



**METRO NORTH
ORAL HEARING**

**Stage 1 Preliminary Ground
Movement Assessment Report
Rev 3_Part2**

Amendment Tracker – Revision 2 to Revision 3

Note that changes from the Revision 2 to Revision 3 are denoted throughout the report by a vertical marker line in the left margin. The main changes to the report are summarised below.

Section	Revision 2 to Revision 3 Amendment
General	Text revised and updated throughout report to include amendments relating to additional alignment sections. Refer to Table A – ‘Revision History’.
Section 1.2	Text reworded for clarity
Section 1.4	Table 1.3 – ‘Summary of Existing Buildings, Utilities and Infrastructure to Progress to Stage 2A updated for inclusion of the alignment sections identified in Table A –‘Revision History’.
Section 1.5	Text deleted: <ul style="list-style-type: none"> • It is recommended that the appointed DBFM Contractor confirm the location of the cross passage Nos. 314 and 315 and update the ground movement predictions accordingly. • It is recommended that the appointed DBFM Contractor confirm the location of the cross passage Nos. 314 and 315 and update the ground movement predictions accordingly.
Section 2.3	<ul style="list-style-type: none"> • Table 2.1 updated for alignment drawing used during this revision • Text reworded for clarity
Section 2.4	Text added to acknowledge that cross passage No. 316 slightly exceeds the 250m design separation.
Section 5.3	Text amended: <ul style="list-style-type: none"> • Chainage 16+660m – 17+530m (South of Mater Stop to North of 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) Text added: <ul style="list-style-type: none"> • Chainage 17+770m – 18+060m (O’Connell Bridge Stop) Text deleted: <ul style="list-style-type: none"> • Reference to cross passages No.314 and No.315 being incorrectly located removed.
Section 7.6	Table 7.4: Drawing references updated to reflect Revision 3 amendments identified in Table A –‘Revision History’
Section 8.2	Table 8.1. Summary of existing buildings with influence zone updated to reflect Revision 3 amendments identified in Table A – ‘Revision History’

Section	Revision 2 to Revision 3 Amendment
Section 9.3	<p>Text amended:</p> <ul style="list-style-type: none"> Chainage 16+660m – 17+530m (South of Mater Stop to North of 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) <p>Text added:</p> <ul style="list-style-type: none"> Chainage 17+770m – 18+060m (O’Connell Bridge Stop)
Section 10.2	<p>Airport Infrastructure Table 2 updated to include correct receipt of information dates for:</p> <ul style="list-style-type: none"> Existing Fuel Hydrants Localiser 10 ILS Structure (LLZRWY16) to reflect Revision 3 amendments identified in Table A –‘Revision History’
Section 11.1	<p>Table 11.1 ‘Number of structures, utilities and infrastructure to progress to Stage 2A updated to reflect Revision 3 amendments identified in Table A –‘Revision History’</p>
Section 11.3	<p>Text deleted:</p> <ul style="list-style-type: none"> It is recommended that the appointed DBFM Contractor confirm the location of the cross passage Nos. 314 and 315 and update the ground movement predictions accordingly. It is recommended that the appointed DBFM Contractor confirm the location of the cross passage Nos. 314 and 315 and update the ground movement predictions accordingly
Appendix B	<ul style="list-style-type: none"> Chainages updated for cross passages Nos. 314. 315 and 316.
Appendix C	<p>Validation data sheets amended for sections:</p> <ul style="list-style-type: none"> O’Connell Bridget Stop – Tunnels (Data Sheet No. 13) O’Connell Bridget Stop – Stop Boxes (Data Sheet No. 14)
Appendix D	<p>Predicted Settlement drawings revised to reflect Revision 3 amendments identified in Table A –‘Revision History’:</p> <ul style="list-style-type: none"> BMN0000TU7050B05 BMN0000TU7051B05.
Appendix E	<p>Building schedule revised for reflect Revision 3 amendments identified in Table A –‘Revision History’</p> <p>Settlement and Building Assessment Drawings revised:</p> <ul style="list-style-type: none"> BMN0000TU7065B04 BMN0000TU7066B04
Appendix G	<p>Infrastructure schedule revised to reflect Revision 3 amendments identified in Table A –‘Revision History’. Refer to Appendix G for schedule identifying inclusions and deletions.</p>

