APPENDIX C

Supplementary Information on Air Quality (Chapter 8, Vol.1)

1. Air Quality Assessment of Commissioning of the Onshore Pipeline.

There will be predicted short term emissions (1-2 weeks) of combustion gases from the diesel generators at the LVI compound employed to power the nitrogen plant for the offshore pipeline commissioning phase. These impacts are associated with the offshore section of the pipeline and have been quantified in Chapter 10 of the Offshore EIS Supplementary Update Report. A summary assessment is provided in the Onshore Pipeline EIS as part of the cumulative impact assessment. This assessment is presented in the final paragraph of Section 17.3.3 “Pre-commissioning of Offshore Pipeline”.

During the commissioning of the onshore pipeline, a temporary nitrogen generation plant containing air compressors may be located within the Terminal Site for a period of one to two weeks. This facility will include a series of mobile diesel generator units, which will generate emissions of combustion gases and will be located at the terminus of the pipeline on the site. The commissioning of the onshore section and the offshore section will not be simultaneous and as such, there will be no cumulative impact between the two operations.

In order to power the compressors it is proposed to locate three 200kW generators in the compressor station. The AERMOD dispersion model was applied to simulate the emissions from these generators and the potential impact on sensitive receptors. All results presented are compared to the statutory limits for the protection of human health (S.I. 271 of 2002). The results of the modelling, incorporating background concentrations, are presented in Table 1. These results represent the worst case receptors – i.e. the receptor that will experience the greatest impact.

The modelling includes all receptors within 1000 metres of the Terminal site boundary. This includes the five residential properties to the north of the site in Leenamore (labelled LN01 to LN01 in Appendix A2), the five residential/commercial properties to the east of the site at the junction between the R314 and L1202 (not listed in Appendix A2) and the four residential receptors to the south west of the site at Bellanaboy Bridge (not listed in Appendix A2).

Table 1: Predicted impact of generator emissions at the Terminal Site on the nearest sensitive receptors.

Parameter	Averaging Period	Background	Predicted Impact from Generators	Total Predicted Impact	Limit for the Protection of Human Health
Nitrogen Dioxide (NO_2)	Annual Average	3 $\mu g/m^3$	0.26 $\mu g/m^3$	3.26 $\mu g/m^3$	40$\mu g/m^3$
	Hourly Maximum	6 $\mu g/m^3$	24.50 $\mu g/m^3$	30.50 $\mu g/m^3$	200$\mu g/m^3$
Nitrogen Oxides (NO_x)	Annual Average	4 $\mu g/m^3$	0.31 $\mu g/m^3$	4.31 $\mu g/m^3$	30$\mu g/m^3$
Particulate Matter PM_{10}	Annual Average	10 $\mu g/m^3$	0.02 $\mu g/m^3$	10.02 $\mu g/m^3$	40$\mu g/m^3$
	24-hour Average	10 $\mu g/m^3$	0.55 $\mu g/m^3$	10.55 $\mu g/m^3$	50$\mu g/m^3$
Carbon Monoxide	8-hour Average	0.4 mg/m^3	0.01 mg/m^3	0.41 mg/m^3	10 mg/m^3
Particulate Matter $PM_{2.5}$	Annual Average	6 $\mu g/m^3$	0.02 $\mu g/m^3$	6.02 $\mu g/m^3$	25 $\mu g/m^3$

The results indicate that the operation of the generators during commissioning will have a “slight adverse” air quality impact of a temporary nature at the nearest sensitive receptors. However, the results will remain at all times well below the limits for the protection of human health. The receptors worst affected (presented in Table 1) are those approximately 500-600 metres south of the terminus of the pipeline on the Terminal Site (Grid Reference 486223

832438). These houses are not listed in the drawings in Appendix A2 but are those residential properties west of the Terminal entrance at Bellanaboy Bridge on the R314.

In addition, the modelling indicates that the emissions from the generators will decrease to levels well below all statutory limits at the Terminal Site boundary and all levels off-site will be within the relevant limits for the protection of human health and vegetation. The maximum predicted boundary concentrations from the operation of the generators during commissioning are presented in Table 2.

Table 2: Maximum predicted impact of generator emissions at the boundary of the Terminal Site.

Parameter	Averaging Period	Predicted Impact from Generators
Nitrogen Dioxide (NO_2)	Annual Average	1.03 $\mu g/m^3$
	Hourly Maximum	39.6 $\mu g/m^3$
Nitrogen Oxides (NO_x)	Annual Average	1.32 $\mu g/m^3$
Particulate Matter PM_{10}	Annual Average	0.08 $\mu g/m^3$
	24-hour Average	0.98 $\mu g/m^3$
Carbon Monoxide	8-hour Average	0.02 mg/m^3
Particulate Matter $PM_{2.5}$	Annual Average	0.08 $\mu g/m^3$

The nearest sensitive ecological receptor to these generators is the Carrowmore Lake Complex cSAC (Site Code 000476) which is approximately 1500 metres south. The impact of NO_x emissions from the generators on this receptor will be negligible.

There will be no emissions to air during maintenance activities of the pipeline during the operational phase.

2.. The locations of the predicted air quality concentrations that are presented in Table 8.4 of the EIS.

The air dispersion model includes for all sensitive receptors within 1000 metres of the source (in this case the generators at the tunnel compound). This included 18 discrete receptors as listed in Table 3 and Figure 1 and includes all residential and other receptor types (schools, places of worship, etc.). The reference presented for each receptor is based on those listed in Appendix A2 of Volume 2 of the EIS.

Table 3: Receptors employed in the model assessment undertaken at Aghoos Compound.

Receptor	X-coordinate	Y-coordinate	Elevation (m)	Note
AG07	84734.79	335845.2	7.27	
AG08	84658.46	335742.7	14.58	
AG09	84783.39	335712.9	8.15	
AG10	84971.74	335502.8	6.1	
AG11	85115.8	335499.3	5.5	
AG12	85092.7	335428.3	8.58	
AG13	85165.69	335392.2	7.94	
AG15	84658.14	335116.8	39.38	
AG16	84630.05	335155	39.44	
AG33	84654.72	335782.4	14.28	Aghoos Church
AG37	84842.1	335708.3	4.91	
LN01	85871.23	334515.9	11.74	
LN02	85819.63	334432.6	15.41	
LN03	85357.45	334490.9	31.63	
LN04	85453.2	334461.7	28.05	
LN05	85665.63	334633	17.95	
RS01	85682.03	336197.5	9.99	
Unlisted	84795.5	335758.7	5.00	Derelict Church

Note: AG14 excluded as SEPIL property and will be unoccupied during construction

All receptors listed above have been included in the air dispersion model analysis. The results presented in Table 8.4 represent the maximum concentrations determined for any of the above receptors, i.e. the worst affected receptor.

In this analysis, Receptor AG13 (approximately 350 metres west of the potential location of the generators) will experience the greatest impact and the results presented in the EIS are relevant to this receptor. All other receptors will experience levels lower than this house.

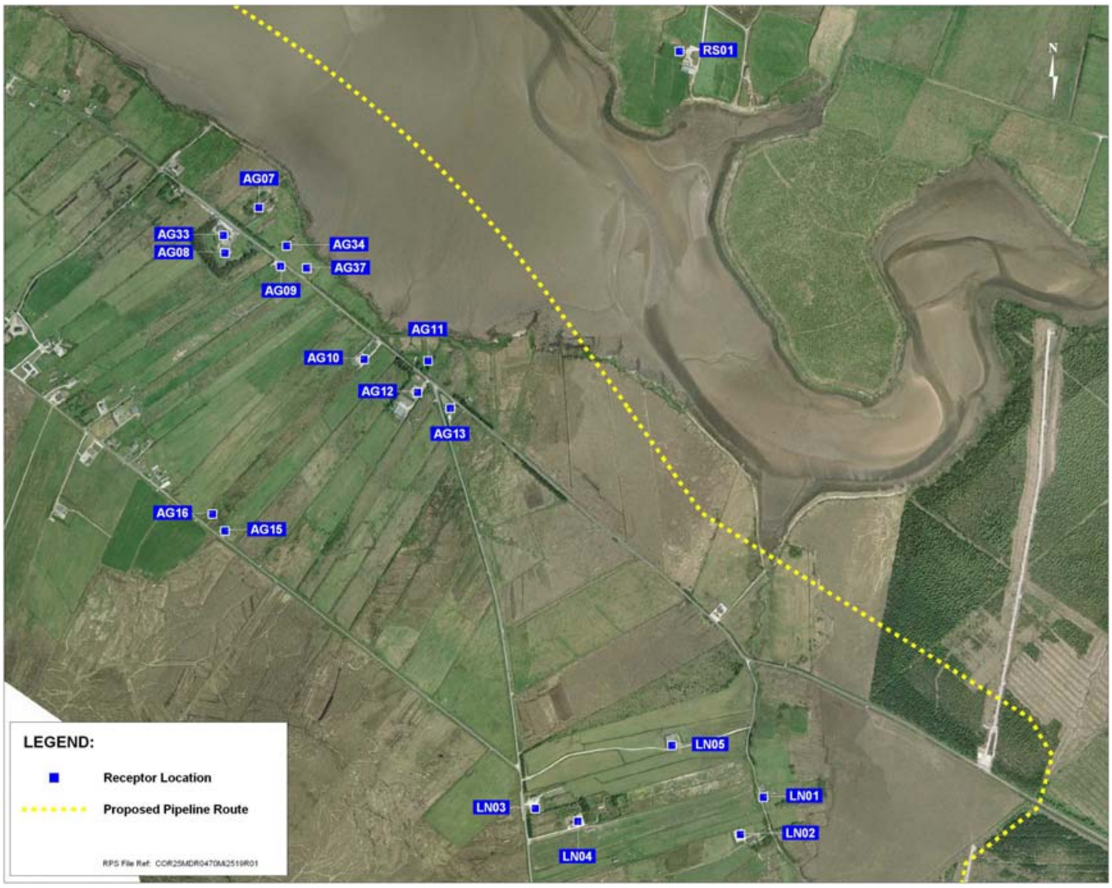


Figure 1: Receptors included in the air dispersion model for the generators at the Aghoos tunnel compound.

3. The extent of the breach of the ecological standard for NOx on the cSAC.

The proposed layout of the Aghoos tunnel compound, as presented in Figure 5.7 of the EIS, is only indicative of a potential layout and the final layout will only be formulated at the construction stage. As such, the air dispersion modelling assessment undertaken has assessed two distinct options:

- Worst case assessment has been undertaken with the generators located at the northern most boundary of the compound (in the area where the settlement pond is located in Figure 5.7). At this point the generators are approximately 50 metres from the boundary of the cSAC (presented in the figures as the outline of the Bay).

- Most likely assessment whereby the generators are located in the area presented in Figure 5.7 of the EIS at the south western boundary of the compound. At this point the generators are approximately 200 metres from the boundary of the cSAC.

The results of the worst case assessment are presented in Figure 2. This figure presents the outline of the tunnel compound, the boundary of the cSAC (i.e. the shoreline of the Bay) and the area affected by annual average emissions of NO_x greater than the limit of 30μg/m^3 for the protection of vegetation (presented in red). The isopleth presented indicates that under this worst case assessment, the annual average levels of NO_x on the cSAC will exceed the limit value in the Bay. This is the assessment reported in the EIS (Section 8.4.3.5) which has lead to the subsequent assessment of nitrogen deposition on the habitat.

Figure 2: Annual Average NO_x emissions from the generators on the tunnel compound – Worst Case Scenario where generators are at nearest boundary to cSAC.

Figure 3 presents the results of a similar assessment for the most likely scenario, whereby the generators are located at the southern section of the compound, as per Figure 5.7 of the EIS. The results indicate an isopleth plume of similar size to the worst case assessment, but the area where the annual limit value is exceeded is contained entirely within the tunnel compound and the cSAC is unaffected by these emissions.

Figure 3: Annual average NO_x emissions from the generators on the tunnel compound – Most Likely Scenario where generators are located as per Figure 5.7.

4. Predicted nitrogen Deposition Levels on the cSAC

As the proposed layout of Aghoos compound presented in the EIS is only indicative, a worst case assessment has been presented in the EIS with the generators located at the northern most boundary of the compound. At this point the generators are approximately 50 metres from the boundary of the cSAC (i.e. the shoreline of the Bay).

At this range the model predicts that annual average levels of NO_2 above 40μg/m^3 will extend out to 75 metres from the generators into the cSAC where the habitats are known to be salt marsh.(refer Section 12 of the EIS) Between this point and the generators the levels will increase up to 70μg/m^3 (see isopleths presented in Figure 4). This equates to annual nitrogen deposition of 4 – 7 kg N ha^{-1} yr^{-1} in the areas between the compound and into the cSAC as a worst case assessment. When compared to the UNECE critical load for salt marshes of 30-40 kg N ha^{-1} yr^{-1}, the impact of these NO_x emissions on the salt marsh is negligible.

Again, using the most likely scenario where the generators are located as per Figure 5.7, levels of annual average NO_2 would not exceed the annual limit at the boundary of the site compound.

Figure 4: Annual average NO_2 emissions from the generators on the tunnel compound (worst case scenario).

5. Maximum hourly NO_2 concentration

The maximum hourly concentration of NO_2 as a result of the generators at the tunnel compound are predicted to be 52μg/m^3 at the worst case receptor compared to the limit for the protection of human health of 200μg/m^3 (Table 8.4). This is the absolute maximum 1-hour NO_2 concentration and not the 99.8th percentile maximum.

The one hour average appears elevated as this is based on the "worst-case" hour where dispersion is poorest ("calm" conditions) and resultant ground level concentrations are at their highest. In an area like the west coast of Ireland, these conditions are very infrequent (typically less than 3% of the year) and hence there is a large disparity between the annual average and 1 hour maximum. The EPA report similar results for NO_2 monitoring at coastal and rural locations around the country (refer Appendix G for data for Kilkitt, Co. Monaghan).

These emissions are based on the simulation of the generators operating continuously over the tunnelling period. There are no significant non-continuous sources on the compound and none have been included in the model.

APPENDIX D

Supplementary Information on Noise & Vibration (Chapter 9, Vol. 1 & Appendix H1, Vol. 2)

9 NOISE & VIBRATION

9.1 INTRODUCTION

9.2 METHODOLOGY

Assessment of noise emissions from the proposed works. Noise prediction modelling was undertaken using the Bruel & Kjaer Type 7810 Predictor Noise Modelling Package to predict noise levels at the nearby houses. The noise-modelling package uses a computer based noise propagation model, in accordance with the ISO 9613-2 standard, "*Acoustics - Attenuation of sound during propagation outdoors*", which is an international standard used to undertake noise prediction modelling. Noise modelling was also undertaken in accordance with the NRA, "*Guidelines for the Treatment of Noise and Vibration during the construction of National Road Schemes, 2004".* The plant and machinery sound power levels were sourced from manufacturer's data for the tunnelling equipment, provided by de la Motte & Partner. Noise data for plant and machinery associated with the construction works other than the tunnelling equipment were sourced from BS 5228, "*Noise and Vibration Control on Construction and Open Sites, 2009,*" and the UK Department for Environment Food and Rural Affairs (Defra), "*Updated Noise Database for Prediction of Noise on Construction and Open Sites, 2005"*. The noise model was constructed based on the ISO 9613-2 standard method using the receptor locations outlined earlier. The proposed pipeline was imported into the noise prediction model along with the local topography. The list of plant and machinery input into the model and the corresponding revised noise data is included in Appendix H1.

9.2.1 Noise Assessment Criteria[1]

9.2.1.1 Construction Noise Criteria

Table 9.1 Maximum permissible noise levels at the façade of dwellings during construction* (NRA Guidelines, October 2004)

Table 9.2 Significance scale for changes in noise levels (perceptible to human beings)

9.2.1.2 Operational Noise Criteria[1]

9.2.2 Vibration Significance Criteria[1]

Table 9.3 Human Response to Vibration from Construction and Demolition Activities

9.2.3 Noise and Vibration Sources

The potential sources of noise and vibration associated with the proposed development have been assessed for the construction phase (including onshore pipeline commissioning works) and the operational phase in Sections 9.2.3.1 – 9.2.3.5. These have been assessed both for 'on land' works and tunnelling works.

Subsequent to the preparation of the EIS in May 2010, the tunnelling works design team have undertaken a review of the noise emissions data associated with the plant and machinery that will be

[1] Please note where the text has been omitted there is no change to the EIS as submitted.

utilised during the construction phase. This review has identified scope for additional noise abatement both in the form of specification of alternative equipment with lower noise output and the design of additional noise abatement measures that will reduce the level of noise generated at source in the tunnelling compound at Aghoos. The noise prediction models have been revised to take into consideration the revised noise specification for the tunnelling works. The results of the revised prediction models are presented in Table 9.8, Table 9.9 and have also been incorporated into the calculation of the total cumulative noise levels presented in Table 9.10. The total cumulative levels have not changed as a result of the changes to the noise sources within the compounds, due to the influence of construction traffic on the overall cumulative noise levels.

In addition to the modifications to the noise sources associated with the tunnelling works at the Aghoos compound, it is also proposed to modify the original proposals associated with the Glengad compound in order to reduce the potential noise impact associated with site preparation works at the tunnel reception compound and at the LVI compound. The noise assessment presented in the EIS prepared in May 2010 considered the noise impact associated with a diesel powered water pump in use during the night-time at Glengad during the temporary construction works. The site design team have revised the assessment regarding the requirement to pump water during the night-time (22:00 – 08:00) and it is now proposed that water will not be pumped from the tunnel reception pit or the LVI site at Glengad during the construction works at either of these sites. This has also been incorporated into the revised noise prediction models.

9.2.3.1 Construction Phase - Noise from Terrestrial Works

9.2.3.2 Construction Phase– Vibration from Terrestrial Works

9.2.3.3 Construction Phase – Groundborne Noise and Vibration from Tunnelling

9.2.3.4 Construction Phase - Noise and Vibration from Traffic

9.2.3.5 Commissioning – Noise and Vibration

9.2.3.6 Operational Phase

9.3 EXISTING ENVIRONMENT

9.3.1 Baseline Monitoring

9.3.1.1 Rotational 15-Minute Measurements

Table 9.4 Locations predominantly impacted by current traffic noise

Table 9.5 Locations predominantly impacted by current non-traffic noises

9.3.1.2 24-Hour Measurements

Table 9.6 24-hour Noise Measurement Results

9.3.1.3 Vibration Measurement Results

Table 9.7 Vibration Monitoring Results

9.4 POTENTIAL IMPACTS

9.4.1 'Do Nothing' Scenario

9.4.2 Construction Phase – Noise from Terrestrial Works

The most noticeable noise impact will occur during activities employed during the various stages of terrestrial pipeline construction. Accordingly, in order to assess the likely significant impacts the predicted impact for this phase of the proposed development is presented below.

A digital noise prediction model for the scheme was constructed using the Bruel and Kjaer 7810 Predictor Version 6 software package. The noise-modelling package uses a computer based noise propagation model, in accordance with the ISO 9613-2 standard, "*Acoustics - Attenuation of sound during propagation outdoors*", which is an international standard used to undertake noise prediction modelling. The plant and machinery sound power levels were sourced from manufacturer's data for the tunnelling equipment, provided by de la Motte & Partner. Noise data for plant and machinery associated with the construction works other than the tunnelling equipment were sourced from BS 5228, "*Noise and Vibration Control on Construction and Open Sites, 2009,*" and the Defra, "*Updated Noise Database for Prediction of Noise on Construction and Open Sites, 2005*". The noise model was constructed based on the ISO 9613-2 standard method using the receptor locations outlined earlier.

To allow for prediction of the likely significant impacts the total number of plant involved in all stages of the construction works was input as individual sources within the boundaries of the construction working areas, which are in relatively close proximity to a number of the sensitive receptors.

Considering the progressive nature of the works, i.e. soil and peat will need to be excavated before the tunnelling launch and reception pits can be constructed and before the trenches can be excavated, each item of plant will not be operating simultaneously. However, in order to predict the greatest level of potentially significant impacts a conservative assessment was undertaken for a scenario whereby, each item of plant that will be operational during the day has been input into the model as operational simultaneously on a regular basis. As outlined above, the noise emissions data associated with the tunnelling works has been revised to take account of additional noise abatement measures that have been identified subsequent to the preparation of the EIS in May 2010. Additional noise attenuation has been designed in the form of increased acoustic cladding and specification of alternative machinery that will generate lower levels of noise at source.

These revisions are summarised as follows:

- Reduction of noise emanating from the three power packs required to power the tunnel boring machine,
- Centrifuges that were previously considered needed to operate on a 24-hour basis will now not operate during the hours 23:00 – 07:00,

- Reduction of noise emanating from the separation plant required to grade/screen material from the tunnel arisings,

- Specification of alternative wheeled loader required intermittently in the temporary storage area, with significantly reduced noise emissions,

- Trucks that were previously considered necessary to operate at times within the tunnelling compound during the night-time will now not operate during the hours 23:00 – 07:00.

In addition to the noise abatement measures at the Aghoos compound, as outlined above modifications have also been incorporated into the proposed construction works at the tunnel reception pit compound and the LVI compound at Glengad, such that water pumping during the night-time that was assessed in the EIS prepared in May 2010, is no longer proposed to be carried out.

Therefore, the results represent a conservative assessment of the potential likely construction noise that may be generated at the site. It should be noted however that the revised assessment has considered the potential noise impacts associated with the site preparation/enabling works being undertaken at Glengad at the same time as tunnelling work are being undertaken at Aghoos. This scenario is representative of the likely noise impacts associated with a temporary stage of the overall construction programme only. The construction works at Glengad reception compound will extend for a period of approximately 3 months (months 16 – 18, refer to Figure 5.2, Chapter 5 of the EIS), and the LVI compound for a period of approximately 3 months (months 2 – 4, refer to Figure 5.2, Chapter 5 of the EIS), whereas the tunnelling works will extend for a period of approximately 15 months (months 5 – 19, refer to Figure 5.2, Chapter 5 of the EIS).

The assessment presented in the EIS prepared in May 2010 considered a scenario whereby, noise emissions associated with plant servicing the tunnelling compound at na hEachú (Aghoos) would be operational on a continuous basis for approximately 15 months duration, although not all noise sources at na hEachú (Aghoos) would typically operate simultaneously. These noise sources had been input into the model as being operational for 100% of the time on a 24-hour basis. Those noise sources had been modelled in tandem with the site preparation noise sources at the reception pit at Gleann an Ghad (Glengad) in order to predict the potential worst-case noise emissions during the construction phase. As outlined above, the noise predictions have been revised to take account of the modifications both in terms of specification of alternative equipment with lower noise output, the design of additional noise abatement measures to reduce the level of noise generated at source, and the elimination of a number of sources that were previously proposed to operate during the night.

The noise sources at the reception pit in glean an Ghad (Glengad) will be present for less than 12 months and will not generate noise on a continuous basis, when present. Night-time works are not anticipated at Gleann an Ghad (Glengad). Details of the revised plant and machinery input into the revised noise models are presented in the revised Appendix H1.

The revised predicted daytime and night-time noise levels at the various receptors are presented in Table 9.8 and Table 9.9 and illustrated in Figures 9.2a and 9.2b (& 9.2bii) (9.2b & 9.2bii are the same figures, but at different scales) respectively. The results were compared to existing baseline noise levels in the vicinity of each receptor (both existing ambient noise levels (L_{Aeq}) and existing background noise levels (L_{A90})). The cumulative noise levels are shown for a combination of the predicted levels with both existing ambient noise levels and existing background noise levels. The predicted noise levels were also compared with assessment criteria adopted by the NRA and the Bellanaboy Bridge Terminal EIS.

The following is an explanation of the information provided in Table 9.8:

- Column 2: Is the measured baseline ambient level, i.e. the measured level during the monitoring period (L_{Aeq}) and represents the continuous steady noise level or the average noise level during the survey;

- Column 3: Is the measured baseline background level, i.e. the measured noise level that is equalled or exceeded for 90% of the monitoring period (L_{A90});

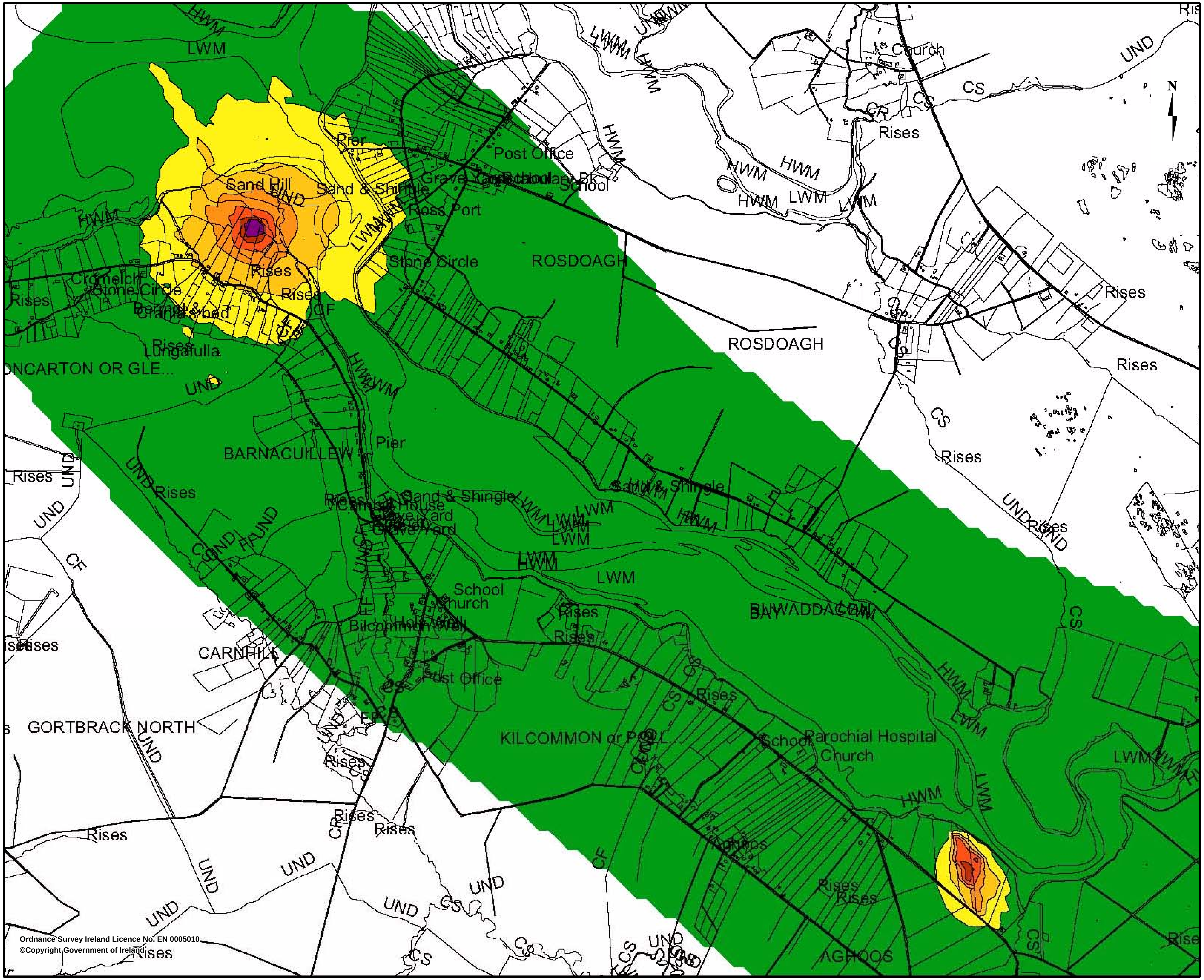
- Column 4: Is the predicted construction noise level (L_{Aeq});
- Column 5: Is the difference between the baseline ambient level (L_{Aeq}) in Column 2 and the predicted construction noise level (L_{Aeq}) in Column 4 and is used to determine the impact rating in Column 7;
- Column 6: Is the cumulative noise level arising from the combination of the baseline ambient level (L_{Aeq}) in Column 2 and the predicted construction level (L_{Aeq}) in Column 4;
- Column 7: Is the impact rating based on the information in Column 5 and compared with Table 9.2;
- Column 8: Is the difference between the baseline background level (L_{A90}) in Column 3 and the predicted construction noise level (L_{Aeq}) in Column 4 and is used to determine the impact rating in Column 10;
- Column 9: Is the cumulative noise level arising from the combination of the baseline background level (L_{A90}) in Column 3 and the predicted construction level (L_{Aeq}) in Column 4;
- Column 10: Is the impact rating based on the information in Column 8 and compared with Table 9.2; and
- Column 11: Is the comparison of the cumulative noise level in Column 9 with the NRA Guideline value of 65 dB(A).

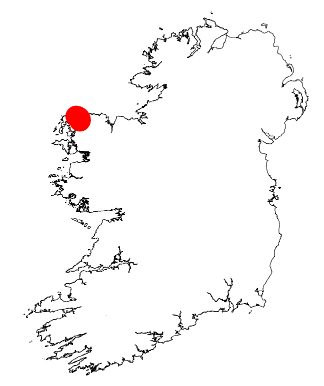
Interpretation of Table 9.9 is similar to the above.

The predicted traffic noise levels associated with the construction phase of the proposed pipeline are presented in Table 9.10. It is predicted that properties located along the haul routes will experience an increase in traffic noise levels ranging from a minimum of less than 1dB (0.2dB), which would be considered as no change or an imperceptible impact, based on existing ambient noise levels measured at the sensitive receptor N22 (located off the L1204); to a maximum of 15.1dB, based on the existing ambient noise levels measured at the sensitive receptor N19 (located off the L1202), which would be considered as a major significant, temporary to short-term impact associated with construction traffic and would occur during the busiest stage of the construction programme (Month 2).

For properties located along the L1202 between Béal an Ghoile Theas (Bellagelly South) and Gleann an Ghad (Glengad), the predicted increase in traffic noise levels due to construction traffic ranges from 0.0dB to 7.8dB, based on predicted construction traffic noise levels compared with predicted future traffic noise levels in the absence of construction traffic on the L1202. These increases would be considered an imperceptible impact and moderate negative impact, respectively.

For properties located along the L1204 between An Srath Mór (Srahmore) and Bellanaboy Bridge, the predicted increase in traffic noise levels due to construction traffic ranges from 0.9dB to 3.3dB (dependent upon proximity to the road), which would be considered as imperceptible and minor negative impacts, respectively.





