



**METRO NORTH
ORAL HEARING**

**Stage 1 Preliminary Ground
Movement Assessment Report
Rev 3_Part4**

1. Of the 393nr. buildings that have been subjected to a Characterisation Survey, 78nr. have a BRE Digest 251 damage classification of 3 or more, 59nr of which are located within the predicted zone of influence and will be taken forward to Stage 2A.
2. 199nr buildings / structures identified for further assessment are protected/listed.
3. 47nr. buildings / structures identified for further assessment are considered to be sensitive to ground movements.

In total 435nr buildings have been identified for further assessment in Stage 2A. This number includes:

- 291nr buildings subject to greater than 10mm ground movement or a ground slope greater than 1/500.
- 123nr buildings subject to less than 10mm movement but have been identified as protected structures or sensitive structures in accordance with points 2 and 3 above.
- 18nr buildings subject to less than 10mm movement, but with a BRE Digest 251 damage classification of 3 or more among the buildings identified by the Characterisation Surveys (see point 1 above).
- 1nr Multi-storey Car Park and Hotel complex at Dublin Airport that does not fulfil the requirements to progress to Stage 2A, however these structures will be subject to further assessment at the requested of DAA..
- 2nr piled buildings, which are non protected, non sensitive structures located along Westmoorland Street and are not subject to ground movements greater than 10mm. It is recommended that these buildings progress to Stage 2A due to their locality in relation to the bored running tunnelling.

It should be noted that due to the extended period of public consultation for the section of the alignment between DCU Stop and Drumcondra Stop, some buildings along this section have not been subjected to sample Characterisation Surveys.

8.3 Recommendations

It is recommended that further assessment of buildings and structures identified in Appendix E are undertaken in the Stage 2A analysis to determine their response to predicted ground movements. This study will comprise assessing structures identified during Stage 1 against specific criteria appropriate for the type of structure being considered and comparing the findings against acceptable values. Where appropriate, consideration will be given to mitigation measures to ensure ground movements are within acceptable limits and damage is limited to category 2 or less in accordance with BRE Digest 251.

9. Utilities to be Assessed in Stage 2A

9.1 General

There are numerous underground utilities located along the proposed Dublin Metro North alignment. These include gas mains, water mains, sewers, drains, power cables and telecommunication ducts. These utilities are likely to be in various states of condition and will have a range of different acceptable tolerances to settlement, differential settlements and strains.

9.2 Assessment Criteria & Assumptions

The Assessment Criteria for identifying utilities and services for inclusion in the Stage 2A assessment is based on the findings of Attewell et al (1986) that states that the risk of damage to brittle and ductile pipelines is negligible provided that maximum ground movements are kept below 10mm and 50mm respectively.

9.3 Utilities Identified for Further Assessment

The locations and details of existing utilities along the proposed tunnels have been obtained by the RPA Utility Team from various utility undertakers. Based on this information 2,925nr. utilities have been identified within the zone of influence. However, the schedules do not include:

- Chainage 13+260m – 15+745m (South of DCU Stop to south of Drumcondra Stop). These utilities have been omitted from this report due to an extended period of public consultation for this section of the alignment. Identification and assessment of utilities between DCU Stop and Drumcondra Stop will therefore need to be undertaken by the DBFM Contractor.

Due to continued design development the utilities schedule presented in Appendix F relate to previous ground movement predictions for the following sections of the alignment.

- Chainage 16+660m – 17+530m (South of Mater Stop to North of O'Connell Bridge Stop)
- Chainage 17+630m – 17+770m (North of O'Connell Bridge Stop)
- Chainage 17+770m – 18+060m (O'Connell Bridge Stop)
- Chainage 18+680m – South end of the alignment (St Stephen's Green Stop, Interconnector Eastbound Tunnel/DMN running tunnels crossing, and Loop arrangement)

Due to insufficient information pertaining to clarity of utility construction it has not been possible to accurately categorise utilities according to the ground movement limiting criteria described by Section 9.2 above. Based on the settlement contour drawings contained in Appendix D a schedule of all utilities that are subjected to 10mm or greater ground movement has been prepared and is contained in Appendix F of this report.