1. Executive Summary

1.1 Overview

This Ground Movement Assessment Report provides an assessment of surface settlements arising from construction of the proposed Dublin Metro North scheme. The predicted ground movements have been plotted as contours on Master Alignment issued on 14th May 2008 (Alignment drawings BMN0000ML00911B01). From the ground movement contour drawings, buildings, structures, utilities and infrastructure which may be adversely affected have been identified for further assessment during the Stage 2A Initial Response Assessment.

1.2 Chainage Discrepancy

This revision (Revision 3), of the Stage 1 Preliminary Ground Movement Assessment Report presents an assessment of the predicted ground movement attributed to construction of Dublin Metro North. The assessment is based on the alignment plan which is included as part of the Railway Order Application, as specified under Section 37 of the Transport (Railway Infrastructure) Act, 2001 (Annex 1). The issue of this report coincides with the preparation of proofs of evidence for the Oral Hearing. However, the following discrepancy concerning alignment chainages has been identified:

The ground movement drawings presented in these reports adopt the chainages set out in the Railway Order Drawings. However, **chainage references within the text of this report are not compatible with the associated ground movement drawings.** This discrepancy has resulted from ongoing design development and alignment revisions, which were implemented by RPA during the initial and subsequent ground movement assessment.

1.3 Settlement Predictions

The settlement predictions have been conducted assuming 'Greenfield Conditions' i.e. ignoring any advantageous affects of soil-structure interaction. Where appropriate the effects of long-term settlement have also been considered.

Values of predicted settlement are presented as contours on background mapping and are included in Appendix D of this report. Table 1-1 provides a summary of predicted maximum settlements calculated for sections of the Dublin Metro North Scheme.

Area	Chainage		Maximum Settlement
	From	To	
Malahide Underpass	3+750m	4+590m	5mm
Fosterstown Underpass	5+120m	5+940m	5mm
Dublin Airport	6+510m	9+220m	15mm
Northwood to South of Ballymun	10+760m	12+170m	5mm
South of Ballymun to South of DCU	12+170m	13+400m	5mm
South of DCU to South of Griffith Avenue	13+400m	14+600m	60mm
South of Griffith Avenue	14+600m	15+880m	40mm
South of Drumcondra to South of Mater	15+880m	16+630m	60mm
South of Mater to O'Connell Bridge	16+630m	17+840m	60mm
O'Connell Bridge to St Stephen's Green	17+840m	18+980m	40mm

Table 1-1: Maximum Settlement Assessment Summary

1.4 Results of Stage 1 Assessment

For this Stage 1 Assessment the following criteria have been applied to determine whether buildings, utilities, and infrastructure should be taken forward to the Stage 2A Initial Response Assessment.

Buildings

- Building or structures where the predicted settlement from tunnelling is greater than 10mm and the predicted ground slope is greater than 1/500.
- Buildings within the zone of influence known to contain sensitive equipment, or buildings which will incur particularly high repair costs.
- Prominent structures, buildings of significant historical or communal importance within the zone of influence.
- Structures within the zone of influence identified by the Building Characterisation Surveys as having an existing damage classification of 3 (serviceability defect) or greater in accordance with BRE Digest 251.

Utilities

- Brittle pipelines exceeding 10mm settlement.
- Ductile pipelines exceeding 50mm settlement.