Legend

- < 45.0 dB(A)
- 45.0 - 50.0 dB(A)
- 50.0 - 55.0 dB(A)
- 55.0 - 60.0 dB(A)
- 60.0 - 65.0 dB(A)
- 65.0 - 70.0 dB(A)
- > 70.0 dB(A)

Predicted Construction Noise Levels (Daytime)

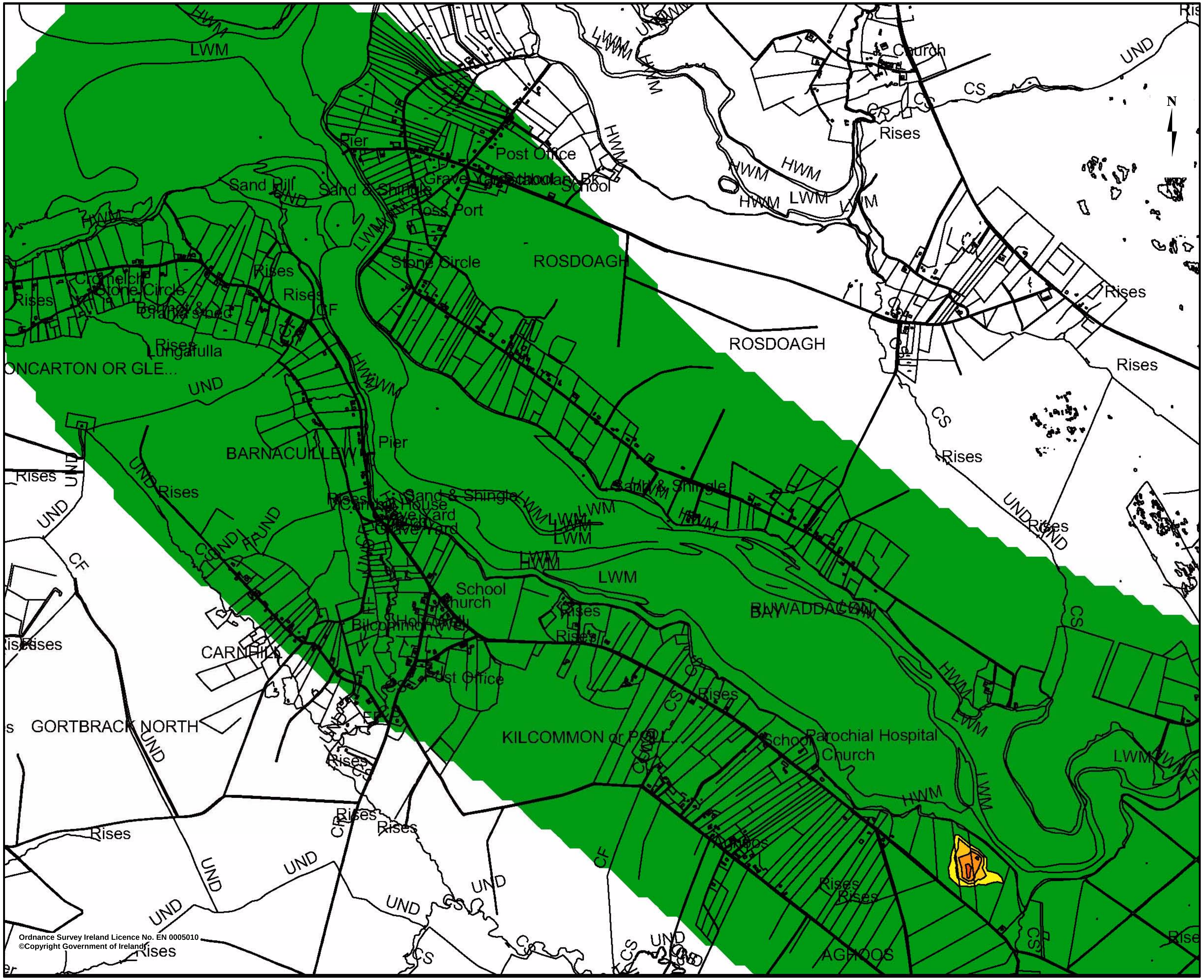
Figure 9.2a

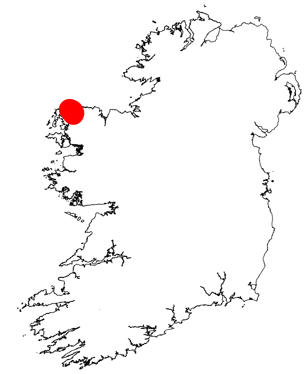
File Ref: COR25MDR0470Mi2458R02
Date: August 2010

CORRIB ONSHORE PIPELINE

Corrib natural gas

RPS





Legend

- < 45.0 dB(A)
- 45.0 - 50.0 dB(A)
- 50.0 - 55.0 dB(A)
- 55.0 - 60.0 dB(A)
- 60.0 - 65.0 dB(A)
- 65.0 - 70.0 dB(A)
- > 70.0 dB(A)

Predicted Construction Noise Levels (Night-time)

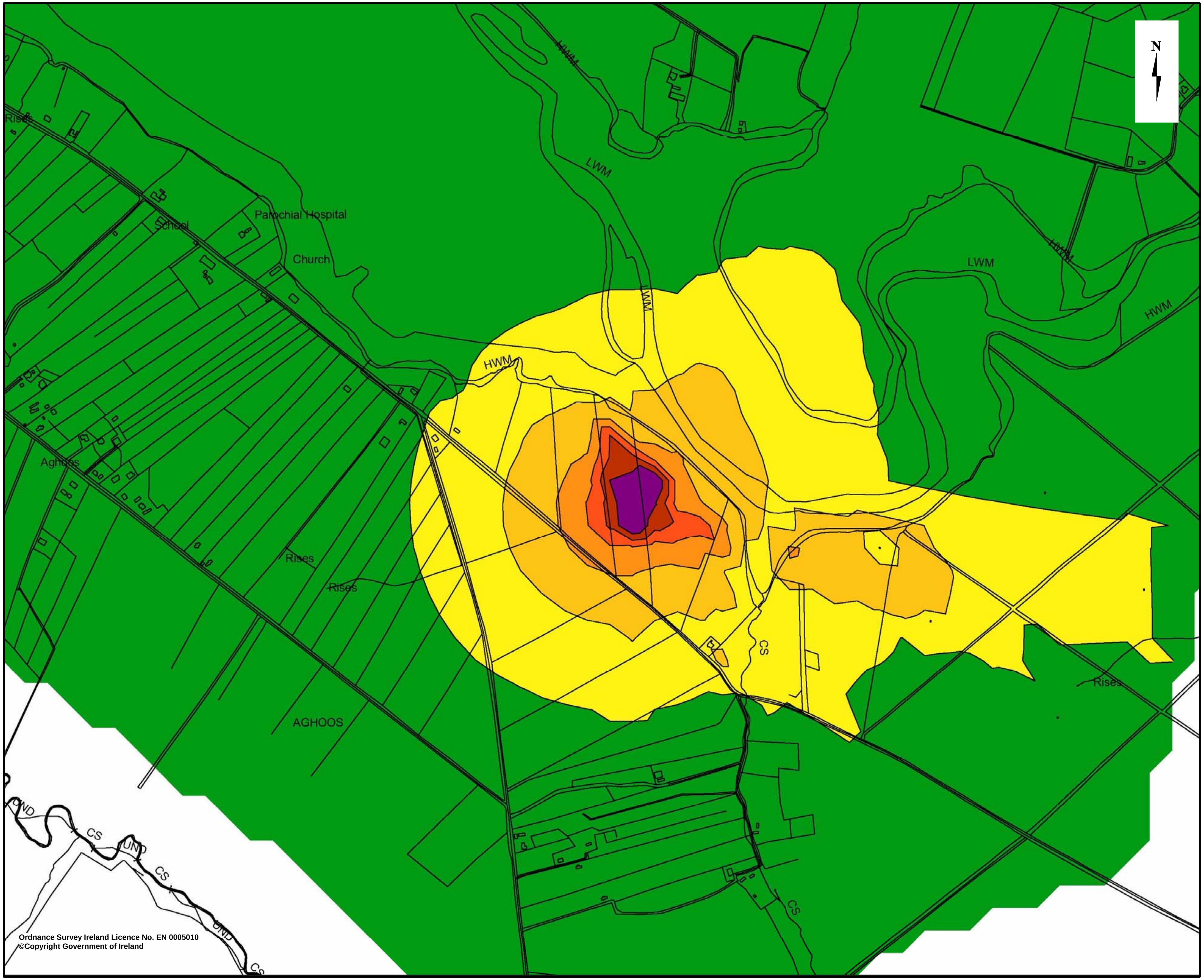
Figure 9.2b

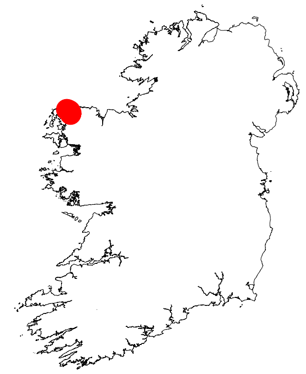
File Ref: COR25MDR0470Mi2459R02
Date: August 2010

CORRIB ONSHORE PIPELINE

Corrib natural gas

RPS





Legend

LEGEND	
	< 30.0 dB(A)
	30.0 - 35.0 dB(A)
	35.0 - 40.0 dB(A)
	40.0 - 45.0 dB(A)
	45.0 - 50.0 dB(A)
	50.0 - 55.0 dB(A)
	> 55.0 dB(A)

Predicted Construction
Noise Levels
(Night-time Enlarged Map)

Figure 9.2bii

File Ref: COR25MDR0470Mi2461R01
Date: August 2010

CORRIB ONSHORE PIPELINE

Table 9.8: Revised Predicted Construction works Daytime Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level dB L_{Aeq}	Measured Baseline Background Level dB L_{A90}	Predicted [Note1] Construction Noise level dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level dB L_{Aeq}	Cumulative [Note 2] Noise level dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level dB L_{Aeq}	Cumulative [Note 2] Noise level dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with NRA Assessment Criteria (65dB(A)
N1	44.1	38.3	48.2	4.1	49.6	Minor	9.9	48.6	Moderate	✓
N2	48.8	30.9	50.9	2.1	53.0	Not Significant	20.0	50.9	Severe	✓
N3	46.5	38.6	45.6	-0.9	49.1	No change	7.0	46.4	Moderate	✓
N4	46.5 (N6)	34.9 (N6)	43.0	-3.5	48.1	No change	8.1	43.6	Moderate	✓
N5	43.0	27.8	34.5	-8.5	43.6	No change	6.7	35.3	Moderate	✓
N6	46.5	34.9	36.8	-9.7	46.9	No change	1.9	39.0	Not significant	✓
N7	38.0	30.6	35.9	-2.1	40.1	No change	5.3	37.0	Minor	✓
N8	43.2	37.8	34.4	-8.8	43.7	No change	-3.4	39.4	No change	✓
N9	49.2	40.4	33.4	-15.8	49.3	No change	-7.0	41.2	No change	✓
N10	41.9	31.3	32.9	-9.0	42.4	No change	1.6	35.2	Not significant	✓
N11	51.9	40.0	29.9	-22.0	51.9	No change	-10.1	40.4	No change	✓
N12	48.8	31.1	31.8	-17.0	48.9	No change	0.7	34.5	Not significant	✓
N13	44.6	28.5	31.1	-13.5	44.8	No change	2.6	33.0	Minor	✓
N14	43.9	37.4	31.9	-12.0	44.2	No change	-5.5	38.5	No change	✓
N15	40.3	33.1	30.6	-9.7	40.7	No change	-2.5	35.0	No change	✓
N16	42.8	31.9	30.3	-12.5	43.0	No change	-1.6	34.2	No change	✓
N17	58.7	32.6	30.2	-28.5	58.7	No change	-2.4	34.6	No change	✓
N18	41.5	33.4	33.2	-8.3	42.1	Not Significant	-0.2	36.3	No change	✓
N19	48.6	35.9	37.3	-11.3	48.9	No change	1.4	39.7	Not significant	✓
N20	46.5	28.7	45.9	-0.6	49.2	N/A [Note3]	17.2	46.0	N/A [Note3]	N/A [Note3]

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 3: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 9.8: Revised Predicted Construction works Daytime Noise Levels at Noise Sensitive Locations during Construction Phase (continued)

Noise Sensitive Receptor	Measured Baseline Ambient Level dB L_{Aeq}	Measured Baseline Background Level dB L_{A90}	Predicted Note1 Construction Noise level dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with NRA Assessment Criteria (65dB(A)
N21	49.9	33.1	17.9	-32.0	49.9	No change	-15.2	33.2	No change	✓
N22	62.8	37.9	12.7	-50.1	62.8	No change	-25.2	37.9	No change	✓
N23	57.1	28.6	15.2	-41.9	57.1	No change	-13.4	28.8	No change	✓
N24	47.9	35.9	19.2	-28.7	47.9	No change	-16.7	36.0	No change	✓
N25	57.9	38.8	22.5	-35.4	57.9	No change	-16.3	38.9	No change	✓
N26	63.5	38.0	21.0	-42.5	63.5	No change	-17.0	38.1	No change	✓

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

The results indicate that the predicted daytime construction noise level associated with site works will not exceed the NRA assessment criteria for construction works or the 65dB(A) limit as applied to the terminal construction works, but as expected will rise significantly above (>3dB(A)) existing baseline levels at a number of properties in the area. There will be a minor negative temporary to short-term impact at N1. It should be noted that N1 represents a monitoring point near the proposed LVI compound at Gleann an Ghad (Glengad) and there is no property located at this point.

As shown in Column 10, the results indicate that the predicted noise levels will have a minor significant negative short-term impact at two locations (N7 and N13), a moderate significant negative temporary to short-term impact at four locations (N1, N3, N4 and N5) based on the existing background (L_{A90}) noise levels in the area. The results indicate that there will be a profound significant negative temporary impact at one property (N2) based on the existing background (L_{A90}) noise levels in the area. It should be noted that the revised assessment has considered the potential noise impacts associated with the site preparation/enabling works being undertaken at Glengad at the same time as tunnelling work are being undertaken at Aghoos. This scenario is representative of the likely noise impacts associated with a temporary stage of the overall construction programme only.

As shown in Column 6, the predicted cumulative noise levels are expected to range between L_{eq} 40.1dB(A) and 63.5dB(A), although it should be noted that whereas the cumulative level of 40.1dB(A) at the sensitive receptor N7 is attributable to the predicted construction noise level, the cumulative level at the sensitive receptor N22 of 62.8dB(A) is based on the existing ambient noise level. . It must also be borne in mind that these elevated noise levels are temporary to short-term impacts during the construction phase.

The predicted daytime construction noise levels would not be considered excessive for construction works. However, considering the existing low baseline noise level the perceived impact will be significant (>3dBs) at up to six properties (although one of these properties is not a sensitive receptor as such) with a profound significant negative (>15dB(A)) impact at one property. The tolerance for elevated noise levels during construction is generally increased if it is known that the works are to be completed within a short-term time frame.

Table 9.9: Revised Predicted Construction works Night-time Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level (Night-time) dB L_{Aeq}	Measured Baseline Background Level (Night-time) dB L_{A90}	Predicted [Note1] Construction Noise level (Night-time) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative [Note 2] Noise level (Night-time) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative [Note 2] Noise level (Night-time) dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with EPA & WHO Assessment Criteria (45dB(A))
N1	39.5 (N2)	25.0 (N2)	7.4	-32.1	39.5	No change	-17.6	25.1	No change	✓
N2	39.5	25.0	7.8	-31.7	39.5	No change	-17.2	25.1	No change	✓
N3	39.5 (N2)	25.0 (N2)	9.7	-29.8	39.5	No change	-15.3	25.1	No change	✓
N4	47.3 (N7)	42.1 (N7)	10.7	-36.6	47.3	No change	-31.4	42.1	No change	✓
N5	34.6 (N13)	26.6 (N13)	11.1	-23.5	34.6	No change	-15.5	26.7	No change	✓
N6	47.3 (N7 - 16/03/10)	42.1 N7-16/03/10	13.1	-34.2	47.3	No change	-29.0	42.1	No change	✓
N6	43.0 (N7 - 18/09/07)	35.9 N7-18/09/07	13.1	-29.9	43.0	No change	-22.8	35.9	No change	✓
N7	47.3 (16/03/10)	42.1 (16/03/10)	12.8	-34.5	47.3	No change	-29.3	42.1	No change	✓
N7	43.0 (18/09/07)	35.9 (18/09/07)	12.8	-30.2	43.0	No change	-23.1	35.9	No change	✓
N8	34.6 (N13)	26.6 (N13)	12.2	-22.4	34.6	No change	-14.4	26.8	No change	✓
N9	34.6 (N13)	26.6 (N13)	12.4	-22.2	34.6	No change	-14.2	26.8	No change	✓
N10	34.7	26.0	14.8	-19.9	34.7	No change	-11.2	26.3	No change	✓
N11	34.6 (N13)	26.6 (N13)	12.6	-22.0	34.6	No change	-14.0	26.8	No change	✓
N12	34.6 (N13)	26.6 (N13)	13.4	-21.2	34.6	No change	-13.2	26.8	No change	✓
N13	34.6	26.6	15.3	-19.3	34.7	No change	-11.3	26.9	No change	✓
N14	34.7 (N15)	26.0 (N15)	16.3	-18.4	34.8	No change	-9.7	26.4	No change	✓
N15	34.7	26.0	17.9	-16.8	34.8	No change	-8.1	26.6	No change	✓
N16	34.7 (N15)	26.0 (N15)	19.3	-15.4	34.8	No change	-6.7	26.8	No change	✓
N17	34.6 (N13)	26.6 (N13)	20.1	-14.5	34.8	No change	-6.5	27.5	No change	✓
N18	34.7 (N15)	26.0 (N15)	26.3	-8.4	35.3	No change	0.3	29.2	No change	✓
N19	37.9 N20 - 12/03/10	22.6 N2012/03/10	30.8	-7.1	38.7	No change	8.2	31.4	Moderate	✓
N19	31.3 N19 – 26/09/07	20 N19 26/09/07	30.8	-0.5	34.1	No change	10.8	31.1	Major	✓
N20	37.9 (12/03/10)	22.6 (12/03/10)	34.8	-3.1	39.6	N/A [Note3]	12.2	35.1	N/A [Note3]	N/A [Note3]
N20	35.8 (06/01/09)	28.1 (06/01/09)	34.8	-1.0	38.3	N/A [Note3]	6.7	35.6	N/A [Note3]	N/A [Note3]

Note 1: Noise level at sensitive receptor as a result of construction plant only. Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values. Results are based on night-time data from 24hour baseline measurements and predicted night-time construction noise levels. Note 3: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 9.9: Revised Predicted Construction works Night-time Noise Levels at Noise Sensitive Locations during Construction Phase (continued)

Noise Sensitive Receptor	Measured Baseline Ambient Level (Night-time) dB L_{Aeq}	Measured Baseline Background Level (Night-time) dB L_{A90}	Predicted Note1 Construction Noise level (Night-time) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with EPA & WHO Assessment Criteria (45dB(A))
N21	38.7	23.4	6.2	-32.5	38.7	No change	-17.2	23.5	No change	✓
N22	38.7 (N21)	23.4 (N21)	0.3	-38.4	38.7	No change	-23.1	23.4	No change	✓
N23	38.7 (N21)	23.4 (N21)	3.0	-35.7	38.7	No change	-20.4	23.4	No change	✓
N24	38.7 (N21)	23.4 (N21)	7.9	-30.8	38.7	No change	-15.5	23.5	No change	✓
N25	38.7 (N21)	23.4 (N21)	12.1	-26.6	38.7	No change	-11.3	23.7	No change	✓
N26	38.7 (N21)	23.4 (N21)	11.8	-26.9	38.7	No change	-11.6	23.7	No change	✓

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

It should be noted that night time construction activities will take place at the Aghoos Compound only. The results indicate that the predicted night-time construction noise levels associated with site works will not exceed the EPA or the WHO assessment criterion of 45dB(A) for night-time noise levels at any of the noise sensitive receptors, and will not give rise to any significant noise impacts at sensitive receptors in the area generally, based on the existing ambient (L_{Aeq}) night-time noise levels in the area. It is acknowledged that night-time noise levels have not been measured at all of the sensitive receptors in the area. However, night-time levels have been extrapolated to the other sensitive receptors in the area based on noise surveys carried out at other receptors in the area. A conservative approach has been taken in terms of extrapolating the noise levels to the different receptors, taking into consideration different surveys in a general area and the location which recorded lower levels of ambient or background noise, which could reasonably be taken as indicative of noise levels at receptors where monitoring was not undertaken.

The results also indicate that the predicted night-time construction noise levels will generally not give rise to any significant noise impacts at sensitive receptors in the area, based on the existing background (L_{A90}) night-time noise levels in the area, with the exception of one property, N19 where it is predicted that there will be a moderate to major significant negative short-term impact based on noise surveys carried out in the area in March 2010 and September 2007 respectively. Noise surveys were carried out at N20 on 12th March 2010, which is located in close proximity to the sensitive receptor N19, the results of this monitoring are provided in the EIS prepared in May 2010. Noise surveys were carried out at a sensitive receptor located opposite N19 on 26th September 2007, the results of which were provided in the EIS prepared in 2009 (receptor labelled N5 in the 2009 EIS). The predicted night-time construction noise levels are representative of the likely noise impacts associated with a the short-term construction programme, whereby night-time construction activities will only be undertaken at the Aghoos tunnelling compound.

It is noted that whereas the predicted night-time construction noise level during the construction phase will be within the EPA and WHO guidelines criterion of 45 dB(A) for night-time noise levels at all of the sensitive receptors in the area, the existing night-time ambient noise level at the sensitive receptor N7 was recorded at L_{eq} 47.3 dB(A) on 16th March 2010. The predicted cumulative noise levels in the area based on the ambient level of 47.3 dB(A) are therefore raised above the criterion of 45 dB(A). However, the existing night-time ambient noise level at the sensitive receptor N7 was recorded at L_{eq} 43.0 dB(A) on 18th September 2007. The predicted cumulative noise levels in the area based on the ambient level of 43.0 dB(A) are with the criterion of 45 dB(A).

The predicted cumulative noise level is expected to range between L_{eq} 34.1dB(A) and 47.3dB(A) based on the measured ambient levels. However, it should be noted that in both instances the predicted cumulative noise level is primarily attributable to the existing ambient night-time noise levels given that the existing ambient levels are 31.3dB(A) at the sensitive receptor N19, and 47.3dB(A) at the sensitive receptor N7 respectively. The corresponding predicted construction noise levels are 30.8dB(A) at N13 and 12.8dB(A) at N7 respectively. It should also be noted that the predicted night-time construction noise levels are short-term impacts.

The predicted night-time construction noise levels would not be considered excessive for construction works and will not give rise to a significant negative impact at any of the noise sensitive receptors in the area, even taking into account the existing low baseline noise levels in the area. The predicted night-time construction noise levels will however give rise to a moderate to major significant negative short-term impact at one property (N19) based on the background noise levels recorded in the area. The predicted night-time construction noise level at all properties is considered acceptable given that the levels are within the EPA and WHO guidelines levels and given significant noise abatement measures have been incorporated into the design of the construction works compounds in order to minimise noise emissions associated with the construction phase.

Table 9.10: Revised Predicted Construction Traffic Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level (Daytime) dB L_{Aeq}	Measured / Calculated Note1 Baseline L_{den} Level (day, evening, night) dB L_{den}	Predicted Note2 Construction Traffic Noise level (2011 DS) (Daytime) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Daytime) dB L_{Aeq}	Cumulative Note 3 Noise level (Daytime) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Total Cumulative Note 4 Construction Noise and Construction Traffic Noise level (Daytime) dB L_{Aeq}	Compliance with NRA Assessment Criteria (65dB(A))
N1	44.1	43.1	42.1	-2.0	46.2	No change	50.3	✓
N2	48.8	52.2	52.3	+3.5	53.9	Minor	55.7	✓
N3	46.5	38.6	57.1	+10.6	57.5	Major	57.7	✓
N4	---	---	---	---	---	---	---	✓
N5	43.0	42.0	52.5	+9.5	53.0	Moderate	53.0	✓
N6	46.5	45.5	40.5	-6.0	47.5	No change	47.8	✓
N7	38.0	56.0	40.8	+2.8	42.6	Minor	43.5	✓
N8	43.2	42.2	40.7	-2.5	45.1	No change	45.5	✓
N9	49.2	48.2	54.5	+5.3	55.6	Minor	55.6	✓
N10	41.9	40.9	43.0	+1.1	45.5	Not significant	45.7	✓
N11	51.9	50.9	51.5	-0.4	54.7	No change	54.7	✓
N12	48.8	47.8	52.2	+3.4	53.8	Minor	53.9	✓
N13	44.6	44.2	53.3	+8.7	53.8	Moderate	53.9	✓
N14	43.9	42.9	43.5	-0.4	46.7	No change	46.9	✓
N15	40.3	44.9	42.3	+2.0	44.4	Minor	44.6	✓
N16	42.8	41.8	42.5	-0.3	45.7	No change	45.8	✓
N17	58.7	57.7	64.4	+5.7	65.4	Moderate	65.4	✓
N18	41.5	40.5	44.2	+2.7	46.1	Minor	46.3	✓
N19	48.6	47.6	63.7	+15.1	63.8	Major	63.8	✓
N20	46.5	45.0	59.2	+12.7	59.4	N/A Note 5	59.6	N/A Note 5

Note 1: L_{den} noise level calculated based on 24-hr noise data used for N2, N7, N13, N15, and N20, L_{den} noise level calculated based on 15-minute short period noise surveys for other noise sensitive locations.
Note 2: Noise level at sensitive receptor as a result of construction traffic only.
Note 3: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 4: Addition of Measured Baseline Level and Predicted Total Construction noise (traffic and site related constriction works). dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 5: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 9.10: Revised Predicted Construction Traffic Noise Levels at Noise Sensitive Locations during Construction Phase (continued)

Noise Sensitive Receptor	Measured Baseline Ambient Level (Daytime) dB L_{Aeq}	Measured / Calculated Note1 Baseline L_{den} Level (day, evening, night) dB L_{den}	Predicted Note2 Construction Noise level (Daytime) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Daytime) dB L_{Aeq}	Cumulative Note 3 Noise level (Daytime) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Total Cumulative Note 4 Construction Noise and Construction Traffic Noise level (Daytime) dB L_{Aeq}	Compliance with NRA Assessment Criteria (65dB(A))
N21	49.9	51.8	54.5	+4.6	55.8	Minor	55.8	✓
N22	62.8	61.8	63.0	+0.2	65.9	Not significant	65.9	✗
N23	57.1	56.1	60.0	+2.9	61.8	Minor	61.8	✓
N24	47.9	46.9	38.0	-9.9	48.3	No change	48.3	✓
N25	57.9	56.9	60.0	+2.1	62.1	Not significant	62.1	✓
N26	63.5	62.5	57.6	-5.9	64.5	No change	64.5	✓

Note 1: L_{den} noise level calculated based on 24-hr noise data used for N2, N7, N13, N15, and N20, L_{den} noise level calculated based on 15-minute short period noise surveys for other noise sensitive locations.
Note 2: Noise level at sensitive receptor as a result of construction traffic only.
Note 3: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 4: Addition of Measured Baseline Level and Predicted Total Construction noise (traffic and site related constriction works). dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

The results indicate that the predicted construction traffic noise level on its own will not exceed the NRA assessment criteria for construction works or the 65dB(A) limit as applied to the Terminal construction works, but as expected will temporarily, rise significantly above (>3dB(A)) existing baseline levels. The predicted cumulative noise level incorporating the construction traffic noise levels and the baseline ambient noise levels indicate that the NRA criterion of 65dB(A) $L_{eq,\ 1hour}$, will be exceeded slightly (0.9 dB) at one property, N22, situated in close proximity to the junction of the R313 and the L1204. The predicted construction noise level at this property, which is attributable to construction traffic, is 63.0dB(A) and is therefore within the NRA assessment criterion of 65dB(A). However, the existing ambient noise level at this property was measured at a level of 62.8dB(A) L_{eq} and it is as a result of this baseline noise level that the cumulative noise level (65.9 dB(A))during the construction phase will be raised slightly above 65dB(A) on a temporary basis. It should be noted that the construction traffic noise levels have been predicted using the heaviest volume of traffic, which is expected to occur during Month 2 of the overall 26-month construction programme; therefore, construction traffic levels during the remainder of the construction period would be expected to be lower at this receptor.

The results also indicate that the predicted construction traffic noise levels will have a minor significant negative temporary impact at eight properties (N2, N7, N9, N12, N15, N18, N21 and N23); a moderate significant negative temporary impact at three properties (N5, N13 and N17); and a major significant negative temporary impact at two properties (N3 and N19) based on the existing ambient (L_{Aeq}) noise levels in the area. The predicted construction traffic noise levels and indeed the predicted total cumulative construction noise levels, which incorporate the existing ambient noise with both the predicted site works and construction traffic noise levels, are within the NRA assessment criteria of 65dB(A) at all of the noise sensitive receptors, with the exception of N22 as described above.

9.4.2.1 Ecologically Sensitive Receptors

9.4.3 Construction Phase – Vibration

The level of vibration attributable to HCV traffic on an uneven road surface would be considered to be more significant than that attributable to shallow pile driving works that may be required for construction works.

As a vehicle travels along a road, vibration can be generated in the road and subsequently propagate towards nearby buildings. Such vibration is generated by the interaction of a vehicle's wheels and the road surface and by direct transmission through the air of energy waves (sound waves). Some of these waves arise as a function of the size, shape and speed of the vehicle, and others from pressure fluctuations due to engine and exhaust noise generated by the vehicle. It has been found that ground vibrations produced by road traffic are unlikely to cause perceptible structural vibration in properties located near well-maintained and smooth road surfaces. Road traffic vibration levels can therefore be largely minimised by maintenance of the road surface.

There will be no significant sources of vibration during reinstatement.

9.4.4 Construction Phase – Groundborne Noise and Vibration from Tunnelling

9.4.5 Operational Phase - Noise

9.4.6 Operational Phase - Vibration

9.5 MITIGATION MEASURES

9.5.1 Construction Phase - Noise from Terrestrial Works

Mitigation measures, as outlined in BS 5228, *"Noise and Vibration Control on Construction and Open Sites,"* will be employed on-site during construction. These measures will include the following:

- With the exception of the 24-hour, 7-day tunnelling works construction activities, normal working hours will be 0700-1900 hours Monday to Friday and 0800-1600 hours on Saturdays. Some additional work may be required outside these hours e.g. inspection, testing and commissioning activities. Night-time security will patrol the temporary compounds and working areas. Apart from the tunnelling works construction activities, Sunday working will be avoided where possible, but cannot be entirely excluded. Aside from the tunnelling works, construction activities outside of normal hours will only take place outside of normal hours after prior consultation with Mayo County Council and the notification of local community.

