b>1.36466</b>	0.2177
14-Oct-07	1.38080	<b>1.38381</b>	0.2177
15-Oct-07	1.43600	<b>1.43913</b>	0.2177
16-Oct-07	1.40390	<b>1.40696</b>	0.2177
17-Oct-07	1.45970	<b>1.46288</b>	0.2177

18-Oct-07	1.52610	<b>1.52942</b>	0.2177
19-Oct-07	1.48840	<b>1.49164</b>	0.2177
20-Oct-07	1.49150	<b>1.49475</b>	0.2177
21-Oct-07	1.46970	<b>1.47290</b>	0.2177
22-Oct-07	1.61620	<b>1.61972</b>	0.2177
23-Oct-07	1.56510	<b>1.56851</b>	0.2177
24-Oct-07	1.55680	<b>1.56019</b>	0.2177
25-Oct-07	1.52230	<b>1.52561</b>	0.2177
26-Oct-07	1.50070	<b>1.50397</b>	0.2177
27-Oct-07	1.51630	<b>1.51960</b>	0.2177
28-Oct-07	1.41090	<b>1.41397</b>	0.2177
29-Oct-07	1.51920	<b>1.52251</b>	0.2177
30-Oct-07	1.61650	<b>1.62002</b>	0.2177
31-Oct-07	1.53300	<b>1.53634</b>	0.2177
01-Nov-07	1.51410	<b>1.51740</b>	0.2177
02-Nov-07	1.45540	<b>1.45857</b>	0.2177
03-Nov-07	1.40420	<b>1.40726</b>	0.2177
04-Nov-07	1.52030	<b>1.52361</b>	0.2177
05-Nov-07	1.63280	<b>1.63635</b>	0.2177
06-Nov-07	1.63660	<b>1.64016</b>	0.2177
07-Nov-07	1.58520	<b>1.58865</b>	0.2177
08-Nov-07	1.41100	<b>1.41407</b>	0.2177
09-Nov-07	1.49700	<b>1.50026</b>	0.2177
10-Nov-07	1.32430	<b>1.32718</b>	0.2177
11-Nov-07	1.36920	<b>1.37218</b>	0.2177
12-Nov-07	1.53500	<b>1.53834</b>	0.2177
13-Nov-07	1.53440	<b>1.53774</b>	0.2177
14-Nov-07	1.51770	<b>1.52100</b>	0.2177
15-Nov-07	1.58020	<b>1.58364</b>	0.2177
16-Nov-07	1.57550	<b>1.57893</b>	0.2177
17-Nov-07	1.53080	<b>1.53413</b>	0.2177
18-Nov-07	1.47840	<b>1.48162</b>	0.2177
19-Nov-07	1.50410	<b>1.50737</b>	0.2177
20-Nov-07	1.62760	<b>1.63114</b>	0.2177
21-Nov-07	1.60200	<b>1.60549</b>	0.2177
22-Nov-07	1.64510	<b>1.64868</b>	0.2177
23-Nov-07	1.77530	<b>1.77916</b>	0.2177
24-Nov-07	1.79890	<b>1.80282</b>	0.2177
25-Nov-07	1.70130	<b>1.70500</b>	0.2177
26-Nov-07	1.84670	<b>1.85072</b>	0.2177
27-Nov-07	1.77420	<b>1.77806</b>	0.2177
28-Nov-07	1.69030	<b>1.69398</b>	0.2177
29-Nov-07	1.66560	<b>1.66923</b>	0.2177
30-Nov-07	1.61650	<b>1.62002</b>	0.2177
01-Dec-07	1.62490	<b>1.62844</b>	0.2177
02-Dec-07	1.63820	<b>1.64177</b>	0.2177
03-Dec-07	1.75540	<b>1.75922</b>	0.2177
04-Dec-07	1.63040	<b>1.63395</b>	0.2177

05-Dec-07	1.56400	<b>1.56740</b>	0.2177
06-Dec-07	1.55740	<b>1.56079</b>	0.2177
07-Dec-07	1.65140	<b>1.65500</b>	0.2177