Due to insufficient information being available for utilities it is not possible to accurately categorise utilities according to the above assessment criteria. Based on the settlement contour drawings contained within this report a schedule of all utilities subject to 10mm or greater ground movement has been prepared. Further consultation with utilities owners is required to ascertain utility construction details. This assessment excludes the identification of utilities between DCU Stop and Drumcondra Stop, due to an extended period of public consultation for this section of the alignment and will therefore need to be undertaken by the DBFM Contractor.

Infrastructure

- Infrastructure falling within the 2mm settlement contour line.

Based on the above criteria Table 1-2 summarises the number of items that have been identified for inclusion in the Stage 2A assessment:

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

A schedule of individual items of buildings, utilities and infrastructure is provided in Appendices E, F and G respectively of this report.

1.5 Recommendations

- Complete the Stage 2A Assessment - Items identified by this Stage 1 study for further assessment to be taken forward to the Stage 2A Initial Response Assessment.
- Confirm and agree settlement assessment criteria with infrastructure and utility owners.

2. Introduction

2.1 Scheme Overview

Metro North is the next phase of Dublin's integrated light rail network, which began with the opening of the Luas Red and Green lines.

Metro North will provide park and ride spaces and good quality bus, rail and air interchanges along an 18 km corridor running from Belinstown in the North through Seatown, Swords, Fosterstown, Dublin Airport, Dardistown, Northwood, Ballymun, Dublin City University, Griffiths Avenue, Drumcondra, Mater Hospital, Parnell Square and O'Connell Bridge to St Stephen's Green in the city centre.

Metro North will generally be separated from road traffic which will be achieved by running in tunnel in the city centre and on road medians or elevated sections in the less congested outer suburbs.

In July 2006, Jacobs was commissioned by the Railway Procurement Agency (RPA) to act as their Railway Engineering, Design and Safety Consultant for the Metro North project. The scope of the framework agreement included:

- Preparation of Reference Design.
- New works assessment.
- New rolling stock assessment.
- Assistance with preparation of Railway Order.
- Assistance with the administration of tenders from pre-qualification through to award.
- Engineering support during the Railway Order Public Inquiry.

2.2 Objectives

The purpose of this Ground Movement Assessment Report is to present the results of the analysis undertaken to predict ground surface movements and to identify existing buildings, utilities and infrastructure which may be adversely affected by the proposed tunnelling and underground construction works that should be taken forward to the Stage 2A assessment (see Table 4-1).

2.3 Chainage Discrepancy

For Dublin Metro North a continuous chainage system has been adopted. The chainage system allows unique points along the alignment to be referenced in relation to its topographical position. The chainage system for Dublin Metro North commences at the north of the alignment (the Depot) and increases southerly along the route.

During the design development process, the Master Alignment model for Dublin Metro North was subject to numerous revisions that necessitated amending chainages along the route.

In the development and subsequent revisions of this Stage 1 Preliminary Ground Movement Report, different Master Alignment drawings have been referenced for the particular sections of alignment being assessed. Alignment models used in the development of the Dublin Metro North ground movement assessment are presented in Table 2-1.

Stage 1 Preliminary Ground Movement Report Issue Status	Master Alignment Drawings		
	Model Reference	Title	Date
First Issue, Feb 2008	BMN0000ML00911B01	Master Alignment 1:500	2 Oct 2007
Revision 1, May 2008	BMN0000ML00911B01	Master Alignment 1:500	22 Feb 2008
Revision 2, Dec 2008	BMN0000ML00911B01	Master Alignment 1:500	14 May 2008
Revision 3 Feb 2009	BMN0000ML00911B01	Master Alignment 1:500	14 May 2008

Table 2-1: Master Alignment Referenced for Dublin Metro North Ground Movement Assessment

Revision 1 of the Stage 1 Report incorporated a section of alignment between DCU Stop and Drumcondra Stop. This portion of the alignment was previously omitted due to an extended period of public consultation. As a consequence of establishing the final design alignment between DCU and Drumcondra, breaks in the chainages south of Drumcondra stop have occurred.