- A dedicated 3m tall noise attenuation barrier will be installed around the perimeter of both the Tunnelling works launch pit at na hEachú (Aghoos) and the reception pit at Gleann an Ghad (Glengad). This noise attenuation barrier has been incorporated into the noise prediction model.

- Additional noise abatement has also been incorporated into the design of plant and machinery that will be used in association with the tunnelling works during the construction phase. The tunnelling works design team carried out a review of the noise emissions data associated with the plant and machinery to be used during the tunnelling works in an effort to determine additional measures that will be implemented in order to reduce the level of noise associated with the tunnelling works, particularly during the night-time due to the requirement that tunnelling works are proposed to be undertaken on a 24-hour basis for the temporary to short-term duration of the proposed works.

- This review has identified scope for additional noise abatement both in the form of specification of alternative equipment with lower noise output and the design of additional noise abatement measures that will reduce the level of noise generated at source in the tunnelling compound at Aghoos. The noise prediction models have been revised to take into consideration the revised noise specification for the tunnelling works.

- It is also proposed to modify the original proposals associated with the Glengad compound in order to reduce the potential noise impact associated with site preparation works at the tunnel reception compound and at the LVI compound. The site design team have revised the assessment regarding the requirement to pump water during the night-time (22:00 – 08:00) and it is now proposed that water will not be pumped from the tunnel reception pit or the LVI site at Glengad during the construction works at either of these sites. This has also been incorporated into the revised noise prediction models.

- The noise predictions have been revised to take account of the modifications both in terms of specification of alternative equipment with lower noise output, the design of additional noise abatement measures to reduce the level of noise generated at source, and the elimination of a number of sources that were previously proposed to operate during the night.

- All plant and machinery that will be used during the construction works, including generators and pumps, will be housed within proprietary acoustic enclosures. Power packs and tunnelling works plant and machinery will also be housed within self-contained acoustic enclosures, designed to reduce noise emissions at source. These mitigations measures will be incorporated into the contract documents for the contractor(s) appointed to undertake the construction works and are in addition to the noise attenuation barriers which will be provided for the tunnelling compounds at na hEachú (Aghoos) and Gleann an Ghad (Glengad).

- A maximum speed limit of 60km/hr on the haul routes on the R313, L1204, R314, L1202 (with the exception of the section of the L1202 from na hEachú (Aghoos) to Gleann an Ghad (Glengad)) will be imposed for HCVs and drivers will be instructed to maintain as far as possible the distances between vehicles. On reduced widths sections of the L1202, a maximum speed limit varying between 30km/hr and 50km/hr will be imposed for HCVs on the section of the L1202 from na hEachú (Aghoos) to Gleann an Ghad (Glengad). A Traffic Management Plan will be put in place to minimise congestion (see Appendix E).

9.5.2 Construction - Vibration from Terrestrial Works

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[1] Please note where the text has been omitted there is no change to the EIS as submitted.

5 POTENTIAL NOISE AND VIBRATION IMPACT

Subsequent to the preparation of the EIS in May 2010, the tunnelling works design team have undertaken a review of the noise emissions data associated with the plant and machinery that will be utilised during the construction phase. This review has identified scope for additional noise abatement both in the form of specification of alternative equipment with lower noise output and the design of additional noise abatement measures that will reduce the level of noise generated at source in the tunnelling compound at Aghoos. The noise prediction models have been revised to take into consideration the revised noise specification for the tunnelling works. The results of the revised prediction models are presented in Table 6.1, Table 6.2 and have also been incorporated into the calculation of the total cumulative noise levels presented in Table 6.3. The total cumulative levels have not changed as a result of the changes to the noise sources within the compounds, due to the influence of construction traffic on the overall cumulative noise levels.

In addition to the modifications to the noise sources associated with the tunnelling works at the Aghoos compound, it is also proposed to modify the original proposals associated with the Glengad compound in order to reduce the potential noise impact associated with site preparation works at the tunnel reception compound and at the LVI compound. The noise assessment presented in the EIS prepared in May 2010 considered the noise impact associated with a diesel powered water pump in use during the night-time at Glengad during the temporary construction works. The site design team have revised the assessment regarding the requirement to pump water during the night-time (22:00 – 08:00) and it is now proposed that water will not be pumped from the tunnel reception pit or the LVI site at Glengad during the construction works at either of these sites. This has also been incorporated into the revised noise prediction models.

5.1 CONSTRUCTION PHASE

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6 PREDICTED NOISE AND VIBRATION IMPACT

6.1 CONSTRUCTION PHASE NOISE IMPACT

A digital noise prediction model for the scheme was constructed using the Bruel and Kjaer 7810 Predictor Version 6 software package. The noise-modelling package uses a computer based noise propagation model, in accordance with the ISO 9613-2 standard, "*Acoustics - Attenuation of sound during propagation outdoors*", which is an international standard used to undertake noise prediction modelling. The plant and machinery sound power levels were sourced from manufacturer's data for the tunnelling equipment, provided by de la Motte & Partner. Noise data for plant and machinery associated with the construction works other than the tunnelling equipment were sourced from BS 5228, "*Noise and Vibration Control on Construction and Open Sites, 2009,*" and the Department for Environment Food and Rural Affairs (defra), "*Updated Noise Database for Prediction of Noise on Construction and Open Sites*," (defra, 2005). The noise model was constructed based on the ISO 9613-2 standard method using the receptor locations outlined previously. The proposed pipeline design was imported into the noise prediction model along with the local topography. The revised list of plant and machinery input into the revised models and the corresponding noise data are included in the revised Appendix D.

To allow for prediction of the likely significant impacts the total plant involved in all stages of the construction works was input as single sources within the boundaries of the construction working areas, which are relatively close to a number of the sensitive receptors.

Considering the progressive nature of the works, e.g. soil and peat will have to be excavated before the tunnelling works launch and reception pits can be constructed, and before the stone road is constructed, and before trenching and constructing the pipe can begin, etc., each item of plant will not be operating simultaneously.

In order to predict the greatest level of potentially significant impacts a conservative assessment was undertaken for a scenario whereby, each item of plant that will be operational during the day has been input into the model as operational simultaneously on a regular basis. As outlined above, the noise emissions data associated with the tunnelling works has been revised to take account of additional noise abatement measures that have been identified subsequent to the preparation of the EIS in May 2010. Additional noise attenuation has been designed in the form of increased acoustic cladding and specification of alternative machinery that will generate lower levels of noise at source.

These revisions are summarised as follows:

- Reduction of noise emanating from the three power packs required to power the tunnel boring machine;
- Centrifuges that were previously considered needed to operate on a 24-hour basis will now not operate during the hours 23:00 – 07:00;
- Reduction of noise emanating from the separation plant required to grade/screen material from the tunnel arising;
- Specification of alternative wheeled loader required intermittently in the temporary storage area, with significantly reduced noise emissions; and
- Trucks that were previously considered necessary to operate at times within the tunnelling compound during the night-time will now not operate during the hours 23:00 – 07:00.

In addition to the noise abatement measures at the Aghoos compound, as outlined above modifications have also been incorporated into the proposed construction works at the tunnel reception pit compound and the LVI compound at Glengad, such that water pumping during the night-time that was assessed in the EIS prepared in May 2010, is no longer proposed to be carried out.

Therefore, the results of the modelling represent a conservative assessment of the potential likely construction noise that may be generated at the site. It should be noted however that the revised assessment has considered the potential noise impacts associated with the site preparation/enabling works being undertaken at Glengad at the same time as tunnelling work are being undertaken at Aghoos. This scenario is representative of the likely noise impacts associated with a temporary stage of the overall construction programme only. The construction works at Glengad reception compound will extend for a period of approximately 3 months (months 16 – 18, refer to Figure 5.2, Chapter 5 of the EIS), and the LVI compound for a period of approximately 3 months (months 2 – 4, refer to Figure 5.2, Chapter 5 of the EIS), whereas the tunnelling works will extend for a period of approximately 15 months (months 5 – 19, refer to Figure 5.2, Chapter 5 of the EIS).

The assessment presented in the EIS prepared in May 2010 considered a scenario whereby, noise emissions associated with plant servicing the tunnelling compound at na hEachú (Aghoos) would be operational on a continuous basis for approximately 15 months duration, although not all noise sources at na hEachú (Aghoos) would typically operate simultaneously. These noise sources had been input into the model as being operational for 100% of the time on a 24-hour basis. Those noise sources had been modelled in tandem with the site preparation noise sources at the reception pit at Gleann an Ghad (Glengad) in order to predict the potential worst-case noise emissions during the construction phase. As outlined above, the noise predictions have been revised to take account of the modifications both in terms of specification of alternative equipment with lower noise output, the design of additional noise abatement measures to reduce the level of noise generated at source, and the elimination of a number of sources that were previously proposed to operate during the night.

The noise sources at the reception pit in glean an Ghad (Glengad) will be present for less than 12 months and will not generate noise on a continuous basis, when present. Night-time works are not anticipated at Gleann an Ghad (Glengad). Details of the revised plant and machinery input into the revised noise models are presented in the revised Appendix H1.

Night-time security will patrol the temporary compounds and working areas. Apart from the tunnelling activities, Sunday working will be avoided, where possible, but cannot be entirely excluded. Aside from the tunnelling works, construction activities outside of normal hours will only take place after prior consultations with Mayo County Council and notification of the local community.

The revised predicted daytime and night-time noise levels at the various receptors are presented in Table 6.1 and Table 6.2 and illustrated in Figures 6.2a and 6.2b (& 6.2bii) (6.2b & 6.2bii are the same figures but at different scales) respectively. The results were compared to existing baseline noise levels in the vicinity of each receptor (both existing ambient noise levels (L_{Aeq}) and existing background noise levels (L_{A90})). Cumulative noise levels are shown for a combination of the predicted levels with both existing ambient noise levels and existing background noise levels. The predicted noise levels were also compared with assessment criteria adopted by the NRA and the Bellanaboy Bridge Terminal EIS.

The predicted traffic noise levels associated with the construction phase of the proposed pipeline are presented in Table 6.3. It is predicted that properties located along the haul routes will experience an increase in traffic noise levels ranging from a minimum of less than 1dB (0.2dB) which would be considered as no change or an imperceptible impact based on existing ambient noise levels measured at the sensitive receptor N22 (located off the L1204), to a maximum of 15.1dB which would be considered as a major significant, short-term to temporary impact associated with construction traffic during the busiest stage of the construction programme (Month 2), and the existing ambient noise levels measured at the sensitive receptor N19 (located off the L1202).

The predicted increase in traffic noise levels due to construction traffic ranges from 0.0dB to 7.8dB for properties located along the L1202 between Belagelly South and Glengad, based on predicted construction traffic noise levels compared with predicted future traffic noise levels in the absence of construction traffic on the L1202. These increases would be considered as an imperceptible impact and moderate negative impact, respectively.

The predicted increase in traffic noise levels due to construction traffic ranges from 0.9dB to 3.3dB (dependent upon proximity to the road) for properties located along the L1204 between Srahmore and

Bellanaboy Bridge, which would be considered as imperceptible and minor negative impacts, respectively.

The following is an explanation of the information provided in Table 6.1:

- Column 2: Is the measured baseline ambient level, i.e. the measured level during the monitoring period (L_{Aeq}) and represents the continuous steady noise level or the average noise level during the survey;
- Column 3: Is the measured baseline background level, i.e. the measured noise level that is equalled or exceeded for 90% of the monitoring period (L_{A90});
- Column 4: Is the predicted construction noise level (L_{Aeq});
- Column 5: Is the difference between the baseline ambient level (L_{Aeq}) in Column 2 and the predicted construction noise level (L_{Aeq}) in Column 4 and is used to determine the impact rating in Column 7;
- Column 6: Is the cumulative noise level arising from the combination of the baseline ambient level (L_{Aeq}) in Column 2 and the predicted construction level (L_{Aeq}) in Column 4;
- Column 7: Is the impact rating based on the information in Column 5 and compared with Table 2.3;
- Column 8: Is the difference between the baseline background level (L_{A90}) in Column 3 and the predicted construction noise level (L_{Aeq}) in Column 4 and is used to determine the impact rating in Column 10;
- Column 9: Is the cumulative noise level arising from the combination of the baseline background level (L_{A90}) in Column 3 and the predicted construction level (L_{Aeq}) in Column 4;
- Column 10: Is the impact rating based on the information in Column 8 and compared with Table 2.3; and
- Column 11: Is the comparison of the cumulative noise level in Column 9 with the NRA Guideline value of 65 dB(A).

Interpretation of Table 6.2 is similar to the above.

Table 6.1: Revised Predicted Construction works Daytime Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level dB L_{Aeq}	Measured Baseline Background Level dB L_{A90}	Predicted Note1 Construction Noise level dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with Assessment Criteria (65dB(A)
N1	44.1	38.3	48.2	4.1	49.6	Minor	9.9	48.6	Moderate	✓
N2	48.8	30.9	50.9	2.1	53.0	Not Significant	20.0	50.9	Severe	✓
N3	46.5	38.6	45.6	-0.9	49.1	No change	7.0	46.4	Moderate	✓
N4	46.5 (N6)	34.9 (N6)	43.0	-3.5	48.1	No change	8.1	43.6	Moderate	✓
N5	43.0	27.8	34.5	-8.5	43.6	No change	6.7	35.3	Moderate	✓
N6	46.5	34.9	36.8	-9.7	46.9	No change	1.9	39.0	Not significant	✓
N7	38.0	30.6	35.9	-2.1	40.1	No change	5.3	37.0	Minor	✓
N8	43.2	37.8	34.4	-8.8	43.7	No change	-3.4	39.4	No change	✓
N9	49.2	40.4	33.4	-15.8	49.3	No change	-7.0	41.2	No change	✓
N10	41.9	31.3	32.9	-9.0	42.4	No change	1.6	35.2	Not significant	✓
N11	51.9	40.0	29.9	-22.0	51.9	No change	-10.1	40.4	No change	✓
N12	48.8	31.1	31.8	-17.0	48.9	No change	0.7	34.5	Not significant	✓
N13	44.6	28.5	31.1	-13.5	44.8	No change	2.6	33.0	Minor	✓
N14	43.9	37.4	31.9	-12.0	44.2	No change	-5.5	38.5	No change	✓
N15	40.3	33.1	30.6	-9.7	40.7	No change	-2.5	35.0	No change	✓
N16	42.8	31.9	30.3	-12.5	43.0	No change	-1.6	34.2	No change	✓
N17	58.7	32.6	30.2	-28.5	58.7	No change	-2.4	34.6	No change	✓
N18	41.5	33.4	33.2	-8.3	42.1	Not Significant	-0.2	36.3	No change	✓
N19	48.6	35.9	37.3	-11.3	48.9	No change	1.4	39.7	Not significant	✓
N20	46.5	28.7	45.9	-0.6	49.2	N/A Note3	17.2	46.0	N/A Note3	N/A Note3

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 3: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 6.1: Revised Predicted Construction works Daytime Noise Levels at Noise Sensitive Locations during Construction Phase (continued)

Noise Sensitive Receptor	Measured Baseline Ambient Level dB L_{Aeq}	Measured Baseline Background Level dB L_{A90}	Predicted Note1 Construction Noise level dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level dB L_{Aeq}	Cumulative Note 2 Noise level dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with Assessment Criteria (65dB(A)
N21	49.9	33.1	17.9	-32.0	49.9	No change	-15.2	33.2	No change	✓
N22	62.8	37.9	12.7	-50.1	62.8	No change	-25.2	37.9	No change	✓
N23	57.1	28.6	15.2	-41.9	57.1	No change	-13.4	28.8	No change	✓
N24	47.9	35.9	19.2	-28.7	47.9	No change	-16.7	36.0	No change	✓
N25	57.9	38.8	22.5	-35.4	57.9	No change	-16.3	38.9	No change	✓
N26	63.5	38.0	21.0	-42.5	63.5	No change	-17.0	38.1	No change	✓

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

The results indicate that the predicted daytime construction noise level associated with site works will not exceed the NRA assessment criteria for construction works or the 65dB(A) limit as applied to the terminal construction works, but as expected will rise significantly above (>3dB(A)) existing baseline levels at a number of properties in the area. There will be a minor negative temporary to short-term impact at N1. It should be noted that N1 represents a monitoring point near the proposed LVI compound at Glengad and there is no property located at this point.

However, the results indicate that the predicted noise levels will have a minor significant negative impact at two locations (N7 and N13), a moderate significant negative temporary to short-term impact at four locations (N1, N3, N4 and N5) based on the existing background (L_{A90}) noise levels in the area. The results indicate that there will be a profound significant negative temporary impact at one property (N2) based on the existing background (L_{A90}) noise levels in the area. It should be noted that the revised assessment has considered the potential noise impacts associated with the site preparation/enabling works being undertaken at Glengad at the same time as tunnelling work are being undertaken at Aghoos. This scenario is representative of the likely noise impacts associated with a temporary stage of the overall construction programme only.

The predicted cumulative noise level is expected to range between L_{eq} 40.1dB(A) and 63.5dB(A), although it should be noted that whereas the cumulative level of 40.1dB(A) at the sensitive receptor N7 is attributable to the predicted construction noise level, the cumulative level at the sensitive receptor N22 of 62.8dB(A) is based on the existing ambient noise level. It must also be borne in mind that these elevated noise levels are temporary to short-term impacts during the construction phase.

The predicted daytime construction noise levels would not be considered excessive for construction works. However, considering the existing low baseline noise level the perceived impact will be significant (>3dBs) at up to six properties (although one of these properties is not a sensitive receptor as such) with a profound significant negative (>15dB(A)) impact at one property. The tolerance for elevated noise levels during construction is generally increased if it is known that the works are to be completed within a short-term time frame.

Table 6.2: Revised Predicted Construction works Night-time Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level (Night-time) dB L_{Aeq}	Measured Baseline Background Level (Night-time) dB L_{A90}	Predicted Note1 Construction Noise level (Night-time) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with EPA & WHO Assessment Criteria (45dB(A))
N1	39.5 (N2)	25.0 (N2)	7.4	-32.1	39.5	No change	-17.6	25.1	No change	✓
N2	39.5	25.0	7.8	-31.7	39.5	No change	-17.2	25.1	No change	✓
N3	39.5 (N2)	25.0 (N2)	9.7	-29.8	39.5	No change	-15.3	25.1	No change	✓
N4	47.3 (N7)	42.1 (N7)	10.7	-36.6	47.3	No change	-31.4	42.1	No change	✓
N5	34.6 (N13)	26.6 (N13)	11.1	-23.5	34.6	No change	-15.5	26.7	No change	✓
N6	47.3 (N7 - 16/03/10)	42.1 N7-16/03/10	13.1	-34.2	47.3	No change	-29.0	42.1	No change	✓
N6	43.0 (N7 - 18/09/07)	35.9 N7-18/09/07	13.1	-29.9	43.0	No change	-22.8	35.9	No change	✓
N7	47.3 (16/03/10)	42.1 (16/03/10)	12.8	-34.5	47.3	No change	-29.3	42.1	No change	✓
N7	43.0 (18/09/07)	35.9 (18/09/07)	12.8	-30.2	43.0	No change	-23.1	35.9	No change	✓
N8	34.6 (N13)	26.6 (N13)	12.2	-22.4	34.6	No change	-14.4	26.8	No change	✓
N9	34.6 (N13)	26.6 (N13)	12.4	-22.2	34.6	No change	-14.2	26.8	No change	✓
N10	34.7	26.0	14.8	-19.9	34.7	No change	-11.2	26.3	No change	✓
N11	34.6 (N13)	26.6 (N13)	12.6	-22.0	34.6	No change	-14.0	26.8	No change	✓
N12	34.6 (N13)	26.6 (N13)	13.4	-21.2	34.6	No change	-13.2	26.8	No change	✓
N13	34.6	26.6	15.3	-19.3	34.7	No change	-11.3	26.9	No change	✓
N14	34.7 (N15)	26.0 (N15)	16.3	-18.4	34.8	No change	-9.7	26.4	No change	✓
N15	34.7	26.0	17.9	-16.8	34.8	No change	-8.1	26.6	No change	✓
N16	34.7 (N15)	26.0 (N15)	19.3	-15.4	34.8	No change	-6.7	26.8	No change	✓
N17	34.6 (N13)	26.6 (N13)	20.1	-14.5	34.8	No change	-6.5	27.5	No change	✓
N18	34.7 (N15)	26.0 (N15)	26.3	-8.4	35.3	No change	0.3	29.2	No change	✓
N19	37.9 N20 - 12/03/10	22.6 N2012/03/10	30.8	-7.1	38.7	No change	8.2	31.4	Moderate	✓
N19	31.3 N19 – 26/09/07	20 N19 26/09/07	30.8	-0.5	34.1	No change	10.8	31.1	Major	✓
N20	37.9 (12/03/10)	22.6 (12/03/10)	34.8	-3.1	39.6	N/A Note3	12.2	35.1	N/A Note3	N/A Note3
N20	35.8 (06/01/09)	28.1 (06/01/09)	34.8	-1.0	38.3	N/A Note3	6.7	35.6	N/A Note3	N/A Note3

Note 1: Noise level at sensitive receptor as a result of construction plant only. Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values. Results are based on night-time data from 24hour baseline measurements and predicted night-time construction noise levels. Note 3: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 9.9: Revised Predicted Construction works Night-time Noise Levels at Noise Sensitive Locations during Construction Phase (continued)

Noise Sensitive Receptor	Measured Baseline Ambient Level (Night-time) dB L_{Aeq}	Measured Baseline Background Level (Night-time) dB L_{A90}	Predicted Note1 Construction Noise level (Night-time) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Difference between Baseline L_{A90} & Predicted Level (Night-time) dB L_{Aeq}	Cumulative Note 2 Noise level (Night-time) dB L_{Aeq} & L_{A90}	Impact Rating (L_{A90})	Compliance with EPA & WHO Assessment Criteria (45dB(A))
N21	38.7	23.4	6.2	-32.5	38.7	No change	-17.2	23.5	No change	✓
N22	38.7 (N21)	23.4 (N21)	0.3	-38.4	38.7	No change	-23.1	23.4	No change	✓
N23	38.7 (N21)	23.4 (N21)	3.0	-35.7	38.7	No change	-20.4	23.4	No change	✓
N24	38.7 (N21)	23.4 (N21)	7.9	-30.8	38.7	No change	-15.5	23.5	No change	✓
N25	38.7 (N21)	23.4 (N21)	12.1	-26.6	38.7	No change	-11.3	23.7	No change	✓
N26	38.7 (N21)	23.4 (N21)	11.8	-26.9	38.7	No change	-11.6	23.7	No change	✓

Note 1: Noise level at sensitive receptor as a result of construction plant only.
Note 2: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

It should be noted that night time construction activities will take place at the Aghoos Compound only. The results indicate that the predicted night-time construction noise levels associated with site works will not exceed the EPA or the WHO assessment criterion of 45dB(A) for night-time noise levels at any of the noise sensitive receptors, and will not give rise to any significant noise impacts at sensitive receptors in the area generally, based on the existing ambient (L_{Aeq}) night-time noise levels in the area. It is acknowledged that night-time noise levels have not been measured at all of the sensitive receptors in the area. However, night-time levels have been extrapolated to the other sensitive receptors in the area based on noise surveys carried out at other receptors in the area. A conservative approach has been taken in terms of extrapolating the noise levels to the different receptors, taking into consideration different surveys in a general area and the location which recorded lower levels of ambient or background noise, which could reasonably be taken as indicative of noise levels at receptors where monitoring was not undertaken.

The results also indicate that the predicted night-time construction noise levels will generally not give rise to any significant noise impacts at sensitive receptors in the area, based on the existing background (L_{A90}) night-time noise levels in the area, with the exception of one property, N19 where it is predicted that there will be a moderate to major significant negative short-term impact based on noise surveys carried out in the area in March 2010 and September 2007 respectively. Noise surveys were carried out at N20 on 12th March 2010, which is located in close proximity to the sensitive receptor N19, the results of this monitoring are provided in the EIS prepared in May 2010. Noise surveys were carried out at a sensitive receptor located opposite N19 on 26th September 2007, the results of which were provided in the EIS prepared in 2009 (receptor labelled N5 in the 2009 EIS). The predicted night-time construction noise levels are representative of the likely noise impacts associated with a the short-term construction programme, whereby night-time construction activities will only be undertaken at the Aghoos tunnelling compound.

It is noted that whereas the predicted night-time construction noise level during the construction phase will be within the EPA and WHO guidelines criterion of 45 dB(A) for night-time noise levels at all of the sensitive receptors in the area, the existing night-time ambient noise level at the sensitive receptor N7 was recorded at L_{eq} 47.3 dB(A) on 16th March 2010. The predicted cumulative noise levels in the area based on the ambient level of 47.3 dB(A) are therefore raised above the criterion of 45 dB(A). However, the existing night-time ambient noise level at the sensitive receptor N7 was recorded at L_{eq} 43.0 dB(A) on 18th September 2007. The predicted cumulative noise levels in the area based on the ambient level of 43.0 dB(A) are with the criterion of 45 dB(A).

The predicted cumulative noise level is expected to range between L_{eq} 34.1dB(A) and 47.3dB(A) based on the measured ambient levels. However, it should be noted that in both instances the predicted cumulative noise level is primarily attributable to the existing ambient night-time noise levels given that the existing ambient levels are 31.3dB(A) at the sensitive receptor N19, and 47.3dB(A) at the sensitive receptor N7, respectively. The corresponding predicted construction noise levels are 30.8dB(A) at N13 and 12.8dB(A) at N7, respectively. It should also be noted that the predicted night-time construction noise levels are short-term impacts for the duration of the construction phase.

The predicted night-time construction noise levels would not be considered excessive for construction works and will not give rise to a significant negative impact at any of the noise sensitive receptors in the area, even taking into account the existing low baseline noise levels in the area. The predicted night-time construction noise levels will however give rise to a moderate to major significant negative short-term impact at one property (N19) based on the background noise levels recorded in the area. The predicted night-time construction noise level at all properties is considered acceptable given that the levels are within the EPA and WHO guidelines levels and given significant noise abatement measures have been incorporated into the design of the construction works compounds in order to minimise noise emissions associated with the construction phase.

Table 6.3: Revised Predicted Construction Traffic Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level (Daytime) dB L_{Aeq}	Measured / Calculated Note1 Baseline Lden Level (day, evening, night) dB L_{den}	Predicted Note2 Construction Traffic Noise level (2011 DS) (Daytime) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Daytime) dB L_{Aeq}	Cumulative Note 3 Noise level (Daytime) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Total Cumulative Note 4 Construction Noise and Construction Traffic Noise level (Daytime) dB L_{Aeq}	Compliance with Assessment Criteria (65dB(A))
N1	44.1	43.1	42.1	-2.0	46.2	No change	50.3	✓
N2	48.8	52.2	52.3	+3.5	53.9	Minor	55.7	✓
N3	46.5	38.6	57.1	+10.6	57.5	Major	57.7	✓
N4	---	---	---	---	---	---	---	✓
N5	43.0	42.0	52.5	+9.5	53.0	Moderate	53.0	✓
N6	46.5	45.5	40.5	-6.0	47.5	No change	47.8	✓
N7	38.0	56.0	40.8	+2.8	42.6	Minor	43.5	✓
N8	43.2	42.2	40.7	-2.5	45.1	No change	45.5	✓
N9	49.2	48.2	54.5	+5.3	55.6	Minor	55.6	✓
N10	41.9	40.9	43.0	+1.1	45.5	Not significant	45.7	✓
N11	51.9	50.9	51.5	-0.4	54.7	No change	54.7	✓
N12	48.8	47.8	52.2	+3.4	53.8	Minor	53.9	✓
N13	44.6	44.2	53.3	+8.7	53.8	Moderate	53.9	✓
N14	43.9	42.9	43.5	-0.4	46.7	No change	46.9	✓
N15	40.3	44.9	42.3	+2.0	44.4	Minor	44.6	✓
N16	42.8	41.8	42.5	-0.3	45.7	No change	45.8	✓
N17	58.7	57.7	64.4	+5.7	65.4	Moderate	65.4	✓
N18	41.5	40.5	44.2	+2.7	46.1	Minor	46.3	✓
N19	48.6	47.6	63.7	+15.1	63.8	Major	63.8	✓
N20	46.5	45.0	59.2	+12.7	59.4	N/A Note 5	59.6	N/A Note 5

Note 1: Lden noise level calculated based on 24-hr noise data used for N2, N7, N13, N15, and N20, Lden noise level calculated based on 15-minute short period noise surveys for other noise sensitive locations.

Note 2: Noise level at sensitive receptor as a result of construction traffic only.

Note 3: Addition of Measured Baseline Level and Predicted Construction noise. dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

Note 4: Addition of Measured Baseline Level and Predicted Total Construction noise (traffic and site related constriction works). dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

Note 5: N20 is a vacant property, owned by SEPIL and is not a noise sensitive receptor as such. Therefore, impacts at this property have not been assessed.

Table 6.3: Revised Predicted Construction Traffic Noise Levels at Noise Sensitive Locations during Construction Phase

Noise Sensitive Receptor	Measured Baseline Ambient Level (Daytime) dB L_{Aeq}	Measured / Calculated Note1 Baseline Lden Level (day, evening, night) dB L_{den}	Predicted Note2 Construction Noise level (Daytime) dB L_{Aeq}	Difference between Baseline L_{Aeq} & Predicted Level (Daytime) dB L_{Aeq}	Cumulative Note 3 Noise level (Daytime) dB L_{Aeq} & L_{Aeq}	Impact Rating (L_{Aeq})	Total Cumulative Note 4 Construction Noise and Construction Traffic Noise level (Daytime) dB L_{Aeq}	Compliance with Assessment Criteria (65dB(A))
N21	49.9	51.8	54.5	+4.6	55.8	Minor	55.8	✓
N22	62.8	61.8	63.0	+0.2	65.9	Not significant	65.9	×
N23	57.1	56.1	60.0	+2.9	61.8	Minor	61.8	✓
N24	47.9	46.9	38.0	-9.9	48.3	No change	48.3	✓
N25	57.9	56.9	60.0	+2.1	62.1	Not significant	62.1	✓
N26	63.5	62.5	57.6	-5.9	64.5	No change	64.5	✓

Note 1: Lden noise level calculated based on 24-hr noise data used for N2, N7, N13, N15, and N20, Lden noise level calculated based on 15-minute short period noise surveys for other noise sensitive locations.
Note 2: Noise level at sensitive receptor as a result of construction traffic only.
Note 3: Addition of Measured Baseline Level and Predicted Total Construction noise (traffic and site related constriction works). dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.
Note 4: Addition of Measured Baseline Level and Predicted Total Construction noise (traffic and site related constriction works). dBs are logarithmic values, therefore cannot be added together arithmetically as is done for linear values.