08-Dec-07	1.65330	<b>1.65690</b>	0.2177
09-Dec-07	1.64990	<b>1.65349</b>	0.2177
10-Dec-07	1.77499	<b>1.77885</b>	0.2177
11-Dec-07	1.83041	<b>1.83439</b>	0.2177
12-Dec-07	1.89919	<b>1.90332</b>	0.2177
13-Dec-07	1.90900	<b>1.91316</b>	0.2177
14-Dec-07	1.86170	<b>1.86575</b>	0.2177
15-Dec-07	1.85090	<b>1.85493</b>	0.2177
16-Dec-07	1.87120	<b>1.87527</b>	0.2177
17-Dec-07	1.90660	<b>1.91075</b>	0.2177
18-Dec-07	1.87540	<b>1.87948</b>	0.2177
19-Dec-07	1.86670	<b>1.87076</b>	0.2177
20-Dec-07	1.90340	<b>1.90754</b>	0.2177
21-Dec-07	1.89629	<b>1.90042</b>	0.2177
22-Dec-07	1.78410	<b>1.78798</b>	0.2177
23-Dec-07	1.76680	<b>1.77065</b>	0.2177
24-Dec-07	1.65170	<b>1.65530</b>	0.2177
25-Dec-07	1.64560	<b>1.64918</b>	0.2177
26-Dec-07	1.67810	<b>1.68175</b>	0.2177
27-Dec-07	1.61990	<b>1.62343</b>	0.2177
28-Dec-07	1.62210	<b>1.62563</b>	0.2177
29-Dec-07	1.65701	<b>1.66062</b>	0.2177
30-Dec-07	1.67360	<b>1.67724</b>	0.2177
31-Dec-07	1.67210	<b>1.67574</b>	0.2177
01-Jan-08	1.65880	<b>1.66241</b>	0.2177
02-Jan-08	1.80440	<b>1.80833</b>	0.2177
03-Jan-08	1.90830	<b>1.91245</b>	0.2177
04-Jan-08	1.80020	<b>1.80412</b>	0.2177
05-Jan-08	1.69330	<b>1.69699</b>	0.2177
06-Jan-08	1.59910	<b>1.60258</b>	0.2177
07-Jan-08	1.76050	<b>1.76433</b>	0.2177
08-Jan-08	1.75260	<b>1.75642</b>	0.2177
09-Jan-08	1.74460	<b>1.74840</b>	0.2177
10-Jan-08	1.68330	<b>1.68696</b>	0.2177
11-Jan-08	1.70010	<b>1.70380</b>	0.2177
12-Jan-08	1.75180	<b>1.75561</b>	0.2177
13-Jan-08	1.69400	<b>1.69769</b>	0.2177
14-Jan-08	1.74170	<b>1.74549</b>	0.2177
15-Jan-08	1.71170	<b>1.71543</b>	0.2177
16-Jan-08	1.70350	<b>1.70721</b>	0.2177
17-Jan-08	1.75270	<b>1.75652</b>	0.2177
18-Jan-08	1.66560	<b>1.66923</b>	0.2177
19-Jan-08	1.58570	<b>1.58915</b>	0.2177
20-Jan-08	1.53830	<b>1.54165</b>	0.2177
21-Jan-08	1.68900	<b>1.69268</b>	0.2177

22-Jan-08	1.76450	<b>1.76834</b>	0.2177
23-Jan-08	1.65030	<b>1.65389</b>	0.2177
24-Jan-08	1.70270	<b>1.70641</b>	0.2177
25-Jan-08	1.74890	<b>1.75271</b>	0.2177
26-Jan-08	1.68020	<b>1.68386</b>	0.2177
27-Jan-08	1.67800	<b>1.68165</b>	0.2177
28-Jan-08	1.77180	<b>1.77566</b>	0.2177
29-Jan-08	1.73420	<b>1.73798</b>	0.2177
30-Jan-08	1.81300	<b>1.81695</b>	0.2177
31-Jan-08	1.84890	<b>1.85293</b>	0.2177
01-Feb-08	1.75330	<b>1.75712</b>	0.2177