Of the 2,925nr utilities identified, a total of 463nr utilities have been identified as being subjected to 10mm or greater ground movement.

9.4 Recommendations

On the basis of this ground movement assessment report it is recommended that the RPA Utility Team provide the settlement contour drawings to the utility owners/authorities who can then review the settlement contour drawings and determine whether their particular utilities are at risk of being damaged.

However the assessment criteria will need to be made clear to the utility owners and approval or clarification of the assumptions obtained. Furthermore it should be noted:

- that the settlement assessment has been conducted on the basis of predicting ground movements at surface, the implication being that ground movements will be underestimated for any utility that is founded at depth below the surface.
- the settlement drawings only indicate the slope of the transverse settlement trough. For utilities parallel or skewed to the line of the tunnel/works, account will need to be taken of the 'bow wave' affect ahead of the TBM that will induce strains in the utility apparatus.

10. Infrastructure to be Assessed in Stage 2A

10.1 Assessment Criteria

Assessment and identification of infrastructure at risk of damage from underground excavation is subject to performance and operation requirements. No limiting criteria in terms of acceptable ground movements to date has been provided by infrastructure owners/authorities (with the exception of Iarnród Éireann who have provided limiting track geometry criteria), and therefore all infrastructure falling within the 2mm settlement contour line has been identified for further assessment at Stage 2A. This adopted assessment criteria is considered prudent during this stage.

In addition Jacobs provided Dublin Airport Authority via RPA with a schedule of assets they considered should be assessed within the Airport lands. The purpose of this exercise was to:

- identify whether Jacobs had omitted any assets that should be considered by the Stage 1 and 2A Assessments based on DAA's intimate understanding of their own assets and
- to request further asset information on individual elements of Airport infrastructure to enable the Stage 2A Assessment to be progressed.

DAA responded by providing an additional column (DAA Comments) to this schedule stating information had been previously provided, whether further information would be made available or that an assessment of the impact of ground movements was not required. This schedule has been used as the basis for deciding which airport property and infrastructure should be considered by the Stage 2A Assessment. The schedule is appended to this Section 10.

A total of 138nr items of infrastructure have been identified and scheduled to be taken forward to the Stage 2A study, and are presented in Appendix G.

10.2 Recommendations

It is recommended:

- Further liaisons continue to be conducted between Jacobs, the RPA and infrastructure owners to establish whether they are in possession of information regarding structural details, and whether they have any particular limiting criteria in terms of ground movements.
- Specific assessment criteria in terms of acceptable ground movements specified by the owners or authorities be established as part of the Stage 2A Assessment. Where criteria are specified, or agreed with owners, these will need to be set down under the Third Party Requirements section of the Output Specification.

Infrastructure that is identified in this Stage 1 assessment is considered in greater detail during the Stage 2A assessment. This assessment will comprise assessing the infrastructure identified in Stage 1 against specific criteria appropriate for the type of infrastructure being considered and compared against acceptable values. Appropriate consideration will be given to mitigation measures to ensure ground movements are maintained within acceptable limits.

Schedule of Airport Infrastructure/Property within DMN Settlement Zone of Influence

1. Airport Buildings & Structures identified within Zone of Influence

Item	Name	Approx Tunnel Chainage		Max Settlement	Structure Information Available	Further Assessment Required	DAA Comments
		Start	End				
1	Official Halting Site	6780m	6820m	8mm	No	No	NOT REQUIRED
2	Hanger 5	7390m	7490m	11mm	No	Yes	SENT 13/02/08
3	Engine Test Cell	7460m	7480m	10mm	No	Yes	NO INFO
4	Block A MSCP	7780m	7840m	2mm	Yes	No	SENT 13/12/07
5	OLD WENDY HOUSE	7880m	7970m	4mm	No	No	BLD DEM
6	OLD WENDY HOUSE	7880m	7970m	4mm	No	No	BLD DEM
7	OLD WENDY HOUSE	7880m	7970m	4mm	No	No	BLD DEM
8	Terminal Building Pier C	7950m	7970m	10mm	Yes	Yes	SENT 13/12/07
8b	ENERGY CENTRE	7880m	7900m	2mm	No	No	SENT 13/02/08