The results indicate that the predicted construction traffic noise level on its own will not exceed the NRA assessment criteria for construction works or the 65dB(A) limit as applied to the Terminal construction works, but as expected will temporarily, rise significantly above (>3dB(A)) existing baseline levels. The predicted cumulative noise level incorporating the construction traffic noise levels and the baseline ambient noise levels indicate that the NRA criterion of 65dB(A) $L_{eq,\ 1hour}$, will be exceeded slightly (0.9 dB) at one property, N22, situated in close proximity to the junction of the R313 and the L1204. The predicted construction noise level at this property, which is attributable to construction traffic, is 63.0dB(A) and is therefore within the NRA assessment criterion of 65dB(A). However, the existing ambient noise level at this property was measured at a level of 62.8dB(A) L_{eq} and it is as a result of this baseline noise level that the cumulative noise level (65.9 db(A)) during the construction phase will be raised slightly above 65dB(A) on a temporary basis. It should be noted that the construction traffic noise levels have been predicted using the heaviest volume of traffic, which is expected to occur during Month 2 of the overall 26-month construction programme.

The results also indicate that the predicted construction traffic noise levels will have a minor significant negative temporary impact at eight properties (N2, N7, N9, N12, N15, N18, N21 and N23); a moderate significant negative temporary impact at three properties (N5, N13 and N17); and a major significant negative temporary impact at two properties (N3 and N19) based on the existing ambient (L_{Aeq}) noise levels in the area.

The predicted construction traffic noise levels and indeed the predicted total cumulative construction noise levels, which incorporate the existing ambient noise with both the predicted site works and construction traffic noise levels, are within the NRA assessment criteria of 65dB(A) at all of the noise sensitive receptors, with the exception of N22 as described above.

6.2 CONSTRUCTION PHASE (TERRESTRIAL) VIBRATION IMPACT

The level of vibration attributable to HCV traffic on an uneven road surface would be considered to be more significant than that attributable to shallow pile driving works that may be required for construction works.

As a vehicle travels along a road, vibration can be generated in the road and subsequently propagate towards nearby buildings. Such vibration is generated by the interaction of a vehicle's wheels and the road surface and by direct transmission through the air of energy waves (sound waves). Some of these waves arise as a function of the size, shape and speed of the vehicle, and others from pressure fluctuations due to engine and exhaust noise generated by the vehicle. It has been found that ground vibrations produced by road traffic are unlikely to cause perceptible structural vibration in properties located near well-maintained and smooth road surfaces. Road traffic vibration levels can therefore be largely avoided by maintenance of the road surface.

There will be no significant sources of vibration during reinstatement.

6.3 OPERATIONAL NOISE AND VIBRATION IMPACT

7 MITIGATION MEASURES

7.1 NOISE MITIGATION

7.1.1 Construction Phase

Although it is predicted that noise levels will not exceed NRA assessment guideline criteria, with the exception of the cumulative level at N22 representative of month 2 of the construction phase, it is recommended that the following mitigation measures are strictly adhered to, as a measure to keep potential noise levels at a minimum. Mitigation measures, as outlined in BS5228 will be employed on-site during construction. The contract documents will clearly specify that the Contractor will be obliged to implement best practice noise abatement measures and comply with the recommendations of BS 5228, "*Noise and Vibration Control on Construction and Open Sites*". These measures will include the following:

- With the exception of the 24-hour, 7-day tunnelling activities, normal working hours will be 0700-1900 hours Monday to Friday and 0800-1600 hours on Saturdays. Some additional work may be required outside these hours, e.g. inspection, testing and commissioning activities. Night-time security will patrol the temporary compounds and working areas. Apart from the tunnelling activities, Sunday working will be avoided, where possible, but cannot be entirely excluded. Aside from the tunnelling works, construction activities outside of normal hours will only take place after prior consultation with Mayo County Council and notification of the local community.

- A dedicated 3m tall noise attenuation barrier will be installed around the perimeter of both the Tunnelling launch pit at Aghoos and the reception pit at Glengad. This noise attenuation barrier has been incorporated into the noise prediction model.

- Additional noise abatement has also been incorporated into the design of plant and machinery that will be used in association with the tunnelling works during the construction phase. The tunnelling works design team carried out a review of the noise emissions data associated with the plant and machinery to be used during the tunnelling works in an effort to determine additional measures that will be implemented in order to reduce the level of noise associated with the tunnelling works, particularly during the night-time due to the requirement that tunnelling works are proposed to be undertaken on a 24-hour basis for the temporary to short-term duration of the proposed works.

- This review has identified scope for additional noise abatement both in the form of specification of alternative equipment with lower noise output and the design of additional noise abatement measures that will reduce the level of noise generated at source in the tunnelling compound at Aghoos. The noise prediction models have been revised to take into consideration the revised noise specification for the tunnelling works.

- It is also proposed to modify the original proposals associated with the Glengad compound in order to reduce the potential noise impact associated with site preparation works at the tunnel reception compound and at the LVI compound. The site design team have revised the assessment regarding the requirement to pump water during the night-time (22:00 – 08:00) and it is now proposed that water will not be pumped from the tunnel reception pit or the LVI site at Glengad during the construction works at either of these sites. This has also been incorporated into the revised noise prediction models.

- The noise predictions have been revised to take account of the modifications both in terms of specification of alternative equipment with lower noise output, the design of additional noise abatement measures to reduce the level of noise generated at source, and the elimination of a number of sources that were previously proposed to operate during the night.

- Plant machinery with low inherent potential for generation of noise and/or vibration will be selected. All construction plant and equipment to be used at the site will be modern equipment and will comply with the European Communities (Construction Plant and Equipment) (Permissible Noise Levels) Regulations.

- Regular maintenance of plant will be carried out in order to minimise noise produced by on-site operations. The regular and effective maintenance of plant can play an important role in reducing noise emissions. In particular, attention will be paid to the lubrication of bearings and the integrity of silencers. Silencers and engine covers will be maintained in good and effective working order.

- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the Contract.

- Compressors will be of the “sound reduced” models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.

- Machines, which are used intermittently, will be shut down or throttled back to a minimum during those periods when they are not in use.

- All plant and machinery that will be used during the construction works, including generators and pumps, will be housed within proprietary acoustic enclosures. Power packs and tunnelling works plant and machinery will also be housed within self-contained acoustic enclosures, designed to reduce noise emissions at source. These mitigation measures will be incorporated into the contract documents for the contractor(s) appointed to undertake the construction works and are in addition to the noise attenuation barriers which will be provided for the tunnelling compounds at Aghoos and Glengad.

- Training will be provided to drivers to ensure smooth machinery operation/driving, and to minimise unnecessary noise generation.

- A maximum speed limit of 60km/hr on the haul routes on the R313, L1204, R314, L1202 (with the exception of the section of the L1202 from Aghoos to Glengad) will be imposed for HCVs and drivers will be instructed to maintain as far as possible the distances between vehicles. On the reduced widths sections of the L1202, a maximum speed limit varying between 30km/hr and 50km/hr will be imposed for HCVs on the section of the L1202 from Aghoos to Glengad. A Traffic Management Plan will be put in place to minimise congestion.

7.1.2 Operational Phase

7.2 VIBRATION MITIGATION

7.3 MONITORING

7.4 RESIDUAL IMPACT

REFERENCES

Appendix A

Calibration Certificates

Appendix B

Noise Terminology

Appendix C

24 hr Noise Monitoring Results

&

Vibration Monitoring Results

Appendix D

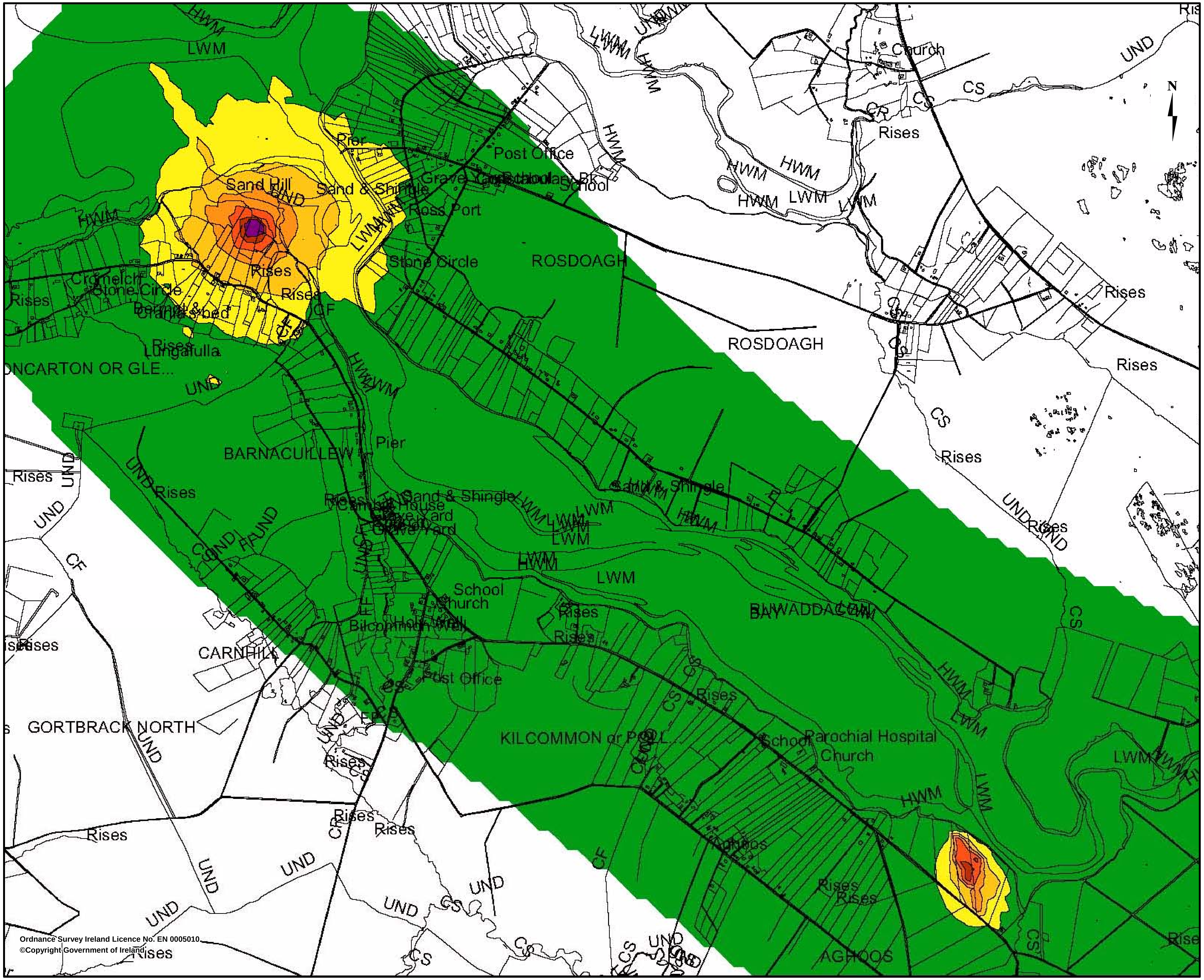
Principal Construction Equipment Sound Power Levels

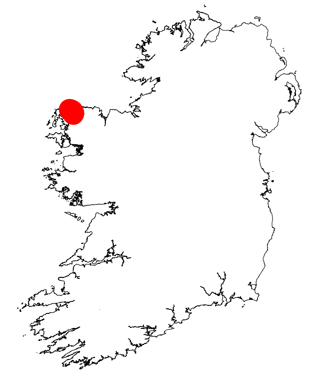
Appendix D: Principal Construction Equipment Sound Power Levels

Description	Purpose	Notes	Number Required (approximate)	Reference BS 5228-1:2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1, Noise	Sound power level L_w dB(A)
Dozer	Topsoil stripping and reinstatement. May also be employed for 'ripping' fractured rock for excavation.	Mobile sources. May also be employed for 'ripping' fractured rock for excavation. Tracked. Diesel engine powered.	5	Table C.2. Ref. no. 10	108
Excavator	Excavating trench, launch and reception pits. Management of materials. General purposes.	Mobile and stationary sources. General purpose machines. A range of machine sizes will be used (20 tonne – 30 tonne). Diesel engine powered.	5 - 10	Table C.2. Ref. no. 3 and 14	106 and 107
Tipper Truck / Dump Truck	Transport of excavated material and stone to and from site works.	Mobile sources. Typically wheeled on low ground pressure wheels. Capacity approx. 30 tonnes. Diesel engine powered.	10	Table C.2. Ref. no. 30 and 31	107 and 115
Rock Breaker	Occasional Rock Breaking	Rock Breaker Mounted on Excavator.	1	Table C.9. Ref. no. 11	121
Vibro Piling Machine	Sheet Piling	Vibrating Piling Rig	2	Table C.3. Ref. no. 8	116
Drum Roller	Rolling and compaction of fill material in compound working areas and on access roads to site working areas.	Mobile sources. Diesel engine powered.	2	Table C.2. Ref. no. 37	107
Water Pump	Dewatering of construction site working areas.	Stationary source. Electrically or diesel engine powered.	10 - 15	Table C.2. Ref. no. 45 Table C.4. Ref. no. 88	93 96
Generator	Provide electricity in remote locations.	Stationary (or mounted on mobile plant). Diesel engine powered.	10 - 15	Table C.4. Ref. no. 84. Table C.4. Ref. no. 86.	102 93
Mobile Crane	Lifting plant and equipment into position	Heavy Plant (400 tonne capacity), Wheeled. Diesel engine powered. Likely to be used in LVI and tunnelling compounds.	4	Table C.4. Ref. no. 38	106
Tracked Loader	Transport of pipe lengths to the pipeline spread	Tracked. Diesel engine powered.	5 - 10	Table D.3. Ref. no. 5	111

Appendix D: Principal Construction Equipment Sound Power Levels

Description	Purpose	Notes	Number Required (approximate)	Reference BS 5228-1:2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites, Part 1, Noise	Sound power level L_w dB(A)
Power Packs	Provide power for tunnel boring machine and associated tunnelling works, including bentonite plant and centrifuge/separation equipment.	Stationary Plant. Diesel engine powered. Contained within acoustic enclosures.	3 (plus 1 reserve)	SEPIL & de la Motte	L_p 85 at 1m L_w93
Tunnel Boring Machine	Excavation of tunnel and installation/construction of segment lined tunnel from Aghoos to Glengad	Below ground noise source within tunnel excavated from Aghoos to Glengad. Electrically powered from power packs at surface level within compound.	1	SEPIL & de la Motte	N/a addressed in Appendix H2 and H3
Centrifuge	Tunnelling Compound launch pit at Aghoos	Separation of bentonite and tunnelling extract matrix. Will now not be in use during the hours 23:00 – 07:00.	2	SEPIL & de la Motte	L_p 85 at 1m L_w93
Separation Plant	Tunnelling Compound at Aghoos	Separation of bentonite and tunnelling extract matrix.	1	SEPIL & de la Motte	L_p 80 at 1m L_w88
Wheeled Loader	Transport of excavated material to temporary storage area	Mobile Plant. Diesel engine powered.	2	SEPIL & de la Motte and Table C.4. Ref. no. 13	L_p 71 at 10m L_w99
Trucks / Lorries	Distribution of materials within tunnelling compound at Aghoos	Mobile Plant. Diesel engine powered. Will now not be in use during the hours 23:00 – 07:00.	Continuous movement within site	SEPIL & de la Motte	L_p 82 at 7.5m L_w108
Gantry Crane	Storage and insertion of liner segments within tunnel launch pit	Electrically powered.	1	Source dB Database Electrically powered gantry crane.	97
Side Boom	Lifting and 'ditching' assembled pipeline into trench	Diesel engine powered.	5	Table C.4. Ref. no. 53	105
Mobile Welding Unit	Provide mobile power and equipment for welding of pipeline.	Wheeled or tracked. Relatively light equipment (<15 tonnes). Diesel engine powered.	10	Table C.3 Ref No. 32	120





Legend

- < 45.0 dB(A)
- 45.0 - 50.0 dB(A)
- 50.0 - 55.0 dB(A)
- 55.0 - 60.0 dB(A)
- 60.0 - 65.0 dB(A)
- 65.0 - 70.0 dB(A)
- > 70.0 dB(A)

Predicted Construction Noise Levels (Daytime)

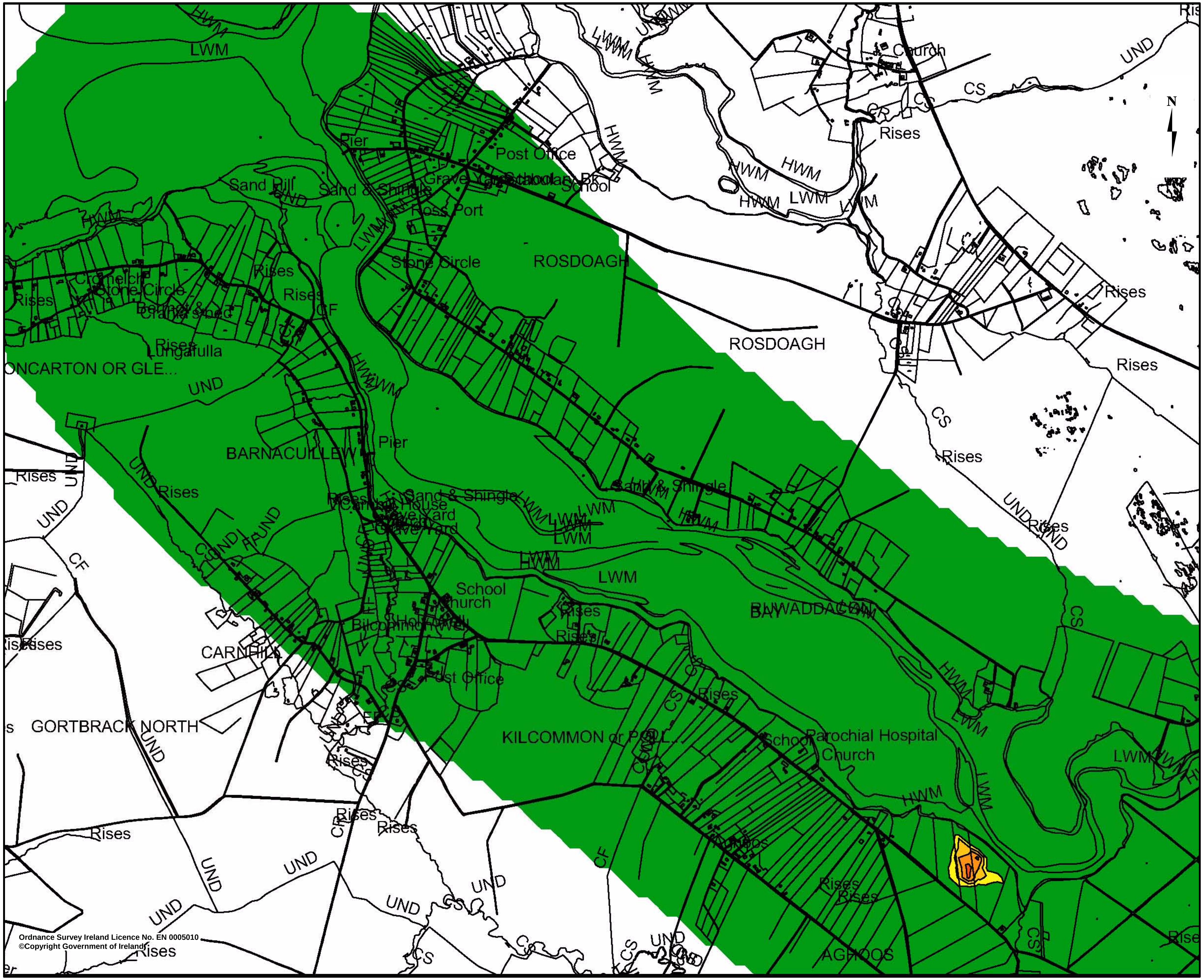
Figure 6.2a

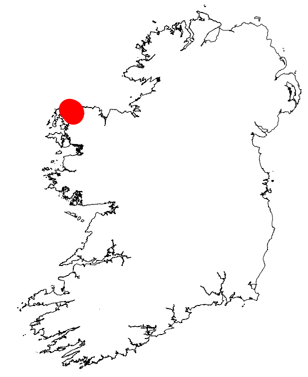
File Ref: COR25MDR0470Mi2458R02
Date: August 2010

CORRIB ONSHORE PIPELINE

Corrib natural gas

RPS





Legend

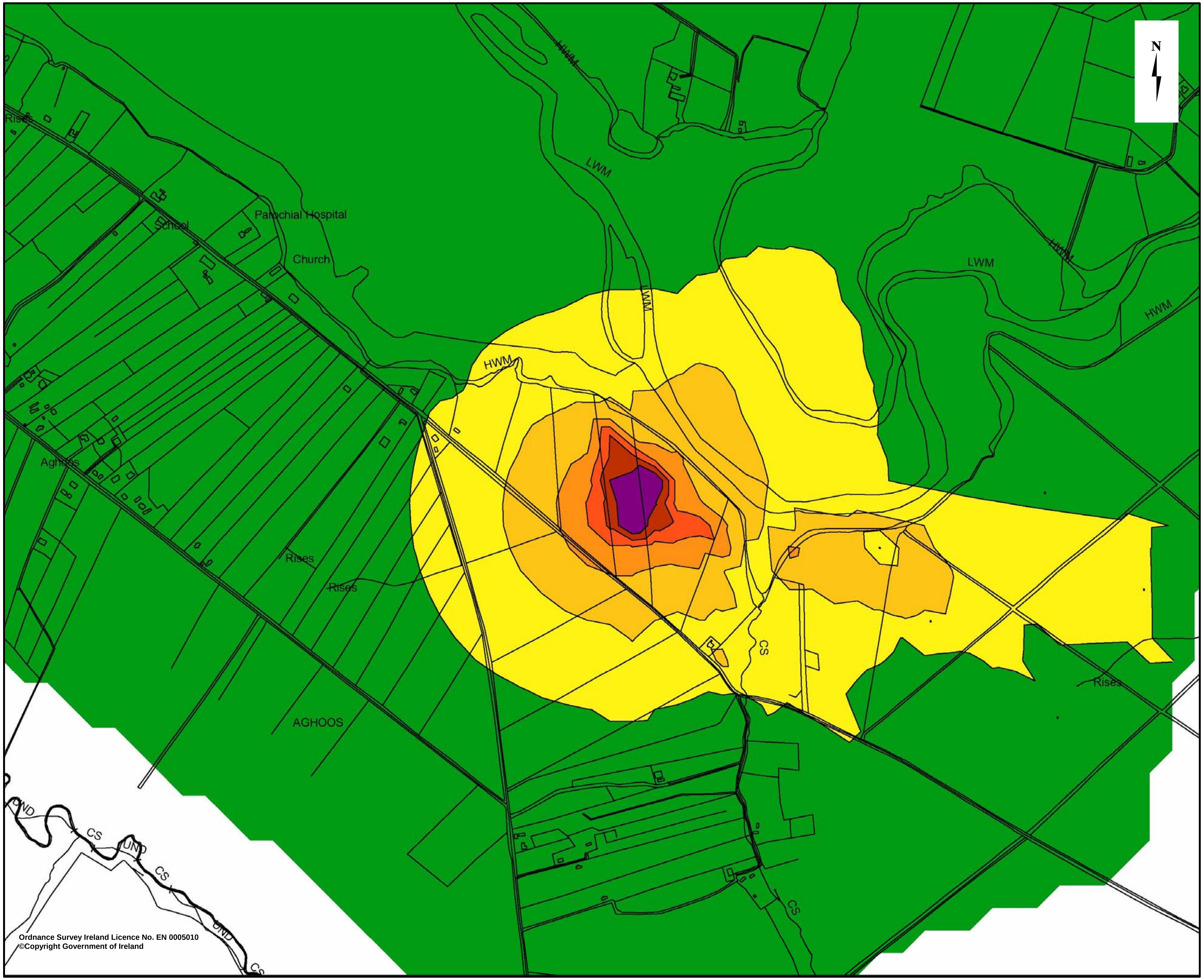
- < 45.0 dB(A)
- 45.0 - 50.0 dB(A)
- 50.0 - 55.0 dB(A)
- 55.0 - 60.0 dB(A)
- 60.0 - 65.0 dB(A)
- 65.0 - 70.0 dB(A)
- > 70.0 dB(A)

Predicted Construction Noise Levels (Night-time)

Figure 6.2b

File Ref: COR25MDR0470Mi2459R02
Date: August 2010

CORRIB ONSHORE PIPELINE



Legend

LEGEND

- < 30.0 dB(A)
- 30.0 - 35.0 dB(A)
- 35.0 - 40.0 dB(A)
- 40.0 - 45.0 dB(A)
- 45.0 - 50.0 dB(A)
- 50.0 - 55.0 dB(A)
- > 55.0 dB(A)

Predicted Construction Noise Levels (Night-time Enlarged Map)

Figure 6.2bii

File Ref: COR25MDR0470Mi2461R01
Date: August 2010

CORRIB ONSHORE PIPELINE

Corrib natural gas

RPS

APPENDIX E

‘Interim Summary Geotechnical Interpretative Report – Foreshore Ground Investigation - Sruwaddacon Bay’

REPORT ON

CORRIB ONSHORE PIPELINE

INTERIM SUMMARY GEOTECHNICAL INTERPRETATIVE REPORT

FORESHORE GROUND INVESTIGATION - SRUWADDACON BAY

Prepared for:

Shell E&P (Ireland) Ltd.

August 2010

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Task	Nominated authority	Approved (signature)
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1 INTRODUCTION

1.1 Background

Applied Ground Engineering Consultants Ltd (AGEC) was requested by Shell E&P Ireland Limited (SEPIL) to prepare a summary geotechnical interpretative report for ground conditions along the proposed gas pipeline route in Sruwaddacon Bay, North Mayo.

It is proposed that the pipeline between Glengad (ch. 83, 910) and Aghoos (ch. 88,770) is installed within a segment lined bored tunnel and which will be constructed using a Tunnel Boring Machine (TBM). The proposed tunnel alignment through Sruwaddacon Bay will be approximately 4.6km long and predominantly through superficial deposits.

At the time of drafting this report ground investigation works were ongoing within Sruwaddacon Bay. This current investigation is being performed subsequent to previous investigation works within the bay, namely Osiris (2007) and Irish Drilling Ltd (IDL, 2008 and 2009). The purpose of the current investigation was to confirm that the bay geology along the proposed pipeline route was consistent with findings of the previous investigation works.

The factual data collated from the current ground investigation provides a geological profile of the sediments and bedrock along with summary geotechnical interpretation within the corridor of the proposed pipeline route in Sruwaddacon Bay.

1.2 Scope of Report

This report describes the ground investigation work carried out to date and provides a summary interpretation of its findings. An interim geological long section with a number of cross sections across the bay are provided as drawings at the end of the report. The long section (Drawing 1045_002 to 1045_004) and two cross sections (Drawing 1045_006 and 1045_007) are based on completed ground investigation to date. Whilst two further cross sections (Drawing 1045_005 and 1045_008) are based on IDL (2008).

1.3 Current Ground Investigation Works

The current ground investigation works (in 2010) within Sruwaddacon Bay have been carried out using cable percussion (CP) and rotary drilling (CD) together with cone penetration testing (CPT). The ground investigation works have been carried out from two jack-up rig barges within the bay. It should be noted that this work was ongoing at the time of reporting.

The currently completed part of the ground investigation (Drawing 1045_002 to 004) has a typical spacing of about 100m. This coverage satisfies the spacing requirements of 20m to 200m for pipelines as set out in IS EN 1997-2: 1997 (Eurocode 7), Annex B.

2 SITE GEOLOGY

2.1 Bedrock Geology

According to the bedrock Geology of Mayo, Sheet No. 6 (Geological Survey of Ireland, 1992), the proposed route is underlain by Dalradian Rocks, laid down over 600 million years ago. The Dalradian Rocks were subjected to massive compression and faulting over an initial 200 million years, due to several periods of continental convergence. As a result, the Dalradian Rocks consist of metamorphic and faulted sedimentary sandstones - quartzites, psammitic schists and pelitic schists with some marbles also present. The Dalradian rocks, having undergone a number of deformation events, are also characterised by extensive multiple phases of folding.

Ground investigations along the terrestrial section of the route by Geotechnical and Environmental Services (GES, 2007) indicated psammite rock with bands of pelitic schist and pelite with rockhead between 1.4m and over 21.0m below ground level.

Ground investigations in Sruwaddacon Bay (IDL, 2008) indicated psammite rock with bands of semi pelite, quartz muscovite schist, semi-pelitic schist and psammitic schist. Rockhead was encountered between 3.3m and 24.8m below seabed level within the bay. The recovered rock cores were generally highly fractured. Rock strength from Point Load and Unconfined Compressive Strength (UCS) testing varied from very weak to extremely strong. Cerchar abrasivity testing on samples from the bedrock indicated that the rock can be classified as very abrasive.

Geophysical surveying in Sruwaddacon Bay (Osiris, 2007) indicated rockhead between about 1m and 25m below seabed level. Rockhead was shallower towards the edges of the bay with the rockhead deeper towards the centre of the bay. Several geophysical anomalies were recorded during the survey (Osiris, 2007), which are likely to correspond to igneous dykes within the bedrock.

2.2 Soils/Subsoils in the Sruwaddacon Bay Area

A small amount of soil derived from windblown sands is present at the northwestern edge of Sruwaddacon Bay. Alluvial deposits comprising mixed granular material (sand to boulder sized particles) are present along river channels in the area.