02-Feb-08	1.62500	<b>1.62854</b>	0.2177
03-Feb-08	1.54320	<b>1.54656</b>	0.2177
04-Feb-08	1.32280	<b>1.32568</b>	0.2177
05-Feb-08	1.23230	<b>1.23498</b>	0.2177
06-Feb-08	1.25491	<b>1.25764</b>	0.2177
07-Feb-08	1.25200	<b>1.25473</b>	0.2177
08-Feb-08	1.22310	<b>1.22576</b>	0.2177
09-Feb-08	1.18600	<b>1.18858</b>	0.2177
10-Feb-08	1.20831	<b>1.21094</b>	0.2177
11-Feb-08	1.25630	<b>1.25903</b>	0.2177
12-Feb-08	1.34230	<b>1.34522</b>	0.2177
13-Feb-08	1.36350	<b>1.36647</b>	0.2177
14-Feb-08	1.36480	<b>1.36777</b>	0.2177
15-Feb-08	1.33800	<b>1.34091</b>	0.2177
16-Feb-08	1.32890	<b>1.33179</b>	0.2177
17-Feb-08	1.36290	<b>1.36587</b>	0.2177
18-Feb-08	1.42460	<b>1.42770</b>	0.2177
19-Feb-08	1.43040	<b>1.43351</b>	0.2177
20-Feb-08	1.39830	<b>1.40134</b>	0.2177
21-Feb-08	1.30210	<b>1.30493</b>	0.2177
22-Feb-08	1.21960	<b>1.22226</b>	0.2177
23-Feb-08	1.16070	<b>1.16323</b>	0.2177
24-Feb-08	1.15100	<b>1.15351</b>	0.2177
25-Feb-08	1.22230	<b>1.22496</b>	0.2177
26-Feb-08	1.18120	<b>1.18377</b>	0.2177
27-Feb-08	1.21410	<b>1.21674</b>	0.2177
28-Feb-08	1.07350	<b>1.07584</b>	0.2177
29-Feb-08	1.00800	<b>1.01019</b>	0.2177
01-Mar-08	0.87140	<b>0.87330</b>	0.2177
02-Mar-08	0.86600	<b>0.86789</b>	0.2177
03-Mar-08	1.00000	<b>1.00218</b>	0.2177
04-Mar-08	1.07480	<b>1.07714</b>	0.2177
05-Mar-08	1.01620	<b>1.01841</b>	0.2177
06-Mar-08	0.92290	<b>0.92491</b>	0.2177
07-Mar-08	0.91670	<b>0.91870</b>	0.2177
08-Mar-08	0.90690	<b>0.90887</b>	0.2177
09-Mar-08	0.90280	<b>0.90477</b>	0.2177

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10-Mar-08	0.99570	<b>0.99787</b>	0.2177
11-Mar-08	0.98010	<b>0.98223</b>	0.2177
12-Mar-08	1.00900	<b>1.01120</b>	0.2177
13-Mar-08	1.00320	<b>1.00538</b>	0.2177
14-Mar-08	0.86230	<b>0.86418</b>	0.2177
15-Mar-08	0.82310	<b>0.82489</b>	0.2177
16-Mar-08	0.93280	<b>0.93483</b>	0.2177
17-Mar-08	1.06910	<b>1.07143</b>	0.2177
18-Mar-08	1.06090	<b>1.06321</b>	0.2177
19-Mar-08	1.08460	<b>1.08696</b>	0.2177
20-Mar-08	1.03350	<b>1.03575</b>	0.2177
21-Mar-08	1.00890	<b>1.01110</b>	0.2177
22-Mar-08	1.03370	<b>1.03595</b>	0.2177
23-Mar-08	1.05300	<b>1.05529</b>	0.2177
24-Mar-08	1.05230	<b>1.05459</b>	0.2177
25-Mar-08	1.25290	<b>1.25563</b>	0.2177
26-Mar-08	1.29520	<b>1.29802</b>	0.2177
27-Mar-08	1.19080	<b>1.19133</b>	0.0449