2. Airport Infrastructure identified within Zone of Influence

Item	Name	Approx Tunnel Chainage		Max Settlement	Infrastructure Information Available	Further Assessment Required	DAA Comments
		Start	End				
9	Access Road	6980m	7080m	3mm	No	No	NOT REQUIRED
10	Access Road	7120m	7250m	3mm	No	No	NOT REQUIRED
11	Possible Tanks	7400m	7440m	11mm	No	Yes	NOT REQUIRED
12	Fuel Pipeline	TBC	TBC	TBC	No	Yes	NOT REQUIRED
13	Road	7490m	7500m	11mm	No	Yes	NOT REQUIRED
14	Swords Road	7530m	7550m	15mm	No	Yes	NOT REQUIRED
15	Airport Car Park	7550m	7670m	15mm	No	Yes	NOT REQUIRED
16	Car Park Ticket Booths	7760m	7830m	3mm	No	No	NOT REQUIRED
17	Swords Road	7840m	7890m	3mm	No	No	NOT REQUIRED
18	Airport Terminal Access Ramp	7860m	7900m	3mm	No	No	NOT REQUIRED
19	South Apron	7970m	8380m	13mm	Yes – Require Apron Drainage drawings	Yes	NOT REQUIRED
19b	Existing Fuel Hydrants and pit locations	7970m	8380m	13mm	Yes	Yes	SENT 12/05/08
20	Taxiway TWY B1	8450m	8485m	10mm	No	Yes	NOT REQUIRED
20a	Localiser 10 Near Field Monitor	8640m	8650m	<2mm	Yes	Yes	SENT 13/12/07, 13/02/08 & 13/05/08

21	ILS Structure (LLZRKY16) Including: <ul style="list-style-type: none"> Localiser 16 Shelter Localiser 16 Antenna Array Localiser 16 Near Field Monitor 	8880m	8900m	10mm	Yes	Yes	SENT 13/12/07, 13/02/08 & 05/06/08
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3. Future Developments Planned within Zone of Influence

Item	Name	Approx Tunnel Chainage		Max Settlement	Structure Information Available	Further Assessment Required	DAA Comments
		Start	End				
22	Terminal 2	7840m	7950m	6mm	Yes	No	SENT 13/12/07
23	Baggage Handling Building (including Holed Baggage Screening (HBS) machines and baggage conveyors and escalators)	7920m	7940m	10mm	Yes	Yes	SENT 13/12/07
24	Pier C	7970m	8380m	13mm	No	Yes	SENT 13/12/07
25	Pier E	TBC	TBC	-	No	-	SENT 13/12/07
26	Proposed northern runway	TBC	TBC	-	No	-	NOT REQUIRED

11. Conclusions and Recommendations

11.1 Conclusions

Greenfield ground surface movements due to the proposed works have been predicted along the alignment. The 'Greenfield Conditions' ignore the advantageous affects of soil-structure interaction. The predictions are based on the planned construction methods and sequence. Where appropriate the effects of long-term settlement due to groundwater drawdown have also been considered and incorporated.

Values of the predicted settlement are presented as contours on the Metro North topographical survey background mapping, and O.S background maps where the topographical survey does not provide adequate coverage. These drawings illustrate the combined effects of construction activities.

For Stage 1 building assessments, buildings with a predicted settlement of 10mm or 1:500 slope have been identified for further assessment at Stage 2A. In addition, sensitive structures have been identified for further assessment including buildings of historical importance, poor condition, housing sensitive equipment, etc. A number of buildings have had a Characterisation Survey undertaken and some of these have existing defects and damage. These have also been taken forward to the Stage 2A assessment.