At the Corrib offshore pipeline landfall location at Gleann an Ghad (Glengad), topsoil is underlain by aeolian sands and gravel over colluvium or weathered rock over weathered to fresh rock. Clayey sands are visible in Sruwaddacon Bay at low tide. On the foreshore cliffs surrounding Sruwaddacon Bay there are exposures of peat underlain by sandy gravely clay. Excavations undertaken by SEPIL in the area of the Landfall Valve Installation site at Gleann an Ghad (Glengad), as part of the offshore pipeline landfall works, exposed sand and gravels with cobbles to a depth of between about 2.5m and 3.0m.

Ground investigations carried out in Sruwaddacon Bay (AGEC 2004, IDL 2008), which comprised boreholes and some trial pits, indicated sediments of dominantly sand and gravel with some cobbles. These sediments where encountered in boreholes to a depth of about 25m below seabed level within the narrow northwest (outer) part of the bay. In the southeast (inner) part of the bay, boreholes encountered occasional clay/silt layers and some thin peat layers. The clay/silt layers become more prominent towards the southwest (inner) shoreline of the bay.

Geophysical investigation survey results for Sruwaddacon Bay (Osiris, 2007) indicated sediments of dominantly granular material to a depth of about 25m below river/seabed level in the northwest (inner) part of the bay and to a depth of about 12m below river/seabed level in the southeast (inner) part of the bay. These sediments become shallower towards the margins of the bay. The sediments comprised a mixture of reworked fine to medium sand through the central part of the bay and mixed gravel sediments, derived from glacial tills and weathered bedrock, at the bay margins and in areas of stronger current flow. The mixed gravel sediments are incised by the Glenamoy and Muingnabo River channels, which enter the bay as one channel at its extreme southeast point.

3 FIELDWORK AND LABORATORY TESTING

3.1 Fieldwork

The current ground investigation work commenced in July 2010 and was still ongoing at the time of preparing this report.

There have been eleven cable percussion (CP) boreholes completed to date. These exploratory holes have been sunk between depths of 5.3m (CP62) and 15m (CP40). These exploratory holes are as follows;

- CP08, CP09, CP15, CP16, CP17, CP18, CP26, CP40, CP42, CP49, and CP62.

There have been thirteen rotary drill holes completed to date. These exploratory holes have been drilled between depths of 22.4m (CD12) and 41.7m (CD42). These exploratory holes are as follows;

- CD08, CD09, CD12, CD15, CD16, CD17, CD18, CD26, CD40, CD42, CD49, CD62 and CD63.

There have been thirty one static cone penetration tests (CPTs) completed to date. These tests have been taken to depths between 5.3m (CPT62) and 21.4m (CPT08). The completed CPTs are as follows;

- CPT08, CPT08A, CPT09, CPT10, CPT10A, CPT14, CPT16, CPT17(Note 1), CPT17A(Note 1), CPT17B(Note 1), CPT17C(Note 1), CPT17D, CPT18, CPT18A, CPT19, CPT20, CPT22, CPT24, CPT26, CPT28, CPT30, CPT31, CPT32, CPT34, CPT40, CPT49, CPT53, CPT57, CPT59, CPT62 and CPT63.

(Note 1: CPT terminated at shallow depth due to obstruction or penetration difficulties)

Insitu testing was carried out in exploratory holes. This included; Standard Penetration Tests (SPT-N) and falling head permeability (FHP) tests.

Representative samples were recovered from exploratory holes for detailed logging and laboratory testing.

Laboratory testing was carried out on representative soil and rock samples from the exploratory holes. The laboratory tests classified soils and measured geotechnical properties of the ground. A minor amount of chemical testing was also carried out on samples.

3.2 Laboratory Tests

The following soil laboratory tests have been carried out:

- Natural Moisture Content (NMC)
- Atterberg Limits
- Particle Size Distribution (PSD)
- Sedimentation
- Compaction
- Chemical (pH, Sulphate and Chloride)
- Organic Content
- Triaxial
- Bulk Density
- Permeability
- Specific Gravity

The following rock laboratory tests have been carried out:

- Point Load Test (PLT)
- Uniaxial Compressive Strength (UCS)
- Cerchar Abrasivity
- Porosity
- Brazilian Tensile Strength
- Petrographic Analysis

The following water laboratory tests have been carried out:

- Total Dissolved Solids
- Chemical (pH, Sulphate and Chloride)
- Iron content
- Total Soluble Salts

4 GROUND PROFILE

The fieldwork has revealed ground conditions in Sruwaddacon Bay as follows:

- Fine to medium sand (estuarine deposit)
- Organic silt and very localised peat
- Sand and gravel (possible glacial soil)
- Bedrock

TABLE 1: GROUND PROFILE

Strata	Depth to Top of Strata (m bsl) (Note 1)	Maximum Thickness of Strata (m) (Note 2)
Fine to medium sand (estuarine deposit)	Seabed level	20.2
Organic silt and very localised peat	12 to 14	2
Sand and gravel (possible glacial soil)	3.8 to 20.2	1.2 to 10.2
Bedrock	5.2 to 24.8	-

Notes
(1) Depth given as metres below seabed level (m bsl)
(2) Maximum recorded strata thickness is based on the current ground investigation data.

4.1 Fine to Medium Sand (Estuarine Deposit)

4.1.1 Soil Description

The estuarine deposit generally comprises very loose to dense light brown, greyish brown and grey medium to fine SAND. They are generally uniformly graded with no fines content (particles less than 63 microns) and occasionally they are slightly gravelly. In several boreholes (CD12, CP16, CP17 & CP18) a gravelly layer with some cobbles was encountered. Shells and shell fragments occur throughout the deposit to varying degrees.

A consistent firm to occasionally stiff silt/clay layer (thickness range from 0.2 to 0.8m) was indicated in CPTs approximately 10m depth (CPT19, CPT20, CPT22, CPT24, CPT26 and CPT28). However, this was not confirmed in the boreholes.

4.1.2 Spatial Variation

The deposit is thickest towards the northwest (outer) part of Sruwaddacon Bay, with a recorded thickness of up to about 20.2m (CD08). In the northwest (outer) part of the bay, the deposit tends to comprise medium sand to a depth of about 6m (CP8) to 8m (CP16) before becoming fine to medium sand with depth. Towards the southeast (inner) part of the bay the deposit comprises fine to medium sand becoming predominantly fine sand with depth.

The deposit in the southeast (inner) end of the bay tends to be thinner (3m to 5m) grey and slightly organic.

4.1.3 Material Properties

4.1.3.1 Soil Classification

Particle size distribution tests were carried out on samples and show fines content (particles less than 63 microns) ranging between 0.8% (CP17 at 4m depth) and 4% (CP49 at 3m to 3.5m depth). The typical fines content in this layer was in the order of 2%.

Following 'Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification' (EN ISO14688-2: 2004, Figure B.1) the material is generally classified as SAND with localised zones of gravelly SAND (CP08) and sandy GRAVEL (CP18). This classification corresponds with borehole log descriptions.

There was a number of natural moisture content tests (Figure 1) carried out in this deposit with values reported between 6.2% (CP42 at 4m depth) and 35.7% (CP62 at 1m depth). The higher moisture content values may be anomalous for sand with nominal fines, and may be attributed to samples containing excess water due to testing below sea level.

4.1.3.2 Shear Strength

SPT's were performed in the deposit at various depths within 10 boreholes (CP8, CP16, CP17, CD17, CP18, CP26, CP40, CP42, CP49 and CP62). The SPT N values ranged from 1 to 65 (Figure 2). These SPT N values indicate densities from very loose to very dense. Similarly, CPT results varied considerably from very loose to dense.

Generally density increases with depth (Figure 2) with the upper layers being loose to medium dense and the lower layers medium dense to dense.

A shear box test was performed on a sample taken from CP18 at 3.25m below seabed level. The result gave a friction angle (phi') of 34 degrees. This friction angle corresponds to dense granular material.

4.1.3.3 Stiffness

SPT N values can be used to derive stiffness values (E'). The E' value can be determined following Burland and Burbridge (1985), see CIRIA Report 143, Table 11 (Clayton, 1995). The E' for the deposit ranges from typically at shallow depth 1.6MPa to increasing stiffness of 300MPa at depth.

The E' value at the proposed tunnel alignment level ranges from about 26MPa to 300MPa based on the range of SPT N values.

Given the granular nature of the deposit any net applied vertical downward load would result in immediate settlement.

4.1.3.4 Permeability

Falling head permeability tests were carried out insitu in a number of boreholes at depths between 6 and 11.45m below seabed level. Permeability values (k) ranged between 1.77×10^{-7} and 6.87×10^{-6} m/s. These k values indicate very fine sand/silty sands and silt and interlaminated silt/sand/clays which corresponds with the descriptions of the sediments in the bay.

4.1.3.5 Chemical Results

Chemical testing was carried out on soils with pH values ranging between 7.98 and 8.83.

4.1.3.6 Earthworks Classification

It is proposed to use the tunnel arisings, including the fine to medium sand, in construction of the stone road for the onshore section of the pipeline.

The deposit has been classified based on borehole records and in accordance with the National Roads Authority's Specification for Road Works (NRA SRW), Volume 1. The material is typically classified as a Class 1A (well graded granular material) and Class 1B (uniformly graded granular material). There is localised zones of Class 6A and Class 6C (selected well graded granular material) in CP18.

A number of laboratory compaction tests were performed to determine the maximum dry density (MDD) of the material. These MDD's ranged from $1.57Mg/m^3$ to $1.68Mg/m^3$ at optimum moisture contents (OMC) ranging 17% to 19%. These results may be used during construction to determine the degree of compaction required for this type of material.

There was a California Bearing Ratio (CBR) test performed on one sample (CP17 at 4m) to determine performance of this material at a dry density of $1.54Mg/m^3$. The CBR values recorded ranged from 16% to 19% which would be acceptable as a road capping material. A capping material is required for the construction of permanent roads and motorways.

4.2 Organic Silt and Peat

4.2.1 Soil Description

This comprised the following:

(1) Brown and greyish brown slightly sandy (fine, micaceous) organic SILT with some shells and shell fragments (generally sand and fine gravel sized), and

(2) Localised dark brown highly decomposed amorphous PEAT with many woody fragments.

4.2.2 Spatial Variation

The greatest thickness of organic silt (approximately 2m) was found in CP40 between 12m and 14m below seabed level. The firm brown to greyish brown slightly sandy organic SILT was recorded as containing thin peaty laminae (less than 0.01m thick) and decayed plant fragments. At the base of the organic silt layer there was a layer of soft to firm woody PEAT some 0.5m thick.

In CP49 a 1.50m thick layer of stiff organic SILT was recorded at a depth of 7.50m below seabed level.

Traces of organic material were encountered in other boreholes (CD16, CP17 and CD42) and consisted of a variety of deposits ranging from an isolated fragment of wood (CP16) and fragments of peat.

The organic material found in the exploratory holes indicates the presence of an organic layer, which appears discontinuous and of variable thickness, in the southern (inner) part of the bay. The organic layer comprises:

(1) Organic silt layer (thickness up to 1.5m) with

(2) Very localised subordinate basal peat layer in vicinity of CP40 (thickness up to 0.5m).

This organic layer was identified in the previous ground investigation (IDL, 2008).

4.2.3 Material Properties

4.2.3.1 Soil Classification

There was one natural moisture content test (Figure 1) carried out in the organic silt with a value of 33.2% in CP49 at 7.75m below seabed level.

4.2.3.2 Shear Strength

SPT's were performed in the organic material within 2 boreholes (CP 40 and CP 49). The SPT N values results ranged from 9 to 78 (Figure 2). These SPT N values indicate likely undrained strength in the range of 50kN/m^2 to greater than 150KN/m^2.

The relatively high undrained strength in the organic silt indicates a degree of over-consolidation.

4.2.3.3 Stiffness

SPT N values were used to derive stiffness values (E_u). The E_u value can be determined following Butler (1975) using $E_u/N = 1.2$, see CIRIA Report 143 (Clayton, 1995). The E_u for the organic silt and peat ranges from 11MPa to 94MPa. The relatively higher stiffness of the silt and peat reflects the relatively higher strength of this material, see above.

Given the cohesive nature of the deposit any net applied vertical downward load would result in consolidation settlement, though this would be limited due to the relatively high strength/stiffness of the deposit.

4.2.3.4 Earthworks Classification

Due to the organic nature of this material it would not be suitable for reuse as an earthworks material.

4.3 Sand and Gravel (Possible Glacial Soil)

4.3.1 Soil Description

These deposits are generally varied and consist of medium dense to very dense grey silty sandy GRAVEL/silty gravelly SAND/sandy gravelly SILT with cobbles. The gravel and cobble constituents of these deposits were found to be usually sub-angular to sub-rounded and composed of a mixture of mainly metamorphic rocks. This well graded material indicates that its origin is likely to have been glacial.

4.3.2 Spatial Variation

These deposits were only sampled in a limited number of cable percussion boreholes (CP40, CP42 and CP62) due to the difficulty of retrieving samples at depth within the marine environment and the cobble content of the deposit.

Medium to coarse gravel and some cobbles of mixed lithologies were recovered from most of the rotary boreholes. The fine component (silt, sand) of the glacial deposits may have been washed out during the drilling process. Given this, these glacial soils are likely to be present across the whole bay. These are estimated to be of thicknesses ranging 1.2m (CD17) to 9m (CD49) at depths from 3.8m (CP62) to 20.20 (CD08).

4.3.3 Material Properties

4.3.3.1 Soil Classification

Particle size distribution tests were carried out on samples and show fines content (particles less than 63 microns) ranging between 6% (CP49 at 10m to 10.95m depth) and 10.6% (CP62 at 3m depth). The typical fines content in this layer was in the order of 8%. Following EN ISO14688-2: 2004, Figure B.1 the material has a mixed classification of SAND (CP16 and CP62), sandy GRAVEL (CP62) and GRAVEL (CP49). This classification typically corresponds with borehole log descriptions.

There was a number of natural moisture content tests (Figure 1) carried out in this stratum with values reported between 13.2% (CP18 at 5m depth) and 38.8% (CP62 at 3m depth). The higher moisture content values may be anomalous for a granular deposit with nominal fines, and may be attributed to samples containing excess water due to testing below sea level.

4.3.3.2 Shear Strength

SPT's were performed in the deposit at various depths within three (3) boreholes (CP16, CP18, and CP 62). The SPT N values ranged from 2 to 55 (Figure 2). These SPT N values indicate densities from very loose to very dense. Similarly, CPT results varied considerably from very loose to dense.

Given the limited number of SPT N results and the difficulties of testing in such a heterogeneous material in the marine environment the lower range of SPT N values are not considered representative.

A shear box test was performed on a sample taken from CP62 at 3m below seabed level. The result gave a friction angle (phi') of 32 degrees. This friction angle corresponds to dense granular material.

4.3.3.3 Stiffness

SPT N values can be used to derive stiffness values (E’). The E’ value can be determined following Burland and Burbridge (1985) assuming a granular soil. The E’ for the deposit ranges from 3MPa to about 250MPa. Given the limited number of SPT N results and the difficulties of testing in such a heterogeneous material in the marine environment the lower range of stiffness values are not considered representative.

Given the generally granular nature of the deposit any net applied vertical downward load would result in immediate settlement.

4.3.3.4 Permeability

A falling head permeability test was carried out insitu in CP62 at a depth of 5.3 m below seabed level. The determined permeability (k) was 1.11 x 10^{-6} m/s. This k value indicates very fine sand/silty sand which corresponds with the descriptions of the glacial soils.

4.3.3.5 Chemical Results

Chemical testing was carried out on soils with pH values ranging between 5.75 and 8.17.

4.3.3.6 Earthworks Classification

It is proposed to use the tunnel arisings, including the sand and gravel, in construction of the stone road for the onshore section of the pipeline.

The material has been classified in accordance to the NRA SRW, Volume 1. The material is typically classified as a Class 1A (well graded granular material) and Class 1B (uniformly graded granular material) in CP16, CP49 and CP62. The material in CP49 between 10m to 10.95m is also classified as Class 1C (coarse granular material) and Class 6C (selected well graded granular material).

A number of laboratory compaction tests were performed to determine the maximum dry density (MDD) of the glacial soil. These MDD’s ranged from 1.66Mg/m^3 to 1.73Mg/m^3 at optimum moisture contents (OMC) ranging 16% to 20%. These results may be used during construction to determine the degree of compaction required for this type of material.

4.4 Bedrock

4.4.1 Rock Description

The rock encountered consisted of metamorphic lithologies of varying composition and strength. These rocks range from extremely strong to strong light grey fine to medium grained PSAMMITE with medium to closely spaced discontinuities to very weak highly weathered green and orange fine to medium grained MICA/SEMI-PELITIC SCHIST with extremely closely spaced discontinuities.

The dip of the rock discontinuities ranged from vertical/sub-vertical (70 to 80 degrees) to horizontal and was often aligned parallel to the dip of the foliation of the rock.

In the upper weathered zones the discontinuities were often open and infilled with sandy clay/silt.

4.4.2 Spatial Variation

In the northwest (outer) part of Sruwaddacon Bay the underlying rock (encountered in CD8, CD12, CD16, CD17 and CD18) generally comprised extremely strong to strong medium fresh light grey fine to medium grained PSAMMITE with medium to closely spaced discontinuities (low Fracture Index (FI)). There was a minor weathered zone at rockhead (typically up to 2.0m thick) where the rock was highly fractured (FI >20) and was recovered as gravel fragments.

In CD26, CD40, CD49 the rock was found to be generally highly to moderately weathered comprising weak grey, green and orange brown fine to medium grained QUARTZ MICA SCHIST and SEMI-PELITIC SCHIST with extremely closely spaced discontinuities (FI >20).

The depth to rockhead (weathered/un-weathered) encountered in the rotary borehole ranged from 5.2m (CD62) to 24.8m (CD8) below seabed level.

On drawings 1045_002 to 004 rock is shown as weathered rock and bedrock. Weathered rock is defined as FI greater than 20.

4.4.3 Material Properties

4.4.3.1 Petrographic Analysis

Thin section petrographic analysis was used to provide a detailed mineralogical description of the rock. Petrographic analyses were performed on four (4) rock samples taken from boreholes CD08, CD17, CD18 and CD62. The analysis is based on ISRM suggested methods (Ulusay and Brown, 2007) and BS 5930. The results are shown in Table 2.

TABLE 2: PETROGRAPHIC ANALYSIS RESULTS

Borehole No.	Depth (m bsl)	Rock Type
BH CD08	32.4 - 32.55	Psammite
BH CD17	23.8 - 23.9	Psammite
BH CD18	30.4 - 30.5	Psammite
BH CD62	13.73 - 13.9	Psammite/Semi-Pelite

4.4.3.2 Rock Density

Bulk density tests were performed on fifteen (15) rock samples taken from holes CD08 CD12, CD17, CD18, CD62 and CD63. The bulk density tests were carried out in accordance with ASTM D7012-07. The results varied from 2414 kg/m^3 to 2657 kg/m^3 with an average of 2574 kg/m^3.

Dry density tests were performed on four (4) rock samples taken from holes CD16, CD17, CD18 and CD63. The dry density tests were carried out in accordance with ISRM 2007 Part 2 (Ulusay and Brown, 2007). The results varied from 2550 kg/m^3 to 2700 kg/m^3 with an average of 2625 kg/m^3.

Porosity tests were performed on four (4) rock samples taken from rotary holes CD16, CD17, CD18 and CD63. The porosity tests were carried out in accordance with ISRM 2007 Part 2. The results varied from 0.7 % to 3.2 % with an average of 1.98 %.

4.4.3.3 Strength

The Brazilian Tensile Strength (BTS) test was used to evaluate the tensile strength of rocks. Tests were performed on four (4) rock samples taken from holes CD12, CD17 and CD63. The BTS tests were carried out in accordance with ISRM 2007 Part 2 (Ulusay and Brown, 2007). The results varied from 7.01 to 15.23 MPa with an average of 10.46 MPa

Unconfined compressive strength (UCS) tests were performed on fifteen (15) rock samples taken from holes CD08, CD12, CD17, CD18, CD62 and CD63. The UCS tests were carried out in accordance with ASTM D7012-07. UCS results were also derived from point load tests on 21 samples taken from holes CD12 CD16, CD17, CD18, CD26, CD40, CD49, CD62 and CD63. The point load tests were carried out in accordance with ISRM Methods.

Figure 3 shows the two sets of UCS results plotted against the depth below seabed level at which the samples were taken within the rotary hole. The range in rock strength reflects the variable weathering encountered at rockhead.

4.4.3.4 Abrasivity

Abrasivity is the property of a material to remove matter when scratching and grinding against another material. The Cerchar abrasivity test is used to calculate the abrasivity of a rock.

The Cerchar abrasivity test was carried out on eleven (11) rock samples taken from rotary holes CD12, CD 16, CD17, CD18, CD62 and CD63. The Cerchar abrasivity mean number varied from 1.8 (medium abrasive to abrasive) to 4.49 (extremely abrasive).

4.4.3.5 Earthworks Classification

It is proposed to use the tunnel arisings, including rock, in construction of the stone road for the onshore section of the pipeline.

The rock material would typically be Class 1 or Class 6 following appropriate processing.

4.5 Water Conditions within Sruwaddacon Bay Sediments

The current ground investigation was carried out below sea level in tidal conditions. From a review of the CPT porewater pressure (u) readings this shows generally hydrostatic water conditions consistent with sea level within the sediments in Sruwaddacon Bay.

During the current ground investigation works at a number of borehole locations difficult boring conditions were encountered as a result of ‘blowing’ sands (water entrained with sand) entering the borehole casing. The ‘blowing’ sands are considered to be attributed to the method of boring in combination with the tidal environment.

Water samples were retrieved for testing from boreholes CP17 (6m) and CP62 (4.5m). Water test results are as follows: total dissolved solids 29,500 mg/l in CP62. Sulphate content 2290 mg/l (CP17) and 2310 mg/l (CP62). Chloride content 17,400 mg/l in CP17. The pH value was reported as 7.87 (CP17) and 7.78 (CP62).