Revisions 2 and 3 of the Stage 1 Preliminary Ground Movement Assessment Report presents a ground movement assessment based on the alignment plan which is included as part of the Railway Order Application, as specified under Section 37 of the Transport (Railway Infrastructure) Act, 2001 (Annex 1). The issue of this report coincides with the preparation of proofs of evidence for the Oral Hearing. However, it should be noted that the ground movement drawings presented in these reports adopt the chainages set out in the Railway Order Drawings. However, **chainage references within the text of this report are not compatible with the associated ground movement drawings.** This discrepancy has resulted from ongoing design development and alignment revisions, which were implemented by RPA during the initial and subsequent ground movement assessment at a number of locations along the alignment.

2.4 Cross passage Spacing

It is apparent from the Railway Order Drawings, (Ref LMN000GA107003 Rev A and LMN000GA107004 Rev A) and the station layouts for O’Connell Bridge Stop that cross passage No. 316 slightly exceeds the 250m design separation distance as specified in B0307000-010/TUN.007\001\1 (Cross Passage Space Proofing & Reference Design Report, May 2007). The separation of cross passage No. 316 from O’Connell Bridge Platform was found to be approximately 261m. However, it should be noted that final arrangement of O’Connell Bridge South box and spacing of cross passages would be subject to the detailed design by the DBFM contractor and acceptance of the final fire strategy.

3. References

The following is a list of references that have been used to develop this Stage 1 Report.

3.1 Metro North Papers

1. Technical Note 12: Strategy for Assessing and Managing Building, Infrastructure and Utility Response to Ground Movements Generated by Underground Excavation.
2. Design Input Statement for Predicting Ground Movements and the Response of Overlying Property to Underground Excavation.
3. Geo Design, Geological Assessment and Primary Lining Design – Mined Sections, O'Connell Street Stop, June 2007. Ref 262211/200707/Rev 01

4. Methodology

The method of predicting ground movement and assessing the behaviour of buildings, utilities and infrastructure is a progressive process. For the Dublin Metro North project a 4 stage assessment process has been adopted. The various stages are summarised in Table 4-1 below:

Stage No.	Description
1	Stage 1 Preliminary ‘Greenfield’ Settlement Analysis – prediction of ground movements generated by underground excavation and the identification of buildings, infrastructure and utilities at potential risk of damage.
2A	Stage 2A Initial Response Assessment- assessment of the response of buildings and infrastructure (identified during Stage 1) to predicted ground movements, and where appropriate consideration of possible mitigation measures.
2B	Stage 2B Review of 2A Initial Response Assessment – the Design Build Finance Maintain (DBFM) Contractor to review and update as appropriate the Stage 1 and 2A assessments.
3	Stage 3 Detailed Response Assessment – Detailed assessment of all buildings, utilities and infrastructure carried over from Stage 2B, and the design and implementation of protection measures as appropriate (to be carried out by the DBFM Contractor.)

Note: Current Stage denoted by bold text

Table 4-1: Settlement Methodology and Stage Description

Prior to submission of the Railway Order, Stages 1 and 2A will be undertaken as part of the Preliminary Design for Metro North by Jacobs. The remaining stages of the process shall be undertaken by the DBFM Contractor.

5. Ground/Site conditions

5.1 General Geological Conditions

The general stratification of the ground along the route of Dublin Metro North consists of the following:

- Made Ground
- Alluvial Deposits
- Fluvioglacial deposits (Glacial Sands and Gravels).
- Glacial Till
- Bedrock – Carboniferous Limestone.

Locally extensive areas of Made Ground are present along the route. The composition of the Made Ground varies widely and generally consists of a mixture of waste materials including, for example, domestic refuse, clinker and demolition rubble. In the city centre, the thickness is generally between 1m and 4m, but locally deeper, and in general reduces to between 1m and 2m to the north of Mater Stop.