Due to limited information on utility construction it has not yet been possible to categorise utilities according to the assessment criteria. However, based on the settlement contour drawings contained within this report a schedule of all utilities subjected to 10mm or greater ground movement has been prepared and included with the exception of utilities lying along the alignment between DCU Stop and Drumcondra Stop due to an extended period of public consultation delaying the finalisation of the alignment.

A schedule of infrastructure falling within the 2mm settlement contour line has also been prepared and included. Table 11-1 summarises the number of items that have been identified for taking forward to the Stage 2A assessment.

Items	Number to Progress to Stage 2A
Buildings & Structures	435
Utilities & Services	463*
Infrastructure Items	138

* Excludes

- Alignment Sections assessed during Stage 1 Preliminary Ground Movement Assessment Revision 1, Revision 2 and Revision 3

Table 11-1: Summary of Existing Buildings, Utilities and Infrastructure to Progress to Stage 2A

The alignment of Dublin Metro North has been selected, so far as reasonably practical, to minimise the impact of construction generated ground movements on overlying and adjacent property.

11.2 Recommendations

11.2.1 Buildings

It is recommended that buildings identified for further assessment be assessed during the Stage 2A phase of the study.

11.2.2 Utilities

It is recommended that the RPA Utility Team provide the settlement contour drawings contained in this report to the utility owners/authorities who should then assess the impact of the predicted ground movements and determine whether their utilities are at risk of being damaged.

During the consultation phase the existing construction and condition of utilities will need to be obtained from the utility owner. Furthermore it should be communicated that the contour drawings provided only indicate the slope of the transverse settlement trough. For utilities parallel/skewed to the line of the tunnel/works, account will need to be taken of the 'bow wave' affect ahead of the TBM that will induce strains in the utility apparatus.

Following consultation with the appropriate utilities owners it is recommended that condition surveys of utilities identified for further assessment be conducted as part of Stage 2B and 3 Assessment stages.

11.2.3 Infrastructure

It is recommended that liaison continues between Jacobs/RPA and infrastructure owners to establish details and drawings showing structural details, and whether they have any limiting criteria in terms of ground movements for the infrastructure concerned.

It is recommended that the assessment criteria be confirmed and agreed with the infrastructure owners during Stage 2A.