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FIGURES

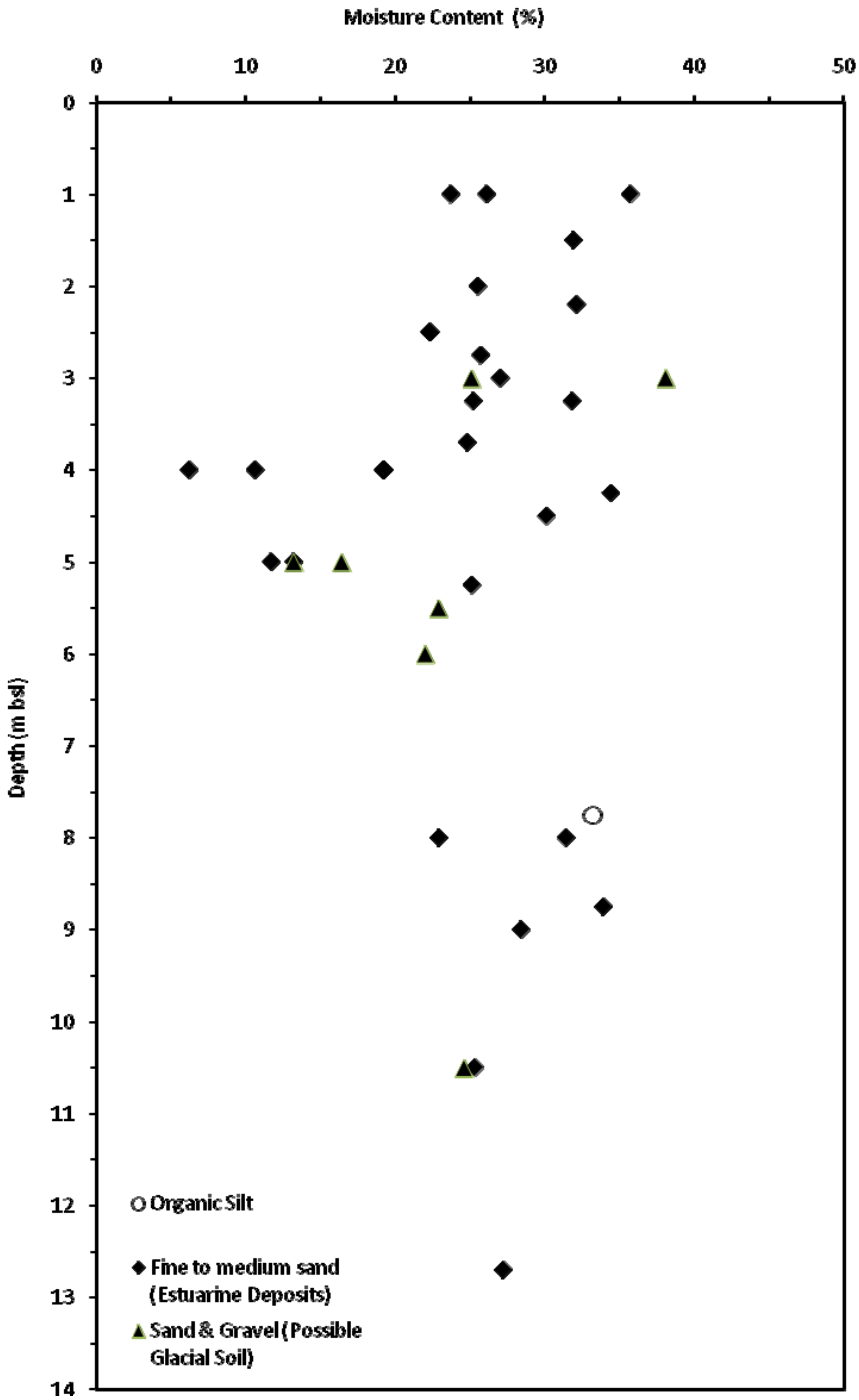


Figure 1: Moisture Content versus Depth

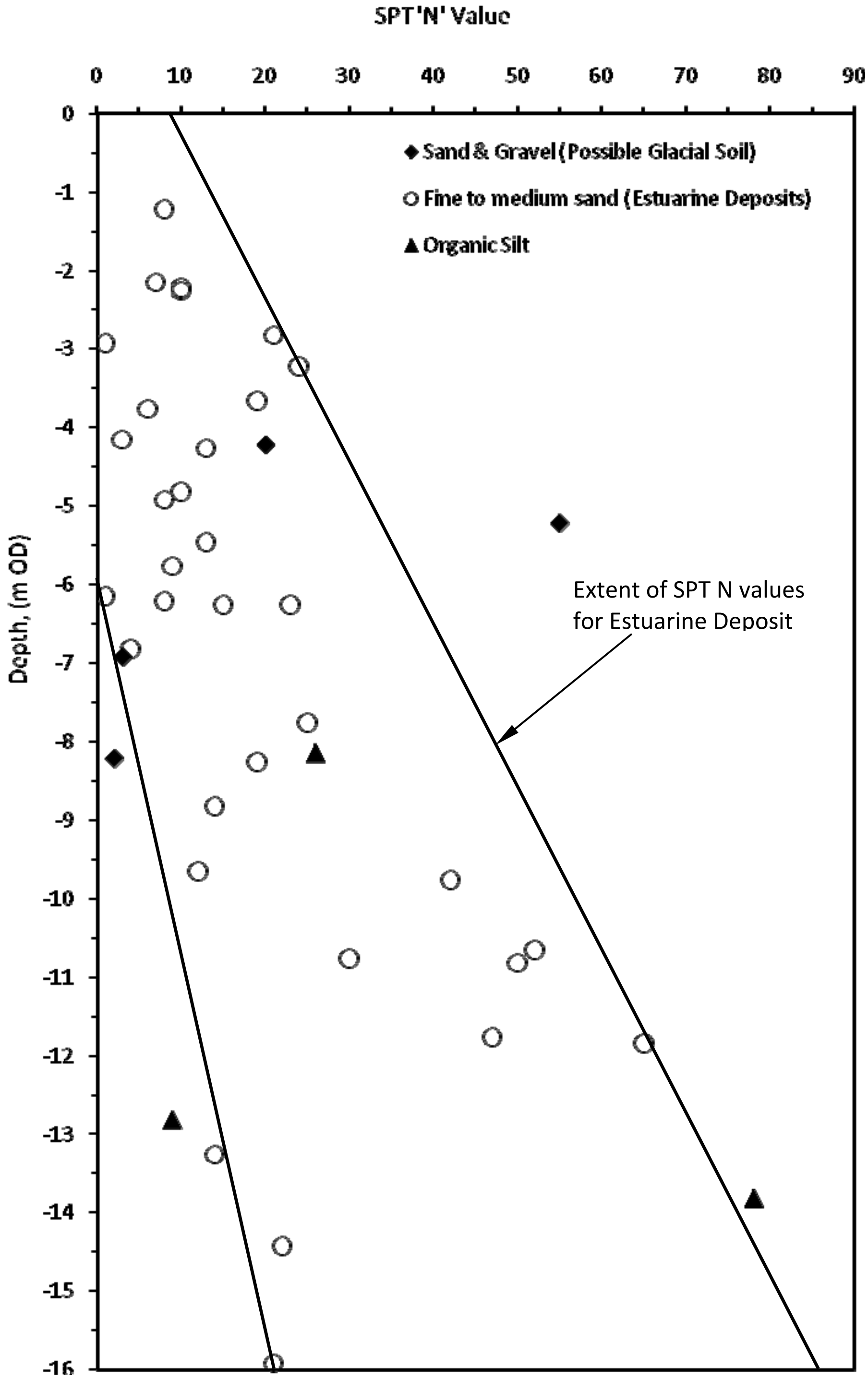


Figure 2: SPT versus Depth

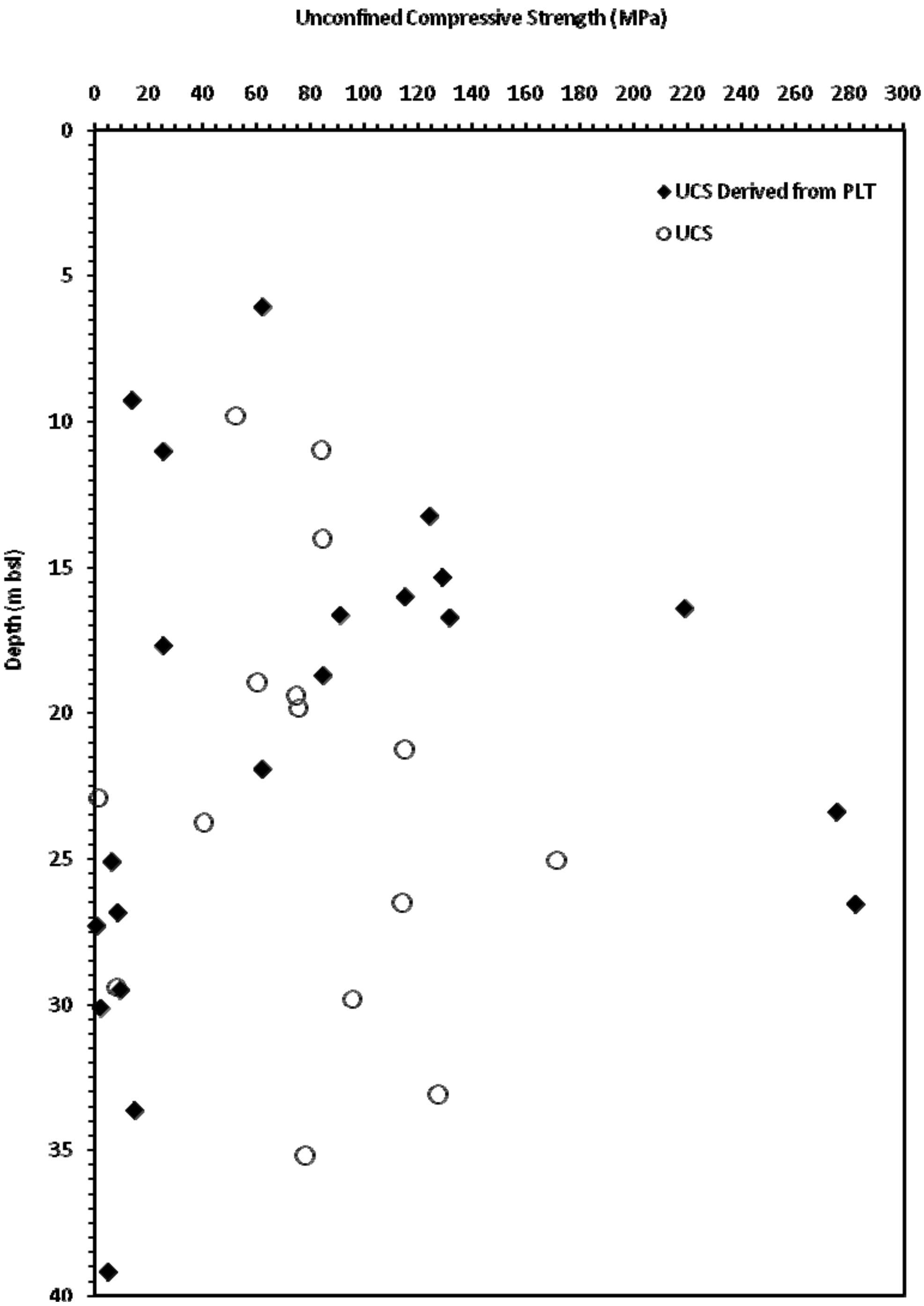
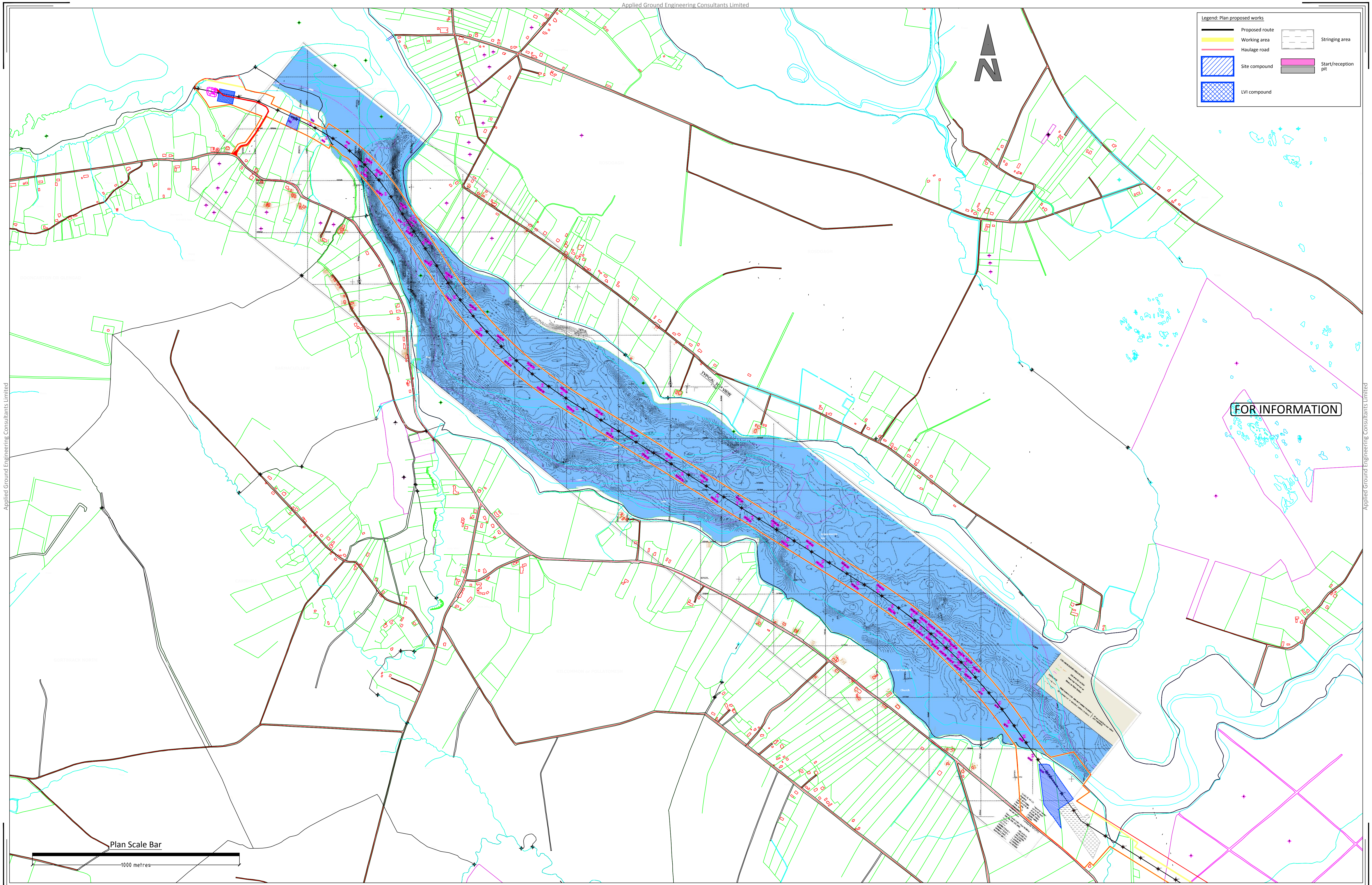


Figure 3: Unconfined Compressive Strength versus Depth

DRAWINGS



Applied Ground Engineering Consultants Limited

Further notes:

S:\2010\1045 Corrib Sruwaddacon Bay SI & Geotech Model\CAD\Corrib Baseplan 30.dwg

Notes:		Client: Shell E&P Ireland Limited	Job: Corrib Onshore Pipeline	Drg. No. - 1045_001	AGEC Ltd
Scale: 1:8,000 (A1)	*Checked: D.B.*			Title: Plan Showing Proposed Ground Investigation	
Date: 23 August 2010	*Revision: 0*				
Drawn: P.O.R.	*Based on:*				

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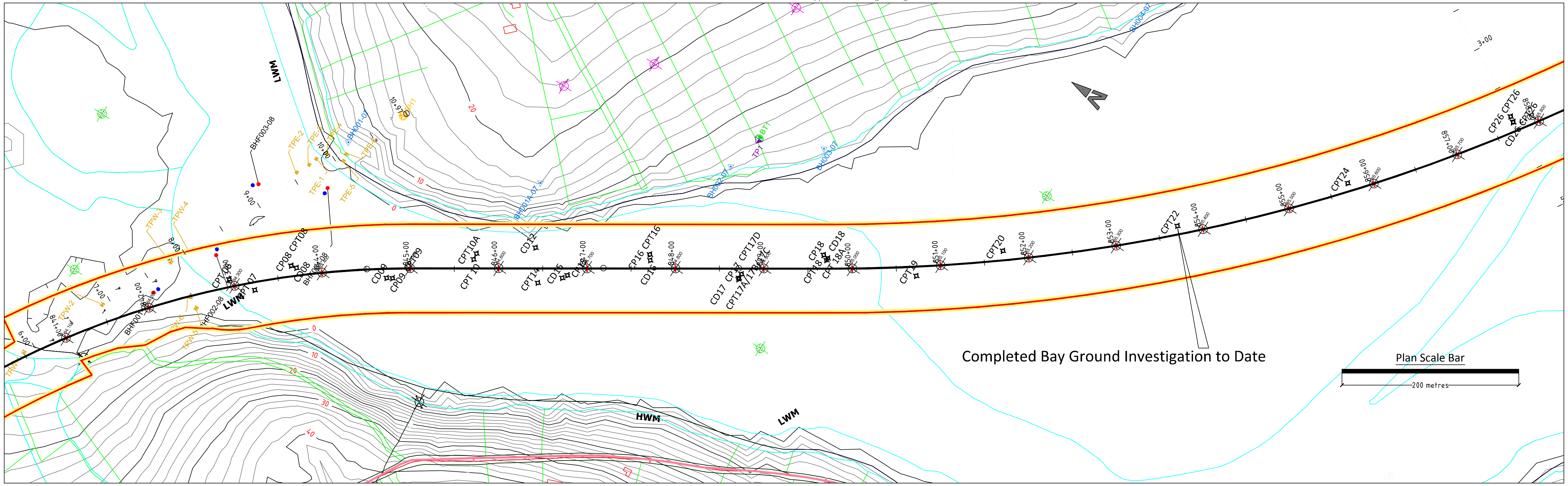


Legend: Plan proposed works

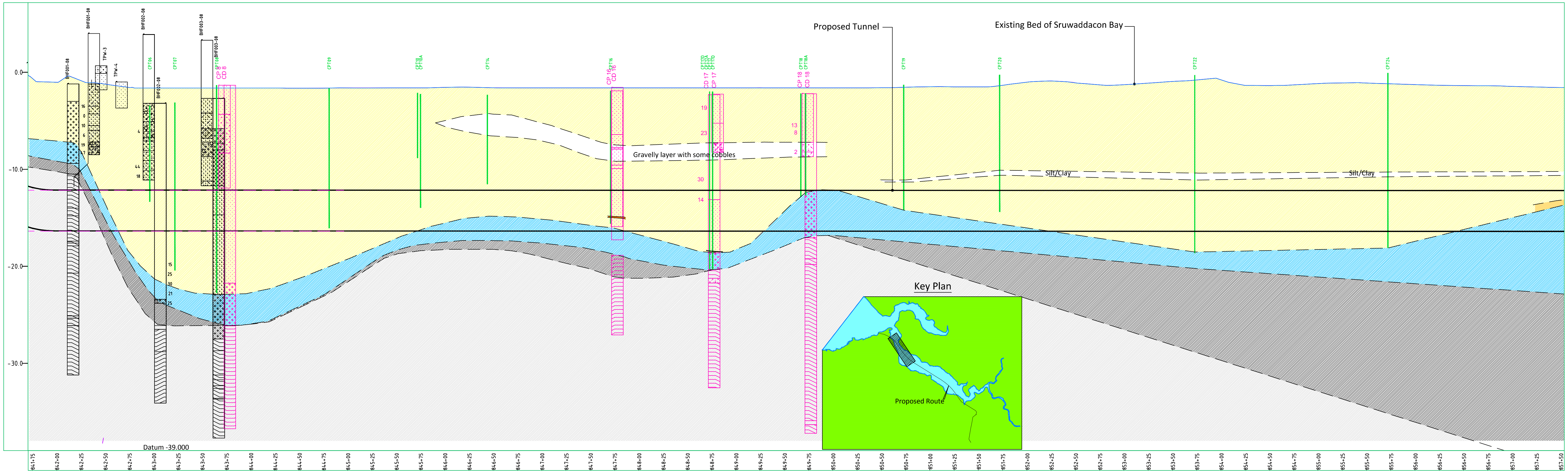
- Proposed route
- Working area
- Haulage road
- Stringing area
- Site compound
- Start/reception pit
- LVI compound

Legend:

- Fine to medium sand (estuarine deposit)
- Organic silt
- Peat
- Sand and gravel (possible glacial soil)
- Weathered rock (psammite/schist)
- Rock (psammite/schist)
- Inferred geological boundaries

PLAN
Scale 1:2500

FOR INFORMATION



LONGITUDINAL SECTION
Horizontal Scale 1:2000
Vertical Scale 1:200

Further notes:	Notes: 1. Geology is Based on Ground Investigation Available at Time of Preparation	Client: Shell E&P Ireland Limited	Job: Corrib Onshore Pipeline	Drg. No. - 1045_002	AGEC Ltd, The Grainstore, Singletons Lane, Bagenalstown, Carlow, Ireland
	Scale: See Above @ A1 / Checked: D.B.		Corrib natural gas	Title: Plan and Section Showing Sruwaddacon Bay Geology (Sheet 1 of 3)	Tel: +353 59 972 3800
	Date: 23 August 2010 / Revision: A				Fax: +353 59 972 3793
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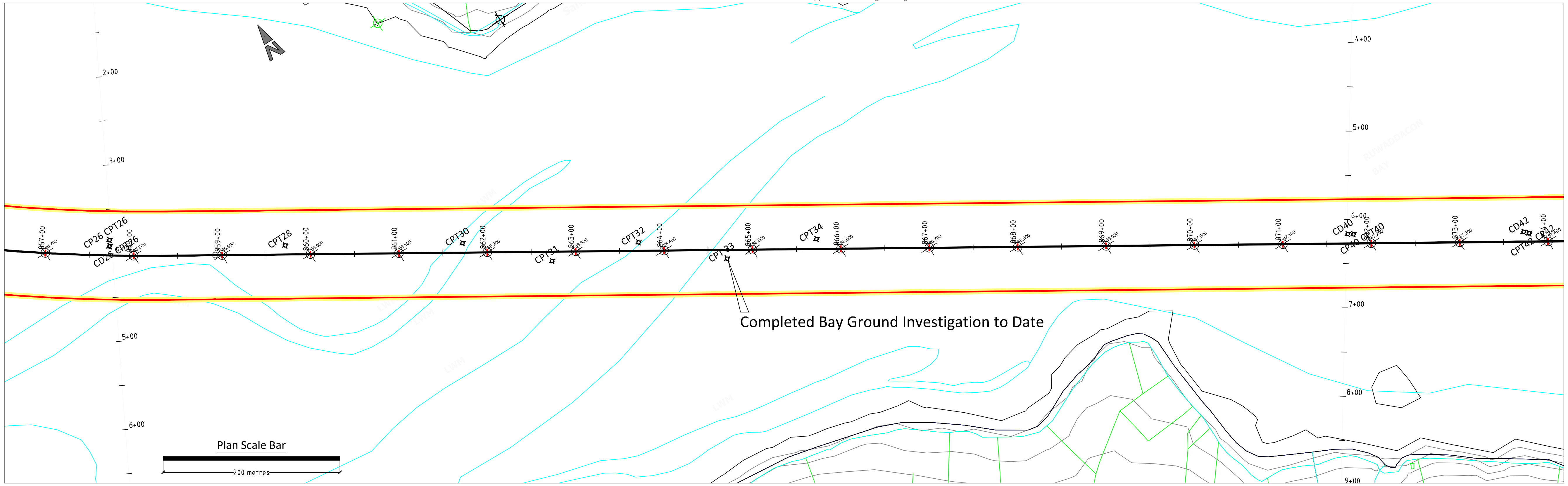

PLAN
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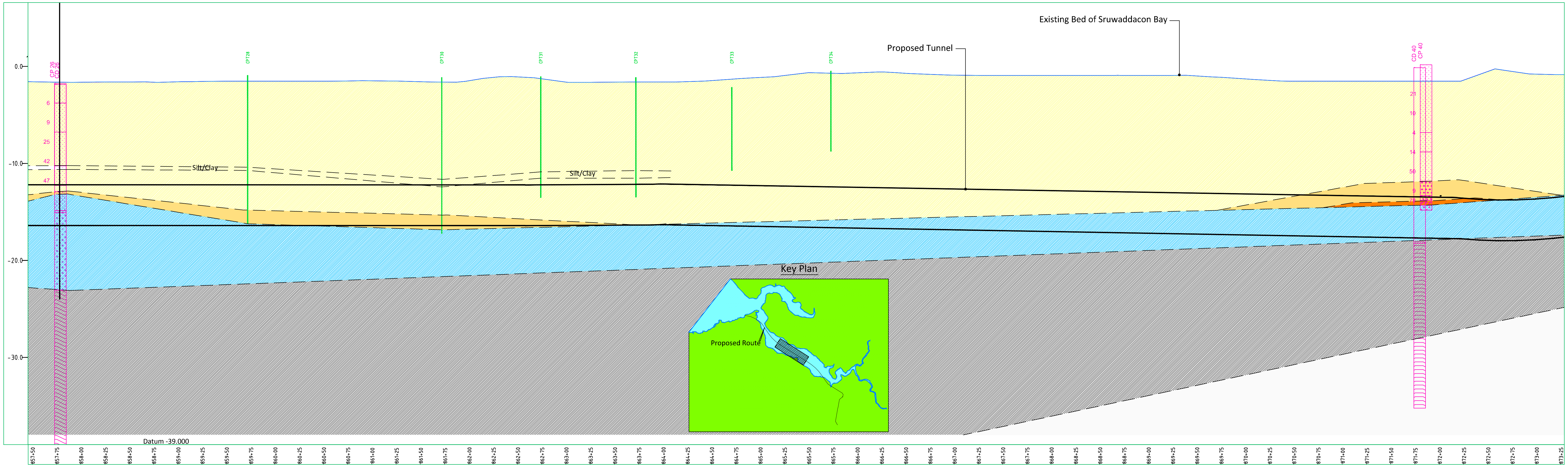
Legend: Plan proposed works
- Proposed route
- Working area
- Haulage road
- Site compound
- LVI compound
- Stringing area
- Start/reception pit

Legend:
- Fine to medium sand (estuarine deposit)
- Organic silt
- Peat
- Sand and gravel (possible glacial soil)
- Weathered rock (psammite/schist)
- Rock (psammite/schist)
- Inferred geological boundaries

FOR INFORMATION



LONGITUDINAL SECTION
Horizontal Scale 1:2000
Vertical Scale 1:200

Further notes:	Notes: 1. Geology is Based on Ground Investigation Available at Time of Preparation	Client: Shell E&P Ireland Limited	Job: Corrib Onshore Pipeline	Drg. No. - 1045_003	AGEC Ltd
	Scale: See Above @ A1 / Checked: D.B.		Corrib natural gas	Title: Plan and Section Showing Sruwaddacon Bay Geology (Sheet 2 of 3)	The Grainstore, Singletons Lane, Bagenalstown, Carlow, Ireland
	Date: 23 August 2010 / Revision: A				Tel: +353 59 972 3800 Fax: +353 59 972 3793
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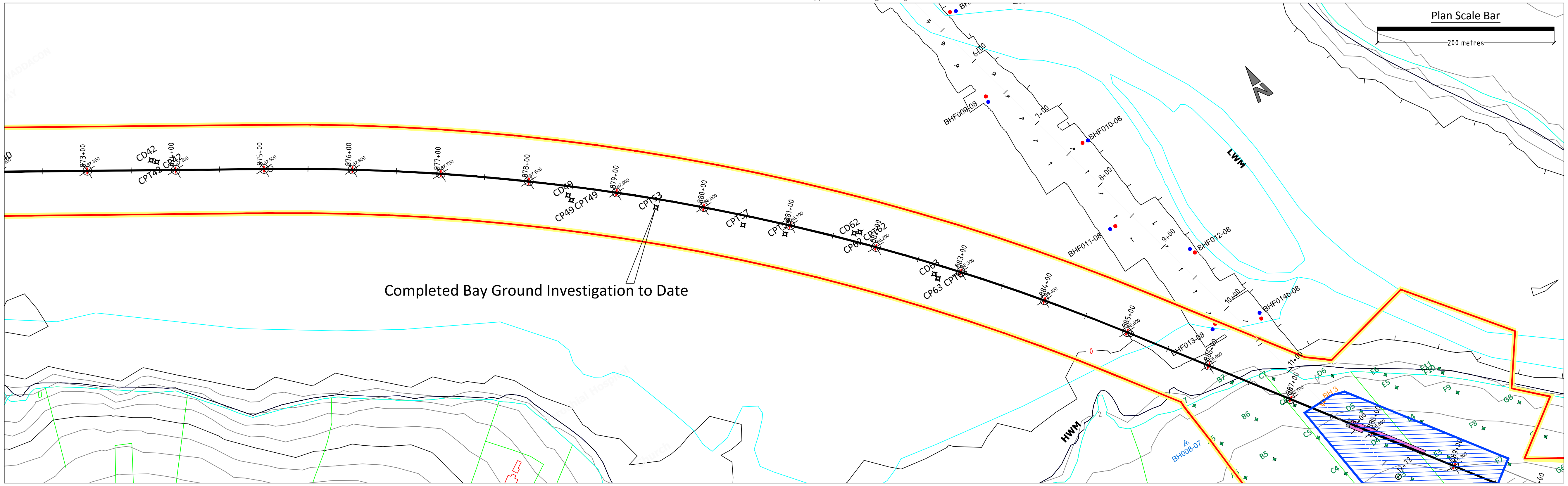

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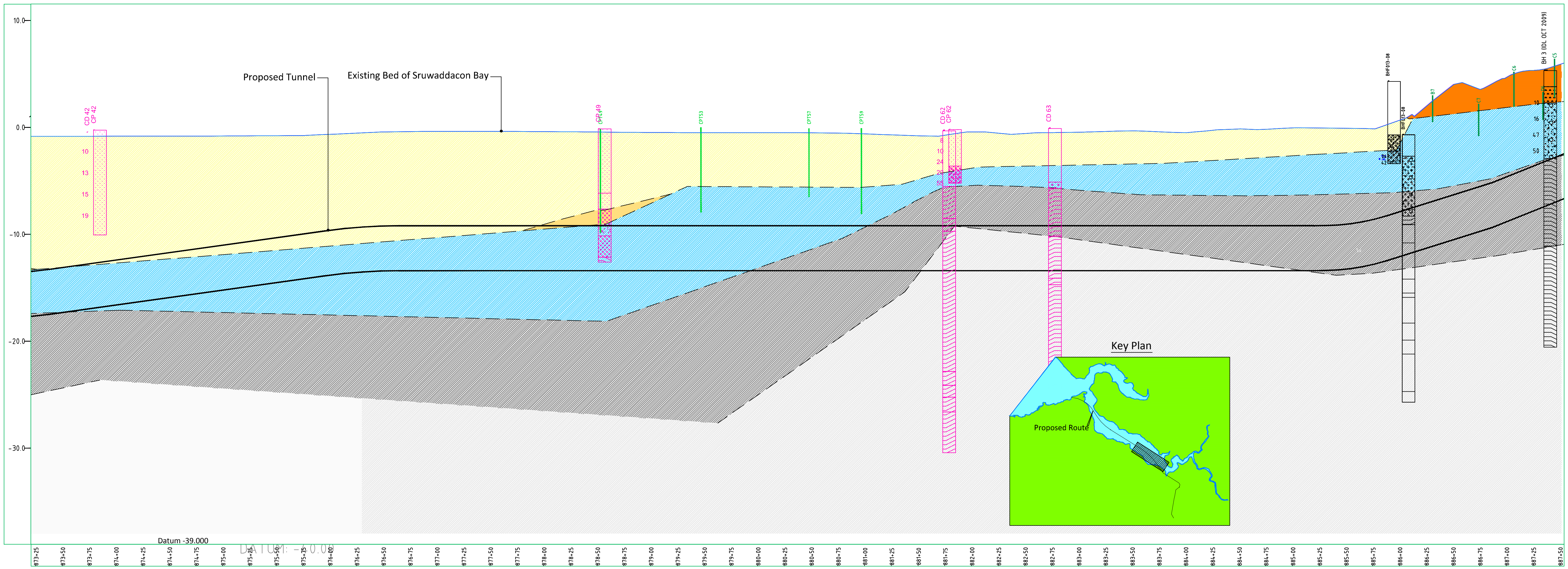
Scale 1:2500

Legend:

- Fine to medium sand (estuarine deposit)
- Organic silt
- Peat
- Sand and gravel (possible glacial soil)
- Weathered rock (psammite/schist)
- Rock (psammite/schist)
- Inferred geological boundaries

FOR INFORMATION



LONGITUDINAL SECTION
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Vertical Scale 1:200

Further notes:

Notes:
1. Geology is Based on Ground Investigation Available at Time of Preparation

Scale: See Above @ A1	Checked: D.B.
Date: 23 August 2010	Revision: A
Drawn: P.O.R.	Based on:

Client:
Shell E&P Ireland Limited

Job:
Corrib Onshore Pipeline

Corrib natural gas

Drg. No. - 1045_004

Title:
Plan and Section Showing Sruwaddacon Bay Geology (Sheet 3 of 3)

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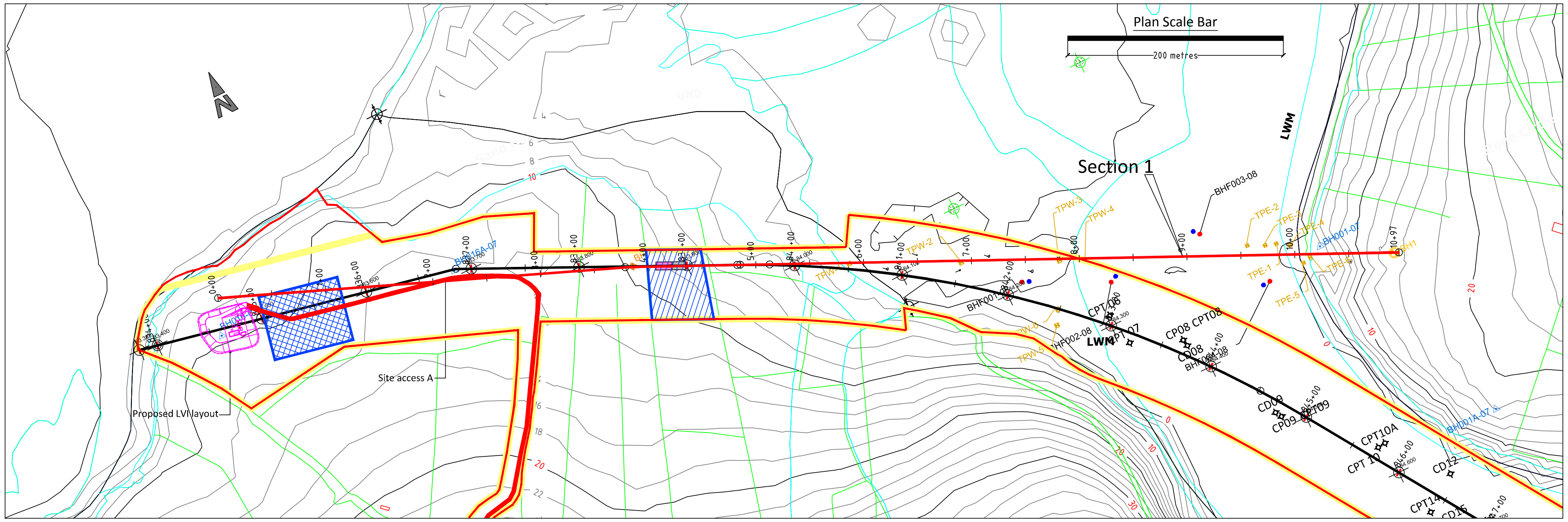
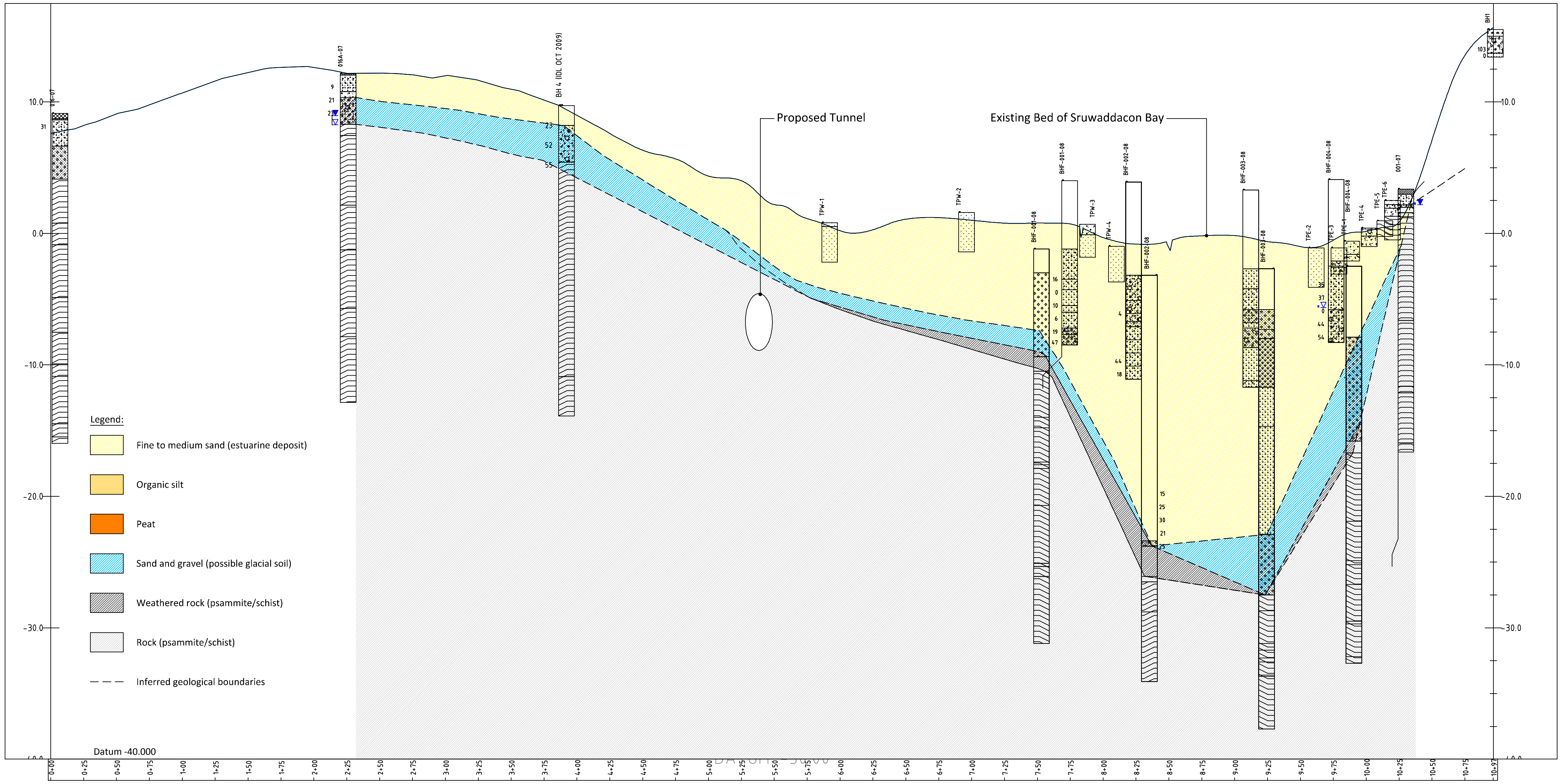
S:\2010\1045 Corrib Sruwaddacon Bay SI & Geotech Model\CAD\Corrib Baseplan 30.dwg