Alluvial Deposits, of generally limited extent, are present locally in the vicinity of the River Liffey, River Tolka and Broadmeadow River. Alluvial Deposits, of limited extent, are also likely to be present in areas associated with existing and former stream courses. The Alluvial Deposits generally consist of loose to medium dense, interbedded, organic silts, sands, gravels and cobbles. Bands of peat have been encountered locally within the Alluvial Deposits in the area of River Liffey.

The Glacial Sands and Gravels comprise sands and gravels with cobbles and occasional boulders. The Glacial Sands and Gravels generally occur as layers or lenses within the predominantly clayey Glacial Till. However, in the area of the pre-glacial channel to the north of the River Liffey (and also to a lesser extent between the River Liffey and St. Stephen's Green) significant thicknesses are present. The geology of the pre-glacial channel area is complex with glacial tills occurring within glacial gravels and vice-versa, and likely reflects the complexity of the variations and different stages of ice sheet advance and withdrawal. Artesian and / or sub-artesian groundwater conditions have been encountered within the Glacial Sands and Gravels in the O'Connell Street and Parnell Square areas.

The Glacial Till consists of a heterogeneous mixture of clay, silt, sand and gravel with cobbles and boulders. It is locally known as Dublin Brown or Black Boulder Clay. The till contains discrete, and in places extensive, layers, lenses and pockets of sand and gravel.

In Dublin city centre the Bedrock consists of carboniferous limestone interbedded with mudstone and shale (Calp limestone), whereas locally at the Airport, the limestone consists of massive limestone and mudstone (Waulsortian limestone). The Waulsortian limestone is more susceptible to the development of karst features. The bedrock has been faulted and partly folded and uplifted. The groundwater level is typically between 2m and 4m below ground level in the city centre area and may be deeper where ground levels are more elevated.

Further details with regards to ground conditions along the route of DMN can be found in the DMN Geotechnical Data Report and 'Reference Ground Conditions Report Provided for Information' held in the Data Room.

5.2 Geological and Alignment Data

Ground levels, alignment, and geological sequence have been determined from the drawings listed in Table 5-1. The inferred geological long sections on which this assessment is based are contained in Appendix A to this report:

Drawing Reference	Title	Date
Alignment Drawings		
BMN0000ML00911B01	Master Alignment 1:500	14 May 2008
Inferred Geological Long Sections		
BMN0000GE(0)(3)006A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 6 of 14	3 Aug 2007
BMN0000GE/227/A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 7 of 14	April 2008
BMN0000GE(0)(3)007A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 7 of 14	3 Aug 2007
BMN0000GE(0)(3)008A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 8 of 14	3 Aug 2007
BMN0000GE(0)(3)009A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 9 of 14	3 Aug 2007
BMN0000GE(0)(3)010A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 10 of 14	3 Aug 2007
BMN0000GE(0)(3)011A03	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 11 of 14	3 Aug 2007
BMN0000GE(0)(3)012A03	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 12 of 14	Dec 07
BMN0000GE/233/A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 13 of 14	April 2008
BMN0000GE(0)(3)013A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 13 of 14	Dec 07
BMN0000GE/234/A01	Exploratory Hole Location Plan and Inferred Geological Section (incl. MGI data), Sheet 14 of 14	April 2008
BMN0000GE(0)(3)014A01	Exploratory Hole Location Plan and Inferred Geological Section, Sheet 14 of 14	3 Aug 2007

Table 5-1: Inferred Geological Long-Sections

It should be noted that the geological profile inferred by the Geological Sections is only an interpretation of the ground conditions likely to be encountered during construction

Revision 1 of the Stage 1 Preliminary Ground Movement Report was based on inferred geological long sections. These sections did not include the Main Ground Investigation (MGI) data due to the programme requirement to progress the ground movement and building response study before an assessment of MGI data could be completed.

Revision 2 of the Stage 1 Ground Movement Report incorporates the MGI data, however, consideration has only been made for revised and updated sections of the

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