11.3 Summary of Outstanding Actions

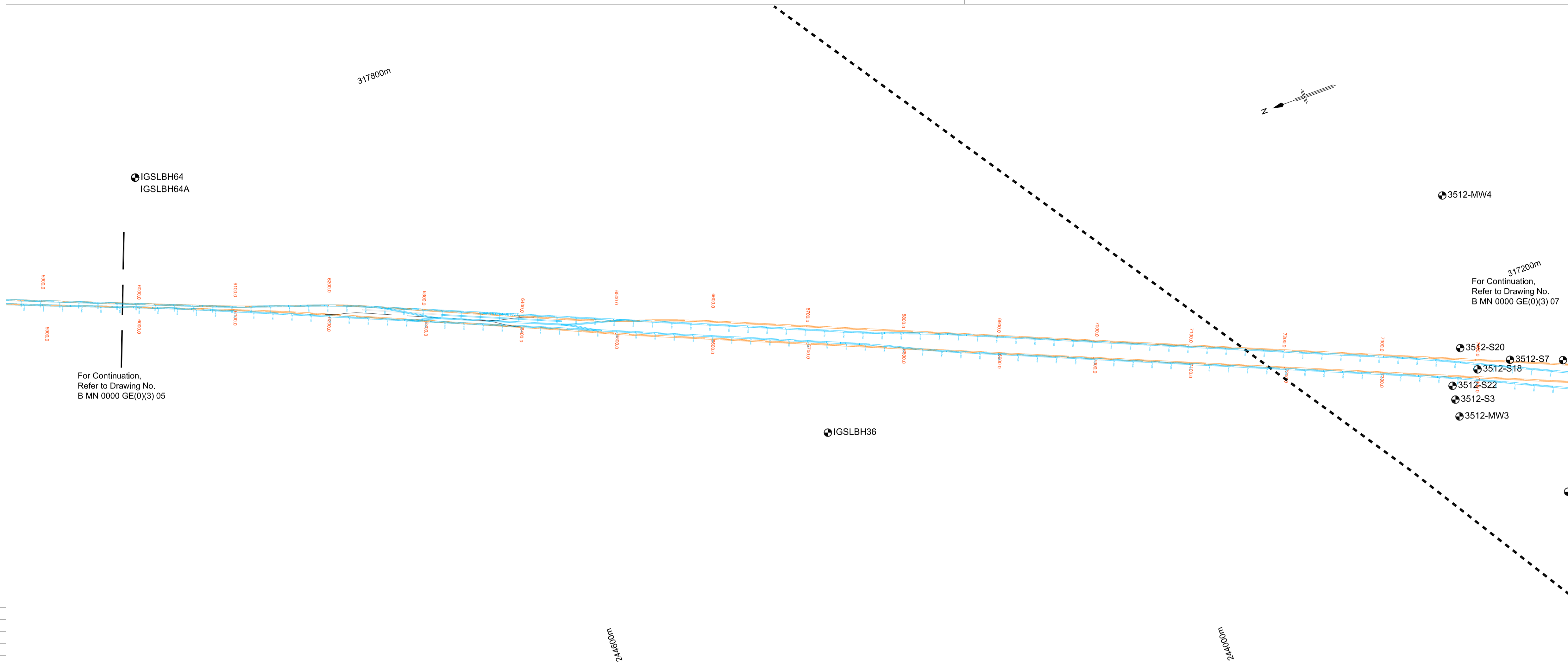
- Complete the Stage 2A Assessment.
- Confirm and agree settlement assessment criteria with infrastructure and utility owners.

Appendix A Inferred Geological Long Sections

Included within this Appendix are the following inferred geological long section drawings:

Refer to Section 2.3, regarding chainages presented within this Stage 1 Preliminary Ground Movement Report.

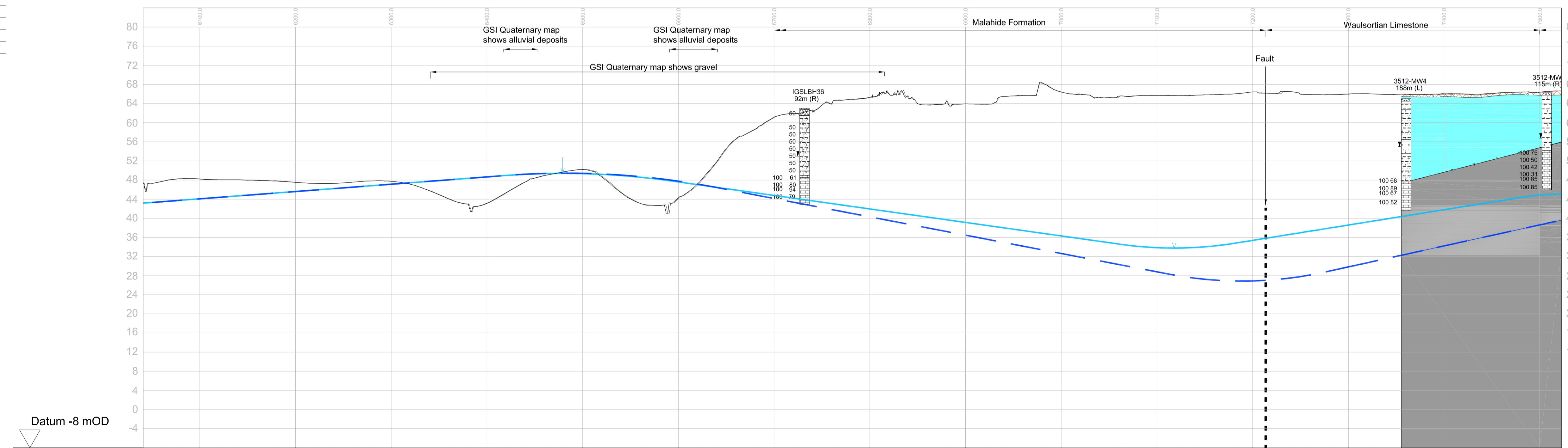
DRAWINGS Reference table				
	Element	Number	Rev	Name
BMN0000	GE(0)(3)	006	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 6 of 14
BM0000	GE	227	A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 7 of 14
BMN0000	GE(0)(3)	007	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 7 of 14
BMN0000	GE(0)(3)	008	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 8 of 14
BMN0000	GE(0)(3)	009	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 9 of 14
BMN0000	GE(0)(3)	010	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 10 of 14
BMN0000	GE(0)(3)	011	A03	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 11 of 14
BMN0000	GE(0)(3)	012	A03	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 12 of 14
BM0000	GE	233	A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 13 of 14
BMN0000	GE(0)(3)	013	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 13 of 14
BM0000	GE	234	A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 14 of 14
BMN0000	GE(0)(3)	014	A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 14 of 14