PLAN
Scale 1:2500

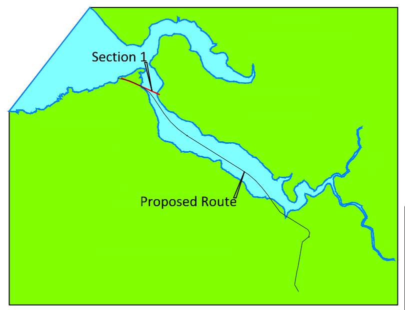
Legend: Plan proposed works
- Proposed route
- Working area
- Haulage road
- Site compound
- LVI compound
- Stringing area
- Start/reception pit

FOR INFORMATION



SECTION 1
Horizontal Scale 1:2000
Vertical Scale 1:200

Key Plan



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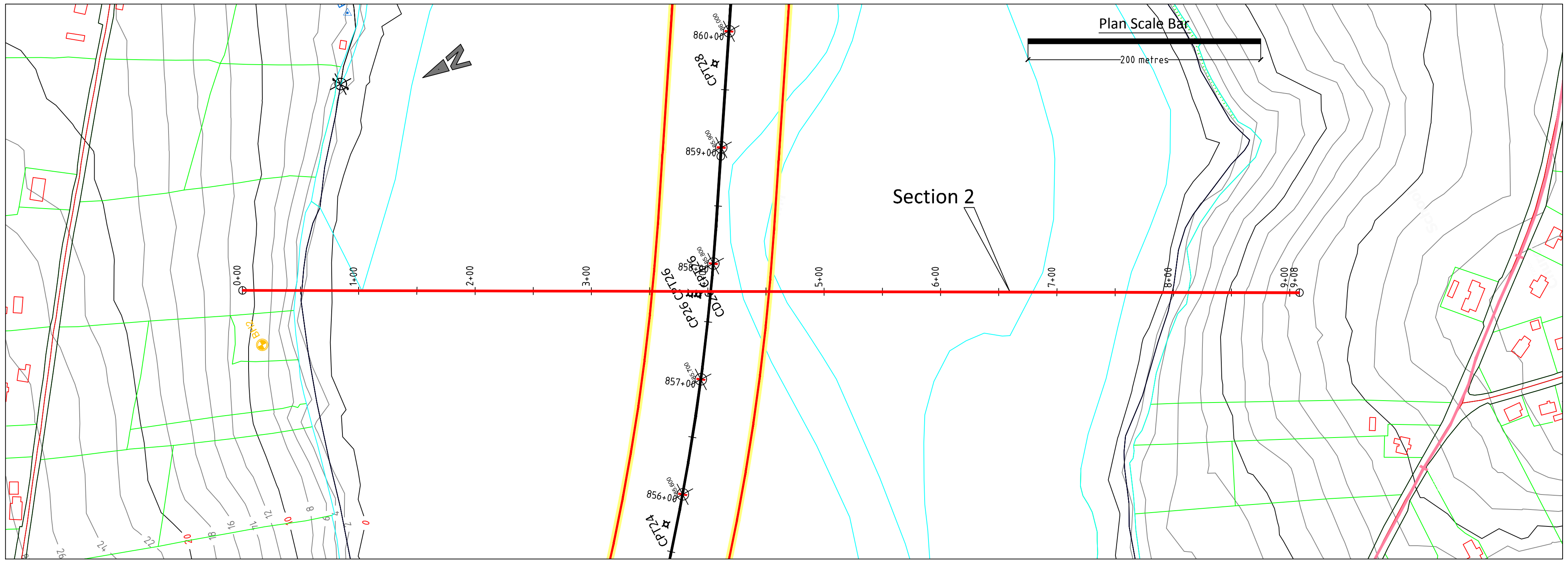

PLAN
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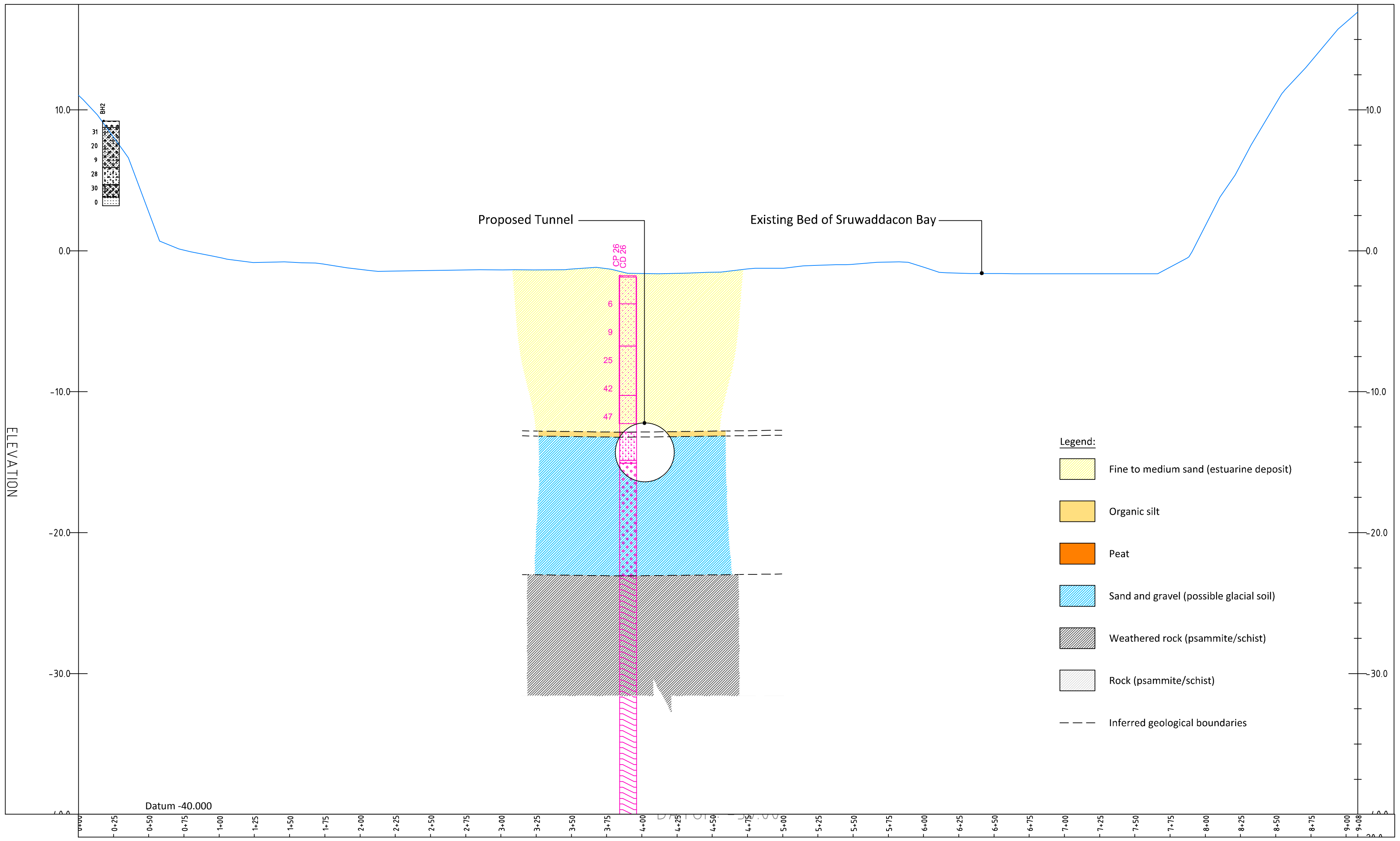
Legend: Plan proposed works

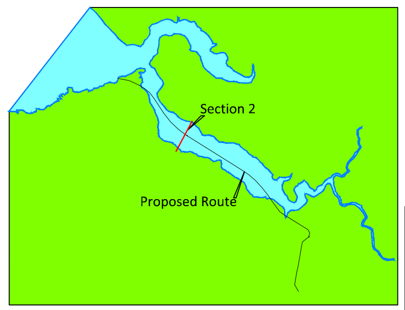
Proposed route	Stringing area
Working area	Start/reception pit
Haulage road	
Site compound	
LVI compound	

FOR INFORMATION



SECTION 2
Horizontal Scale 1:2000
Vertical Scale 1:200

Key Plan



Further notes:

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Scale: See Above @ A1	Checked: D.B.
Date: 23 August 2010	Revision: A
Drawn: P.O.R.	Based on:

Client: Shell E&P Ireland Limited

Job: Corrib Onshore Pipeline

Corrib natural gas

Drg. No. - 1045_006

Title: Section 2. Geology Based on Ground Investigation Available at Time of Preperation

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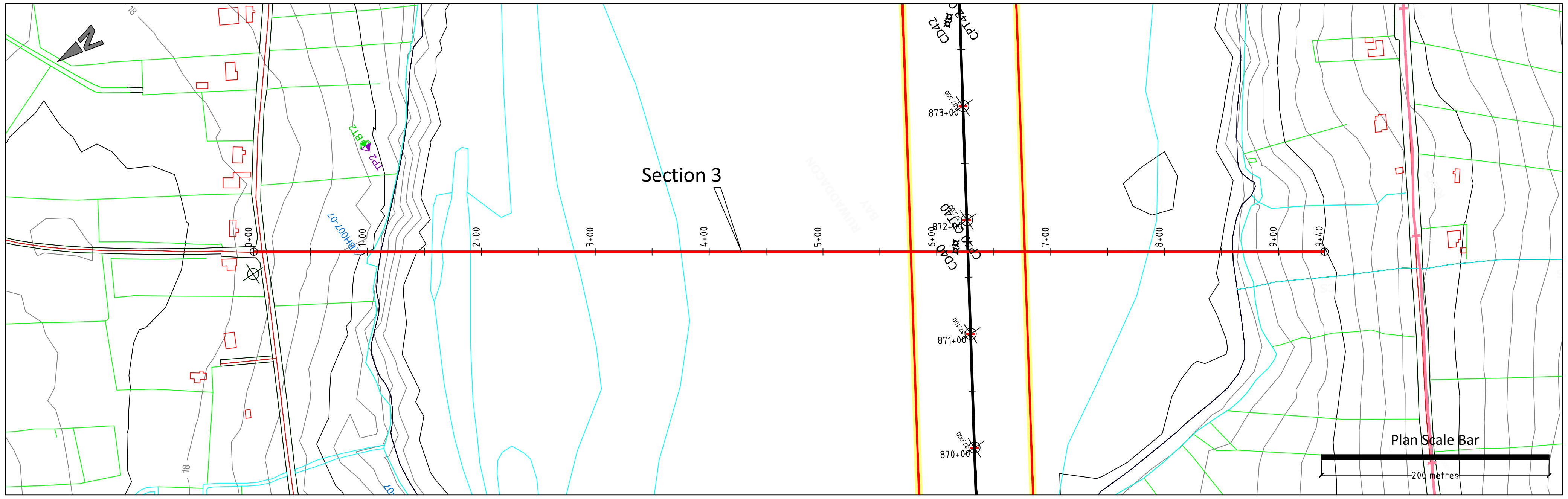
Applied Ground Engineering Consultants Limited

Legend: Plan proposed works

- Proposed route
- Working area
- Haulage road
- Site compound
- LVI compound
- Stringing area
- Start/reception pit



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Scale 1:2500

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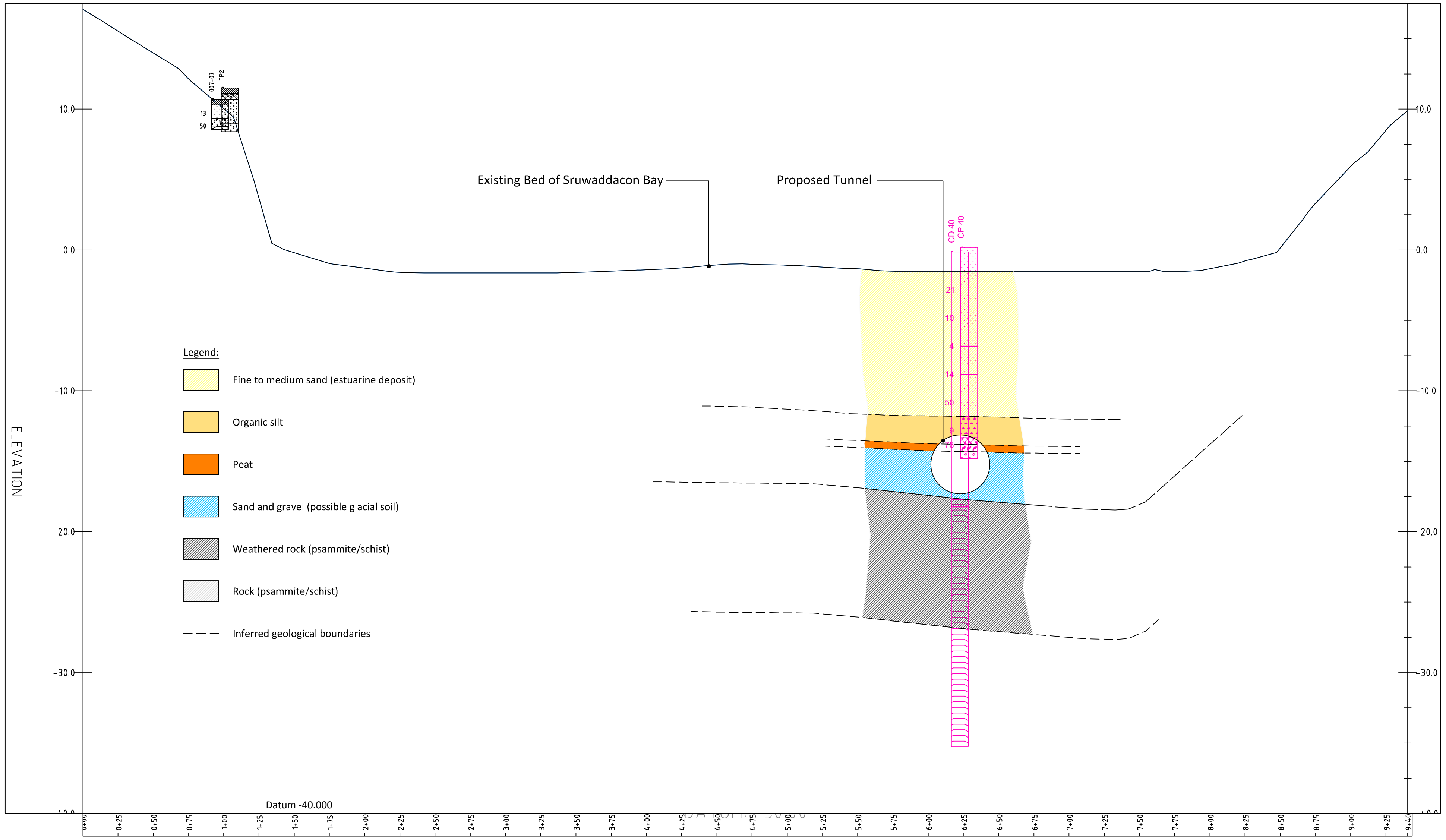
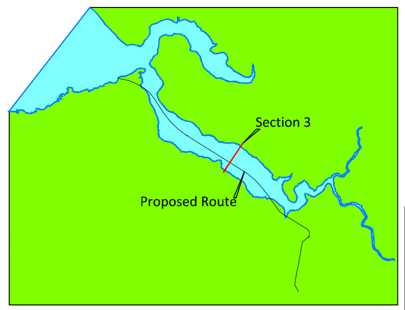


SECTION 3
Horizontal Scale 1:2000
Vertical Scale 1:200

Key Plan



Further notes:

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Date: 23 August 2010	Revision: A
Drawn: P.O.R.	Based on:

Client: Shell E&P Ireland Limited

Job: Corrib Onshore Pipeline

Corrib natural gas

Drg. No. - 1045_007

Title: Section 3. Geology Based on Ground Investigation Available at Time of Preperation

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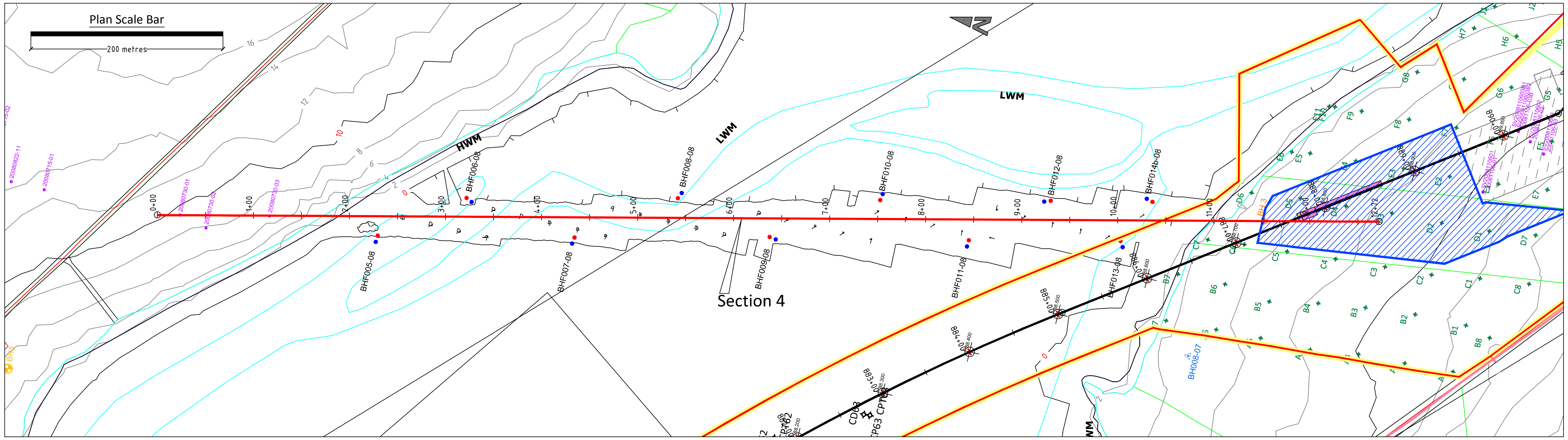
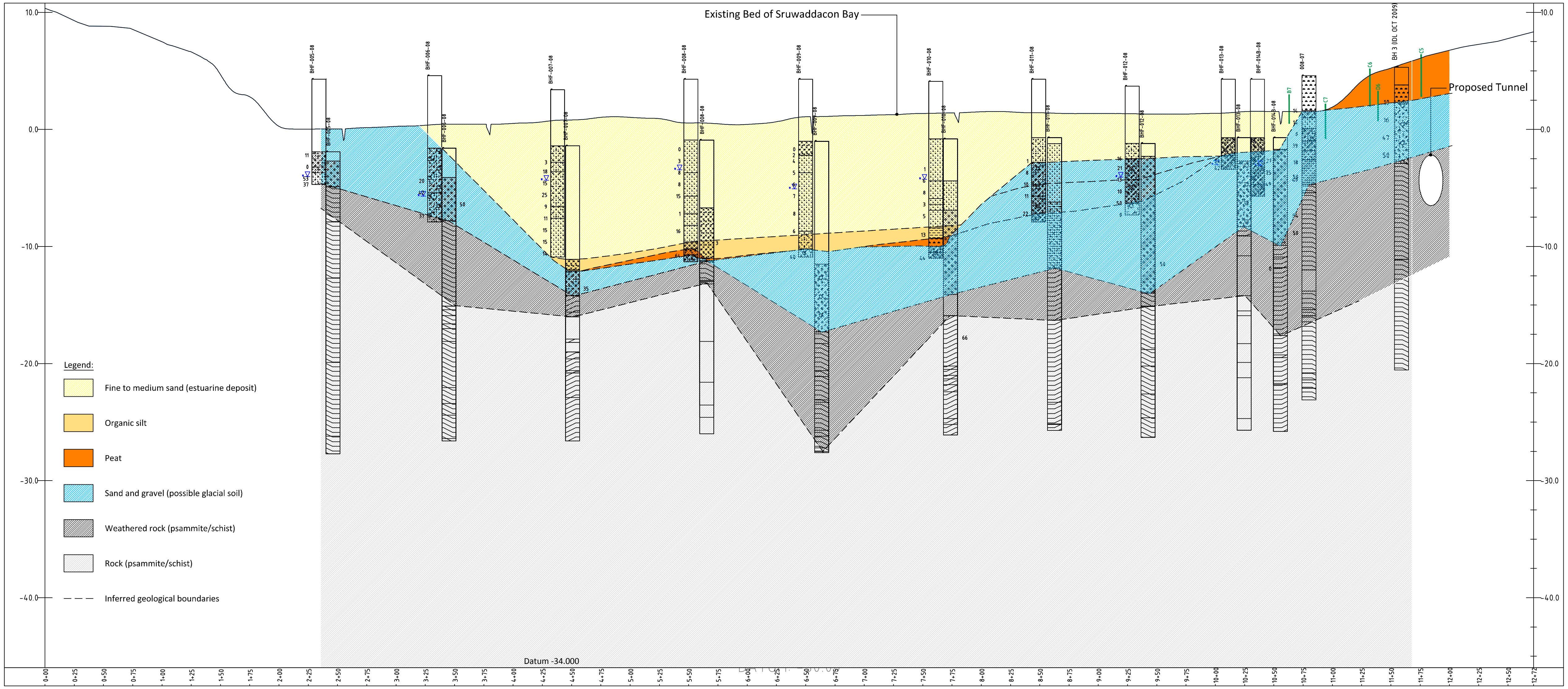
Applied Ground Engineering Consultants Limited



Legend: Plan proposed works

- Proposed route
- Working area
- Haulage road
- Site compound
- LVI compound
- Stringing area
- Start/reception pit

PLAN
Scale 1:2500



Legend:

- Fine to medium sand (estuarine deposit)
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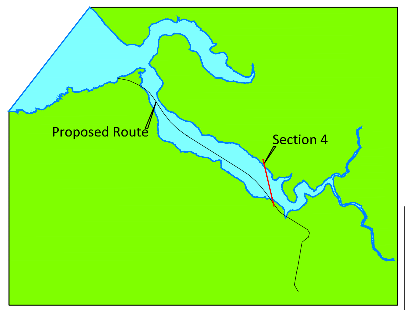
- Sand and gravel (possible glacial soil)
- Weathered rock (psammite/schist)
- Rock (psammite/schist)
- Inferred geological boundaries

SECTION 4
Horizontal Scale 1:2000
Vertical Scale 1:200

Key Plan



Further notes:

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Date: 23 August 2010	Revision: A
Drawn: P.O.R.	Based on:

Client: Shell E&P Ireland Limited

Job: Corrib Onshore Pipeline

Corrib natural gas

Drg. No. - 1045_008

Title: Section 4. Geology Based on IDL (2008) Ground Investigation

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Applied Ground Engineering Consultants Limited

APPENDIX F

Flood Risk Assessment Report

DETAILED FLOOD RISK ASSESSMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

The purpose of this report is to produce a robust Detailed Flood Risk Assessment for the Corrib Onshore Pipeline project, in accordance with the requirements of *The Planning System and Flood Risk Management Guidelines for Planning Authorities*, *November 2009*[3].

The Planning System and Flood Risk Management Guidelines for Planning Authorities (the 'Guidelines') inform the planning system at national, regional and local levels. The Guidelines provide "*comprehensive mechanisms for the incorporation of flood risk identification, assessment and management into the planning process*". In particular planning authorities are required to ensure that an appropriate flood risk assessment is submitted for the general environs of each development site and that, where required, a development *Justification Test* shall be carried out. The *Justification Test* has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk.

Elements of the proposed onshore pipeline development are planned adjacent to the coast at Glengad, and along the southern shoreline of Sruwaddacon Bay estuary. These elements include the permanent LVI (Landfall Valve Installation) at Glengad, and the temporary construction compounds at Glengad (SC2) and Aghoos (SC2). These locations are shown in Volume 2, Appendix A1 of the Corrib Onshore Pipeline EIS.

An assessment is made of the Flood Zone boundaries as defined in the Guidelines where the proposed permanent Landfall Valve Installation(LVI) development and both temporary site tunnelling compounds, Aghoos (SC3) and Glengad (SC2), lie in relation to the zones.

There are three levels of flood zones defined in the Guidelines, as follows:

- Flood Zone A – where the probability of flooding from rivers and the sea is the highest (greater than 1% or 1 in 100 for river flooding or 0.5% or 1 in 200 for coastal flooding);
- Flood Zone B – where the probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% or 1 in 100 for river flooding and between 0.1% or 1 in 1000 and 0.5% or 1 in 200 for coastal flooding); and
- Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding).

Flooding risk is assessed under the headings of coastal flooding (for the area of Sruwaddacon Bay), fluvial flooding (for areas with nearby watercourses), groundwater flooding and flooding from storm generated overland flows (i.e. from rainfall generated runoff).

2 COASTAL FLOODING

2.1 GENERAL

This section of the report provides a summary of the analysis and results of the extreme tidal analysis – the full detailed report is provided in **Appendix 1**. A detailed extreme tidal analysis has been undertaken to assess the levels of the 1 in 200 year and 1 in 1000 year return period tidal flood levels in Sruwaddacon Bay, which define the tidal Flood Zones A and B in *The Planning System and Flood Risk Management Guidelines for Planning Authorities*. These extreme tide levels quantify the risk posed by coastal flooding to development on the project in the vicinity of Sruwaddacon Bay – the permanent LVI and the temporary tunnelling compounds, SC2 and SC3.

2.2 METHODOLOGY

The various tidal records along the west coast of Ireland have been collated by RPS as part of the Irish Coastal Protection Strategy Study(1) which RPS is undertaking for the Office of Public Works. This data has been used to generate a synthetic time series record of water levels for Broadhaven Bay to facilitate a statistical analysis to determine the 1 in 200 and 1 in 1000 year return period water levels for the area. The extreme tidal water levels for the pipeline site have then been established by computational modelling techniques to account for the wind shear and bathymetry effects which are particular to the tidal and storm surge regime in and around Sruwaddacon Bay i.e. the model includes for extreme, wind, storm surge, sea/estuary bed profiles, and atmospheric conditions..

The tidal level time series data for the assessment has been derived using a combination of the predicted astronomical tides for Broadhaven Bay combined with storm surge residuals taken from the tide gauges at Killybegs and Malin Head. This allowed an almost continuous 13 year hourly time series record of water levels to be produced for the Broadhaven Bay tide gauge location at Ballyglass for the period December 1996 to December 2009 inclusive.

A validation exercise, comparing the synthesized time series against the actual tidal measurements of the Broadhaven Bay and Malin Head tide gauges, indicated that the synthesized water level time series is likely to accord with or be slightly higher than the water levels which actually occurred during the period December 1996 to December 2009.

The results of the statistical analysis of extreme tidal water levels, undertaken using the Extreme Value Analysis tool in the MikeZero suite of coastal process modelling software, are applicable to the water levels in and around the tide gauge site and other parts of Broadhaven Bay which experience a similar hydraulic regime.

Using the Broadhaven Bay tidal data further computational modeling was completed to assess the increase in extreme tidal water levels in Sruwaddacon Bay due to the influence of its bathymetry and onshore winds.

2.3 RESULTS

The statistical analysis of the extreme water levels derived from the synthesised water level time series for Ballyglass, Broadhaven Bay gave the following water levels:-

1 in 200 year return period event:	+2.929m OD Malin
1 in 1000 year return period event	+3.143m OD Malin

The above figures are the best fit values and the 95% confidence limits were +/- 0.106m for the 1 in 200 return period event and +/- 0.132m for the 1 in 1000 year event. The results of the surge residual analysis gave values of 1.442m and 1.625m for the 1 in 200 and 1 in 1000 year return period events respectively. Incorporation of these values into the extreme tidal analysis formula of the UK

Department of Energy offshore installation guidance document[(2)] provided results that were consistent with the above figures.

The results of the analysis and modelling give the following extreme water levels for Sruwaddacon Bay:-

Table 2.1 Extreme Tidal Water Levels for Sruwaddacon Bay

Location	Return period event	Water level to OD Malin
Entrance to Sruwaddacon Bay	1 in 200	+3.029m
Head of Sruwaddacon Bay	1 in 200	+3.289m
Entrance to Sruwaddacon Bay	1 in 1000	+3.247m
Head of Sruwaddacon Bay	1 in 1000	+3.429m

For the 1 in 200 year return period event, the water levels at the entrance to Sruwaddacon Bay were estimated to be 0.1m higher than at Ballyglass while the levels at the inland head of the Bay are some 0.36m above Ballyglass. The equivalent increases for a 1 in 1000 year return period event are estimated to be 0.104m and 0.386m for the entrance area and the head of the Bay respectively.