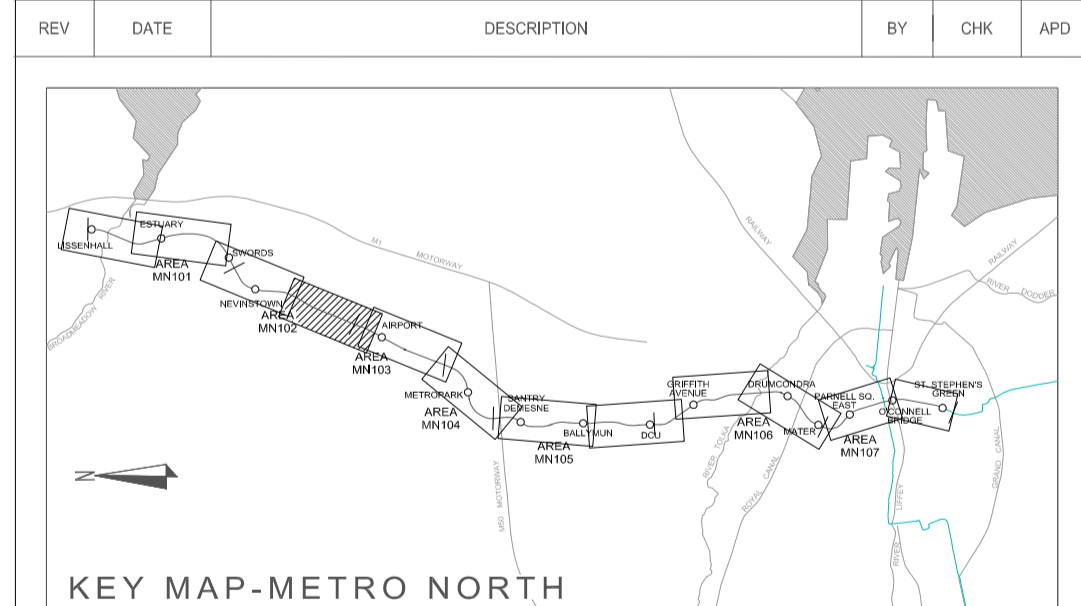
- Geological Legend**
- Made Ground
 - Alluvial Deposits
 - Glacial Till
 - Glacial Sands and Gravels
 - Weathered Bedrock
 - Bedrock
- Borehole Legend**
- Wimtech BH36 (1999)
 - IGSL BH1 - IGSL (2006)
 - 2543/BH1 - GSI Borehole Data
 - GBH1 - Geotech (2006)
 - LuBH - Luas BH (2002)

- Recorded water level in open borehole or standpipe.
- Groundwater level rose to in 20 min. in open borehole.
- Inferred anticline axis
- Inferred fault (tick indicates downthrow side)
- Inferred syncline axis
- Approximate location of fault shown on GSI Geology of Meath Map (Sheet 13)
- GSI City Centre Rockhead Contours (mOD)
- Inferred geological boundary
- Railway alignment
- Existing ground level
- Location of railway stops

- Borehole Legend**
- Topsoll
 - Made Ground
 - Sand
 - Silt
 - Silty Sand
 - Gravel
 - Clay
 - Mudstone
 - Limestone
- SPT 'N' Value
- Rock Quality Designation
- Total Core Recovery
- NOTE: Composite soil types will be signified by combined symbols, for example



Draft



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Existing Ground Level	Proposed Rail Level	Chainage
47.654	41.449	6980.000
48.270	43.754	6986.000
48.187	44.000	6990.000
48.613	44.386	6995.000
48.912	44.671	6999.000
47.903	44.977	7003.000
47.733	45.263	7007.000
47.498	45.588	7011.000
47.300	45.924	7015.000
47.298	46.199	7019.000
47.552	46.505	7023.000
47.801	46.811	7027.000
47.756	47.116	7031.000
47.123	47.422	7035.000
45.806	47.728	7039.000
44.118	48.033	7043.000
43.001	48.339	7047.000
43.091	48.645	7051.000
45.201	48.950	7055.000
47.538	49.259	7059.000
48.922	49.570	7063.000
49.705	49.874	7067.000
50.927	50.160	7071.000
48.845	50.398	7075.000
45.489	50.639	7079.000
43.143	50.873	7083.000
42.704	51.209	7087.000
44.651	51.767	7091.000
46.929	52.148	7095.000
51.623	52.451	7099.000
56.447	52.694	7103.000
58.539	52.898	7107.000
61.633	53.131	7111.000
61.906	53.489	7115.000
62.636	53.899	7119.000
63.987	54.339	7123.000
64.462	54.809	7127.000
65.258	55.299	7131.000
66.104	55.839	7135.000
65.932	56.299	7139.000
63.732	56.899	7143.000
64.397	57.339	7147.000
63.895	57.899	7151.000
63.628	58.499	7155.000
65.496	59.039	7159.000
65.696	59.489	7163.000
68.345	59.849	7167.000
66.386	60.299	7171.000
65.976	60.899	7175.000
65.220	61.399	7179.000
65.294	61.899	7183.000
65.610	62.499	7187.000
65.677	62.899	7191.000
65.689	63.350	7195.000
65.746	63.843	7199.000
65.631	64.375	7203.000
65.598	64.899	7207.000
65.598	65.499	7211.000
65.395	66.099	7215.000
66.126	66.726	7219.000
66.482	67.325	7223.000
65.994	67.937	7227.000
65.833	68.487	7231.000
65.847	69.086	7235.000
66.690	69.705	7239.000
65.684	70.353	7243.000
65.697	70.941	7247.000
65.929	71.520	7251.000
65.840	72.109	7255.000
65.623	72.677	7259.000
66.302	73.256	7263.000
66.427	73.825	7267.000
66.500	74.414	7271.000
66.622	74.993	7275.000

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All Os data used for plans are printed under Ordnance Survey nps, O.S. 6417

CONTRACT NO: B030700 AREA: CHAINAGE: 6050 - 7500

LOCATION: Dublin Metro North

DRAWING TITLE: Exploratory Hole Location Plan and Inferred Geological Section Sheet 6 of 14

PREPARED: AIM DESIGNED BY: AH APPROVED BY:

CHECKED: CHECKED: AS BUILT BY:

DATE: August 07 SCALES: 1:2500H; 1:500V SHEET SIZE: A1

STAGE: B LINE: MN CONTRACT: 0000 ELEMENT: GE (0)(3) DRW NO: 006 DRW REV: A01

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