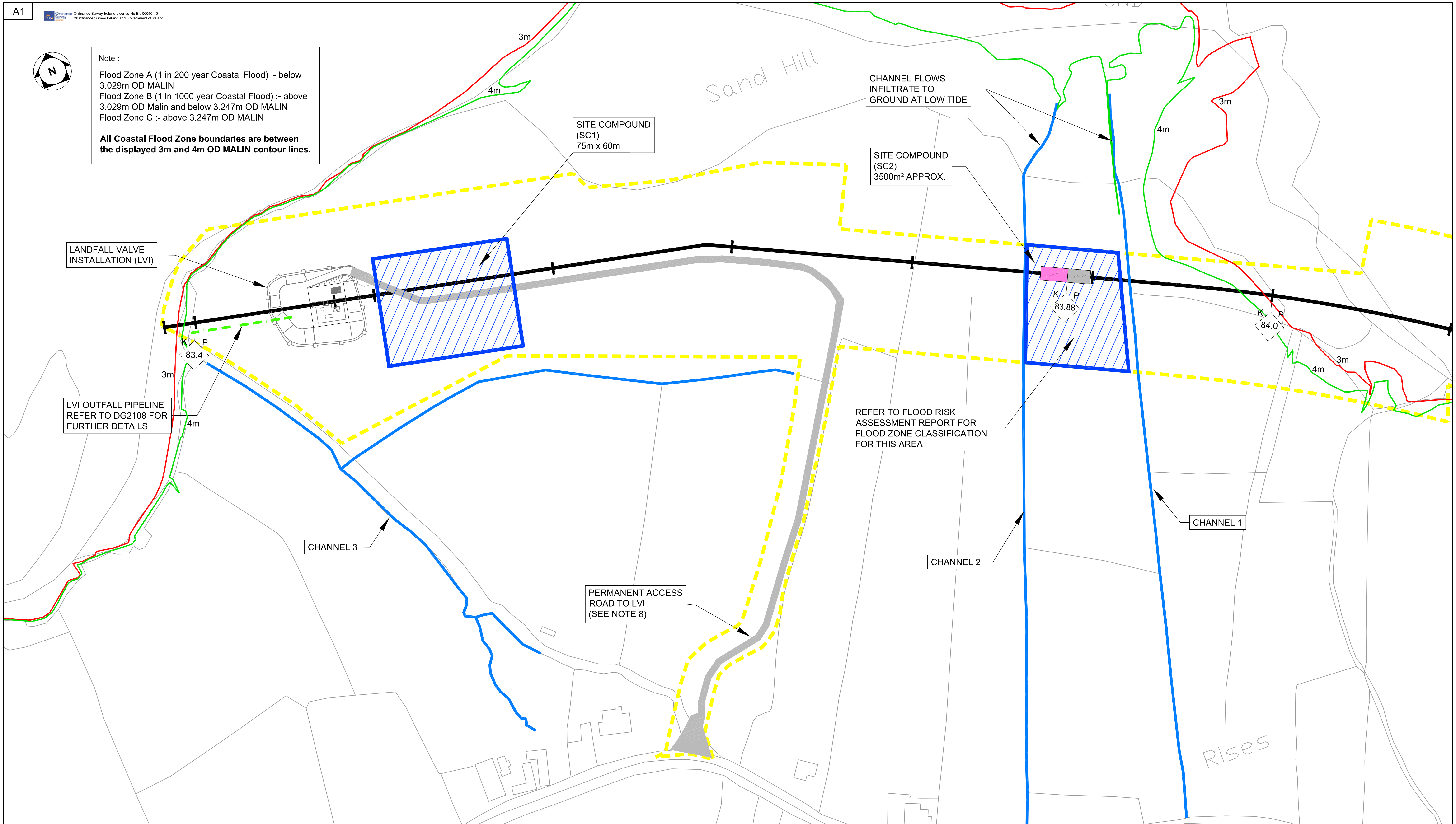
Figure 1 and **Figure 2** indicate the approximate extent of the 1 in 200 and 1 in 1000 year return period coastal flooding events, both of which lie within the displayed 3m and 4m OD Malin Head contour lines.

The extreme still water levels at the Landfall Valve Installation (LVI) and SC2 will be the similar to the values at the entrance to Sruwaddacon Bay. The proposed finished ground level for the LVI is 6.33mOD Malin, 3.08m above the estimated 1 in 1000 year return period event. The lowest existing ground level at SC2 is 6.93mOD, 3.68m above the estimated 1 in 1000 year return period event.

The extreme still water levels at the SC3 will be the similar to the values at the head of Sruwaddacon Bay. The proposed finished ground level for SC3 is 5.43mOD Malin, 2.00m above the estimated 1 in 1000 year return period event.

Based on the results above, it can be concluded that the risk of coastal flooding to the LVI, SC2 and SC3 is minimal.

A1



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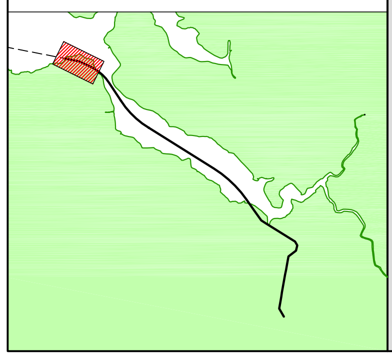


LEGEND

- PROPOSED PIPELINE ROUTE
- TEMPORARY WORKING AREA
- SITE COMPOUNDS
- STRINGING AREA
- START / RECEPTION PIT
- KILOMETRE POINT (K P 84.0)
- WATERCOURSE
- 3m OD MALIN CONTOUR
- 4m OD MALIN CONTOUR

TEMPORARY WORKS (All dimensions approximate)

SC1	LVI Site Compound (75m x 60m approx.)
SC2	Reception Pit (3500m² approx.)
SC3	Tunnelling Compound (24000m² approx.) Pipe stringing area (21000m² approx.)
SC4	80m x 50m approx.
SC5	125m x 80m approx.
L1	Reception Pit for Tunnel
L2	Starting Pit for Tunnel
RDX1	Road crossing 1

NOTES

1. All wayleaves shall be fenced off during construction.
2. All pipe bundle stringing areas shall be fenced off during construction. Working areas shall be fenced off with a security fence during construction.
3. For open cut road crossings bypass traffic lanes may be put in place.
4. The list of features is preliminary only and will be completed during the detailed design.
5. Marker posts will be provided at field boundaries, crossings and at significant changes in direction of the pipeline - locations to be completed in the detailed design.
6. All construction details are typical and indicative. Final specification subject to detailed design.
7. Where the pipe stringing wayleave adjoins the public road a temporary 6m wide access road will be constructed. For safety reasons the access roads widen at the location of the public road.
8. During construction a 6m wide access road will be constructed from the public road to the LVI. Upon completion of the project a permanent access road 3.5m wide will be retained.
9. Cathodic protection (CP) test post locations to be specified in detailed design.
10. Location of outfall vent valves are indicative only, to be specified in detailed design.
11. Corrosion coating will be 3 layer poly-propylene (3LPP) for onshore and trenchless sections and may be asphalt enamel for open cut water crossings.
12. For details of outfall pipe and umbilicals please refer to drawing DG801 and DG802.
13. IP 0.0 denotes the location of the offshore/onshore pipeline specification break.
14. IP 8.0 denotes the location of the onshore/terminal interface.
15. The majority of changes of direction of the pipeline will be constructed with field bends. The exact centre line of the pipeline is dependent on bending radius restriction of the field bends and on field construction tolerances.
16. The vertical alignment may vary between a minimum cover of 5.5m and a maximum depth of 10m below the indicated centreline.
17. All Levels refer to Ordnance Survey Datum, Malin Head.
18. Do not scale, use figured dimensions only.
19. Temporary Working Area shown includes possible deviation of the pipeline and the pipeline construction spread. The pipeline construction spread will typically be 40m wide. The Temporary Working Area also includes all compounds and ancillary areas.

REFERENCE DRAWINGS

DRAWING No.	TITLE
SERIES 2100	Land Valve Installation
SERIES 800	Standard Details
SERIES 700	Crossing Details
SERIES 600	Construction Details
SERIES 400	Bay Crossing
SERIES 300	Alignment Sheets

DRAWING REVISIONS

REV	DATE	REVISION	BY	CHK	ENG	CL'NT
D01	19.08.10	DRAFT	HF	FF	CB	

CLIENT
Shell E&P Ireland Limited
Corrib House,
52 Leeson Street Lower,
Dublin 2.

RPS
RPS
West Pier Business Campus,
Dun Laoghaire,
Co. Dublin.

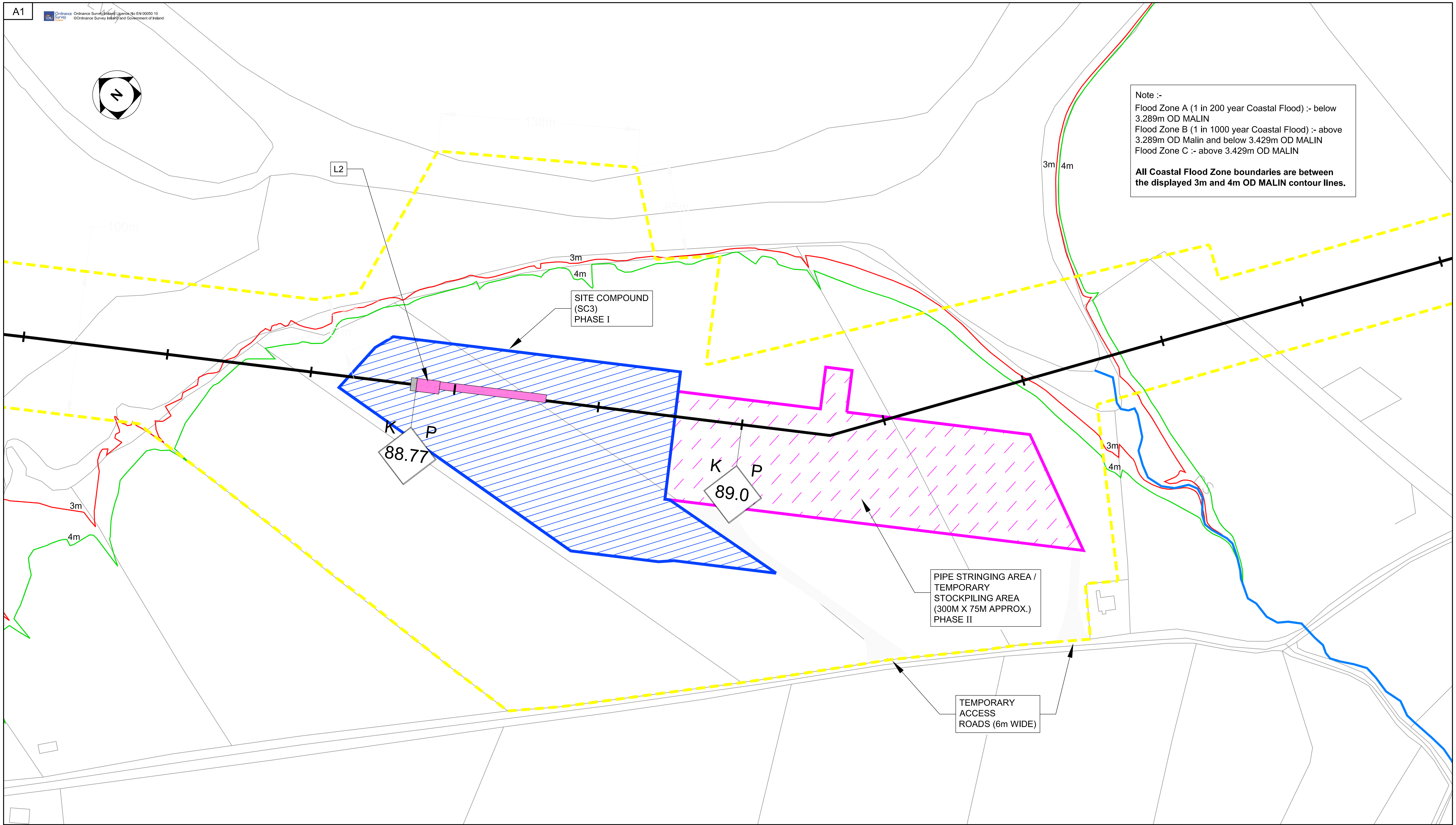
PROJECT
CORRIB ONSHORE PIPELINE

TITLE
FLOOD ZONES FOR AREA
AT ENTRANCE TO SRUWADDACON BAY

Drawn:	Checked:	Approved:	Date:	Scale:
HF	FF	CB	18.08.10	1:1000 @ A1; 1:2000 @ A3

Job No. MDR0470
File No: MDR0470FG0001D01_Flood Zones
Drg. No. FIG. 1.0
Rev: D01

A1



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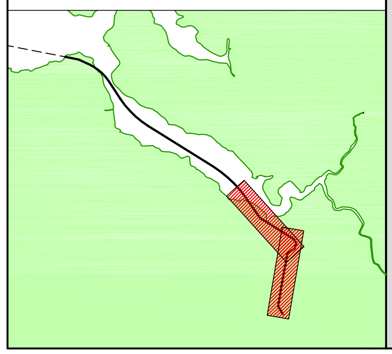

LEGEND

PROPOSED PIPELINE ROUTE	KILOMETRE POINT
TEMPORARY WORKING AREA	WATERCOURSE
SITE COMPOUNDS	3m OD MALIN CONTOUR
STRINGING AREA	4m OD MALIN CONTOUR
START / RECEPTION PIT	

TEMPORARY WORKS (All dimensions approximate)

SC1	LVI Site Compound (75m x 60m approx.)
SC2	Reception Pit (3500m² approx.)
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DRAWING No.	TITLE
SERIES 2100	Land Valve Installation
SERIES 800	Standard Details
SERIES 700	Crossing Details
SERIES 600	Construction Details
SERIES 400	Bay Crossing
SERIES 300	Alignment Sheets

REFERENCE DRAWINGS

REV	DATE	REVISION	BY	CHK	ENG	CL'NT
D01	19.08.10	DRAFT	HF	FF	CB	

DRAWING REVISIONS

CLIENT
Shell E&P Ireland Limited
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52 Leeson Street Lower,
Dublin 2.

RPS
West Pier Business Campus,
Dun Laoghaire,
Co. Dublin.

PROJECT
CORRIB ONSHORE PIPELINE

TITLE
FLOOD ZONES FOR AREA AT HEAD OF SRUWADDACON BAY

Drawn:	Checked:	Approved:	Date:	Scale:
HF	FF	CB	18.08.10	1:1250 @ A1; 1:2500 @ A3

Job No.	Drg. No.	Rev:
MDR0470	FIG. 2.0	D01

File No: MDR0470FG0002D01_Flood Zones

3 FLUVIAL FLOODING

3.1 GENERAL

The risk of fluvial or watercourse flooding is examined in this section for the LVI and SC2 where nearby watercourses exist (refer to **Figure 1**). Although the Leenamore River is in close proximity to SC3, there is not considered any risk of watercourse flooding impacting SC3 due to the substantial difference in elevation between the two sites (over 5m).

There are two channels in the vicinity of SC2 – one channel on the eastern boundary and another channel on the western boundary. Both these channels (Channels 1 and 2) have small upstream catchment areas of approximately 6 and 15 hectares each. Up-gradient of the LVI, there is a channel or small first order stream (Channel 3) with a catchment area of approximately 12 hectares, running in a south-north direction, which is also fed by a small tributary, indicated on Figure 1, that runs in an east-west direction.

3.2 FLOW ESTIMATIONS

The catchment sizes involved are too small for use in many commonly used ungauged catchment flow estimation equations such as the Institute of Hydrology Report No.124 (IH124). The use of another commonly used method for small catchments, ADAS (The UK Agricultural Development and Advisory Service), was also examined but considered inappropriate as the large 'time to peak' results generated by the methodology were deemed inconsistent with the steep and short length nature of the catchments. Therefore, it has been decided to use the more conservative Modified Rational Method to estimate peak flows.

The Modified Rational Method Equation is displayed in **Equation 3.1** below:

$$Q=2.78 \times Cv \times Cr \times I \times A$$

where:-
Q = Flow (litres/second)
Cv = Volumetric Runoff Coefficient
Cr = Routing coefficient
I = Average rainfall intensity during the time of concentration (mm/hr)
A = Contributing area (ha)

Equation 3.1 Modified Rational Method

Table 3.1 indicates the estimated flows for a 60 storm minute duration for each of the channel catchments. Rainfall intensity rates have been estimated using Met Éireann Belmullet rainfall records. The values chosen for the Cv and Cr combine to give a conservative runoff reflecting catchment characteristics.

Table 3.1 Run-off from upstream green area

Sub-Catchment	Area (ha)	Cv	Cr	100 year return period		1000 year return period	
				Rainfall (mm/hr)	Flow (m^3/s)	Rainfall (mm/hr)	Flow (m^3/s)
Channel 1 (east of SC2)	6.20	0.6	1.2	34.6	0.43	65.1	0.81
Channel 2 (west of SC2)	14.70	0.6	1.2	34.6	1.02	65.1	1.91
Channel 3 (west of LVI)	12.26	0.6	1.2	34.6	0.85	65.1	1.60

Table 3.2 below indicates the calculated carrying capacity of the three channels.

Table 3.2 Channel Flow Capacity Calculations

Location	Channel dimensions (m)			Area (m^2)	Wetted Perimeter (m)	Hydraulic Radius, R (m)	Slope (S)	*n	Flow, Q (m^3/s)
	Bottom width	Top width	Depth				(1 in 50)		
Channel 1	1.00	1.50	0.50	0.63	2.12	0.30	0.0200	0.030	1.30
Channel 2	1.00	1.50	0.50	0.63	2.12	0.30	0.0200	0.030	1.30
Channel 3	1.25	1.75	1.00	1.50	3.31	0.45	0.0200	0.030	4.17

* With reference to *Open Channel Hydraulics* (Chow, 1959) it was decided a Manning's roughness co-efficient value of 0.030 was most applicable for the channel.

From the results indicated in Tables 3.1 and 3.2, it can be seen that the risk of fluvial flooding at the LVI is minimal as Channel 3 has an estimated flow carrying capacity comfortably in excess of the estimated 1 in 1000 year peak flows.

At SC2 both Channels 1 and 2 have flow carrying capacities comfortably in excess of the estimated 1 in 100 year peak flows. The flow carrying capacity of Channel 1 is also in excess of the estimated 1 in 1000 year peak flows. However, the estimated 1 in 1000 year peak flow is in excess of the carrying capacity of Channel 2 indicating that the existing channel may be at risk of flooding during extreme storm events (approximately 1 in 300 years extrapolating from the data above). Accordingly a classification of Flood Zone B applies. However, given the nature of the development – a temporary compound site with an estimated duration of 12 months – this site is classified as "*Less Vulnerable Development*" in accordance with *Table 3.1 Classification of vulnerability of different types of development* of *The Planning System and Flood Risk Management Guidelines for Planning Authorities.* The guidelines consider that "*Less Vulnerable Development*" on Flood Zone B is "*appropriate*" and, therefore, as with development in Flood Zone C, a planning Justification Test is not required.

Based on the results above, it can be concluded that fluvial flooding risk to the LVI and SC2 is minimal.

4 GROUNDWATER FLOODING

The proposed finish ground level of the LVI is lower than the existing ground and as such the risk of groundwater flooding has been examined for this area. Groundwater flooding risk is not a parameter used to define the Flood Zones within the *The Planning System and Flood Risk Management Guidelines for Planning Authorities.* Details of the proposed layout of the LVI are contained in Volume 1, Chapters 4 and 5 of the Corrib Onshore Pipeline EIS and reference to its layout, including details of the proposed drainage system, should be made to the series of drawings COR25MDR0470DG2101P03 - COR25MDR0470DG2109P03.

Groundwater levels were measured at the proposed LVI site at Gleann an Ghad (Glengad) in December 2007 and January 2008 (representing periods of elevated rainfall and associated elevated groundwater levels). The highest water level recorded during this period for the proposed LVI site was 5.73mOD (Malin Head), which is 600mm below the proposed finished ground level of 6.33mOD Malin Head. Observations made during the excavation of this area in preparation for the construction of the pipeline indicated much lower groundwater levels (below 2.8mOD Malin Head).

The proposed perforated drainage pipe network, installed at the toe of the site slopes with approximately 900mm cover to the proposed finish ground level, will intercept both groundwater and surface water and divert elevated groundwater from the LVI site to a concealed outfall in the cliff face. As such, it is considered that the risk of groundwater levels rising above the finished ground level of the LVI is very low.

5 OVERLAND FLOW FLOODING

Mitigation measures to reduce the risk of overland flows causing flooding throughout all areas of the construction site, principally through the proposed use of open channel interceptor drains, are discussed elsewhere in the EIS in Chapters 5 and 15 and Appendices M5, M6 and M7. Overland flow flooding risk is not a parameter used to define the Flood Zones within the *The Planning System and Flood Risk Management Guidelines for Planning Authorities.*

A water level alarm is included in the LVI drainage design, which would allow early detection in the unlikely event of overland or groundwater flooding of the LVI area.

6 SUMMARY AND CONCLUSIONS

A Flood Risk Assessment has been undertaken for the Corrib Onshore Pipeline project in accordance with the requirements of *The Planning System and Flood Risk Management Guidelines for Planning Authorities*. A key aspect of the Flood Risk Assessment is to determine if a planning Justification Test is required. The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of particular developments that are being considered in areas of moderate or high flood risk.

The types of flooding considered in this report include coastal flooding (a detailed extreme tide level analysis), fluvial or watercourse flooding, groundwater flooding and flooding from storm generated overland flows. Tidal factors are dominant for the LVI and both compounds (SC2 and SC3). Consideration of tidal, fluvial and groundwater factors together is not required by the Guidelines. However, the probability of such extreme tidal, fluvial and groundwater events occurring simultaneously is extremely low.

In accordance with *The Planning System and Flood Risk Management Guidelines for Planning Authorities* the proposed permanent LVI development is located within Flood Zone C defined as "*Flood Zone C – where the probability of flooding from rivers and the sea is low (less than 0.1% or 1 in 1000 for both river and coastal flooding)".* The proposed ground level of the LVI is 3.08m above the estimated 1 in 1000 year return period tidal event. A nearby watercourse is not predicted to flood for the 1 in 1000 year event due to its large channel size.

Similarly the proposed temporary tunnelling compound at Aghoos (SC3), is located within Flood Zone C with the lowest existing ground level in this location is approximately 2.00m above the estimated 1 in 1000 year return period tidal event. Due to its location SC3 is not predicted to be impacted by watercourse flooding.

The lowest existing ground level at the proposed temporary tunnelling compound at Gleann an Ghad (Glengad) (SC2), is approximately 3.68m above the estimated 1 in 1000 year return period tidal event. It is predicted that some watercourse flooding may impact the existing site location during extreme events between the 1 in 100 and 1 in 1000 year return period events. Accordingly a classification of Flood Zone B applies. However, given the nature of the development – a temporary compound site with an estimated duration of 12 months – this site is classified as "*Less Vulnerable Development*" in accordance with *Table 3.1 Classification of vulnerability of different types of development* of *The Planning System and Flood Risk Management Guidelines for Planning Authorities*. The guidelines consider that "*Less Vulnerable Development*" on Flood Zone B is "*appropriate*". In addition the risk of flooding can be substantially reduced by the relatively minor mitigation measure of raising the channel banks by 200mm within the site compound to improve conveyance capacity, which due to the site's proximity to the sea, will have no detrimental effects downstream.

Based on the flood zone categorization and type of development involved, in accordance with the sequential approach to planning required within the *The Planning System and Flood Risk Management Guidelines for Planning Authorities (*refer *Fig. 3.2: Sequential approach mechanism in the planning process),* a Justification Test is not required for planning purposes for the Corrib Onshore Pipeline. Referring to Table 3.2 of the Guidelines, which is a matrix of development vulnerability and flood zone categorisation, all development within the Corrib Onshore Pipeline project is classified as "*appropriate*".

In addition suitable flood mitigation measures have been included in the development proposal to reduce the risk of overland flow flooding, at all proposed compounds and along the pipeline route, and the risk of groundwater flooding at the LVI.

REFERENCES

(1) Office of Public Works, Dublin, Ireland. – “Irish Coastal Protection Strategy Study – A Strategic Assessment of Coastal Flooding and Erosion Extents” A report being undertaken in various stages by RPS Consulting Engineers on behalf of the OPW. Phase 4 Extreme water levels on the west coast of Ireland (in production).

(2) Department of Energy UK – “Offshore Installations: Guidance on design, construction and certification - Section 11 Environmental considerations” Fourth edition 1990.

(3) Department of Environment Heritage and Local Government and Office of Public Works - The Planning System and Flood Risk Management Guidelines for Planning Authorities, November 2009

Appendix 1

Extreme Tidal Level Analysis

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Corrib Onshore Pipeline

Extreme tidal level analysis

July 2010

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CONTENTS

1.0 INTRODUCTION

Sections of the Corrib onshore pipeline and its associated infrastructure works are to be constructed on the shoreline at the entrance to and within Sruwaddacon Bay. Broadhaven, Co Mayo. An issue has been raised in relation to the significance of potential coastal flooding in this area and thus this study has been undertaken to assess the levels of the 1 in 200 and 1 in 1000 year return period tidal flood levels at the site of the inshore pipeline works.

This report gives details of the data, methodology and modelling used in the study as well as the extreme tidal levels at the various parts of the site.

2.0 STUDY METHODOLOGY

2.1 General

In areas where there are long term tidal records, the extreme tidal levels for flood risk assessment are established by statistical analysis of the tidal record data set. These tidal records include the influence of storm surges as well as the astronomical tidal effects due to the gravitational pull of the sun and the moon. On the west coast of Ireland there is only a limited amount of long term tidal data and there are no long term records of tidal levels in the Broadhaven area as the tidal gauge at Ballyglass has only been operational since about May 2008.

The various tidal records along the west coast of Ireland have been collated by RPS as part of the Irish Coastal Protection Strategy Study(1) which RPS is undertaking for the Office of Public Works (OPW). This data has been used to generate a synthetic time series record of water levels for Broadhaven Bay to facilitate a statistical analysis to determine the 1 in 200 and 1 in 1000 year return period water levels for the area. The extreme water levels for the pipeline site have then been established by computational modelling techniques to account for the wind shear and bathymetry effects which are particular to the tidal and storm surge regime in and around Sruwaddacon Bay.

2.2 Tidal level time series

The tidal level time series data for the study has been derived using a combination of the predicted astronomical tides for Broadhaven Bay combined with storm surge residuals taken from the tide gauges at Killybegs and Malin Head. This allowed an almost continuous 13 year hourly time series record of water levels to be produced for the Broadhaven Bay tide gauge location at Ballyglass for the period December 1996 to December 2009 inclusive.

The astronomical tides were derived by harmonic analysis using 49 constants derived from the Marine Institute's gauge records for Ballyglass for the period from May 2008 onwards. The storm surge residuals from Killybegs spanned the period from 2001 to 2004 and 2007 to 2009 inclusive. The surge residual from Malin spanned the period 1997 to 2001 inclusive and 2004 to mid 2009 inclusive. The storm surge residual values from Killybegs were used in preference to the Malin data when both surge residual values were available as Killybegs is closer to Broadhaven Bay.

The resulting synthesized time series of water levels for Broadhaven Bay is shown in Figure 1 below. It will be noted that there are three gaps in the time series which occurred when there was no storm surge residual values available from either Killybegs or Malin Head. The effective length of the time series record is 12.375 years.

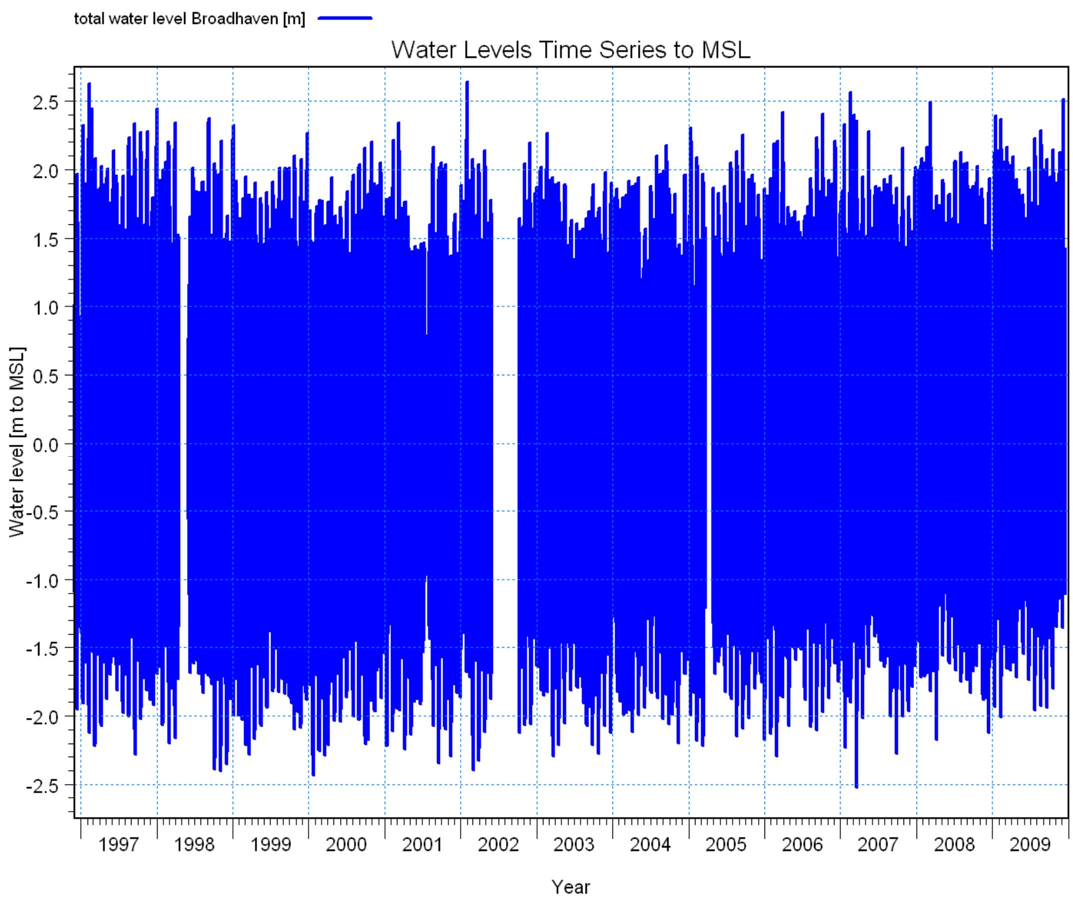


Figure 1 **Water level time series derived for Broadhaven Bay.**

2.3 Validation of water level time series

The validation of the approach of using the storm surge residual from Killybegs and Malin has been validated by comparing the synthesized time series against the actual tidal measurements at the Broadhaven Bay tide gauge at Ballyglass for which records are available. Figure 2 shows the comparison of the water levels for the period May 2008 to December 2009. Figure 3 gives a more detailed picture for a storm surge event in January 2009. As the storm surges were taken from Killybegs during this time period, the synthesized time series peak levels are generally above those measured at the Ballyglass gauge as due to its location, Killybegs tends to experience larger surges than occur at Broadhaven Bay. Thus the approach of using storm surges records from Killybegs is considered to be conservative.

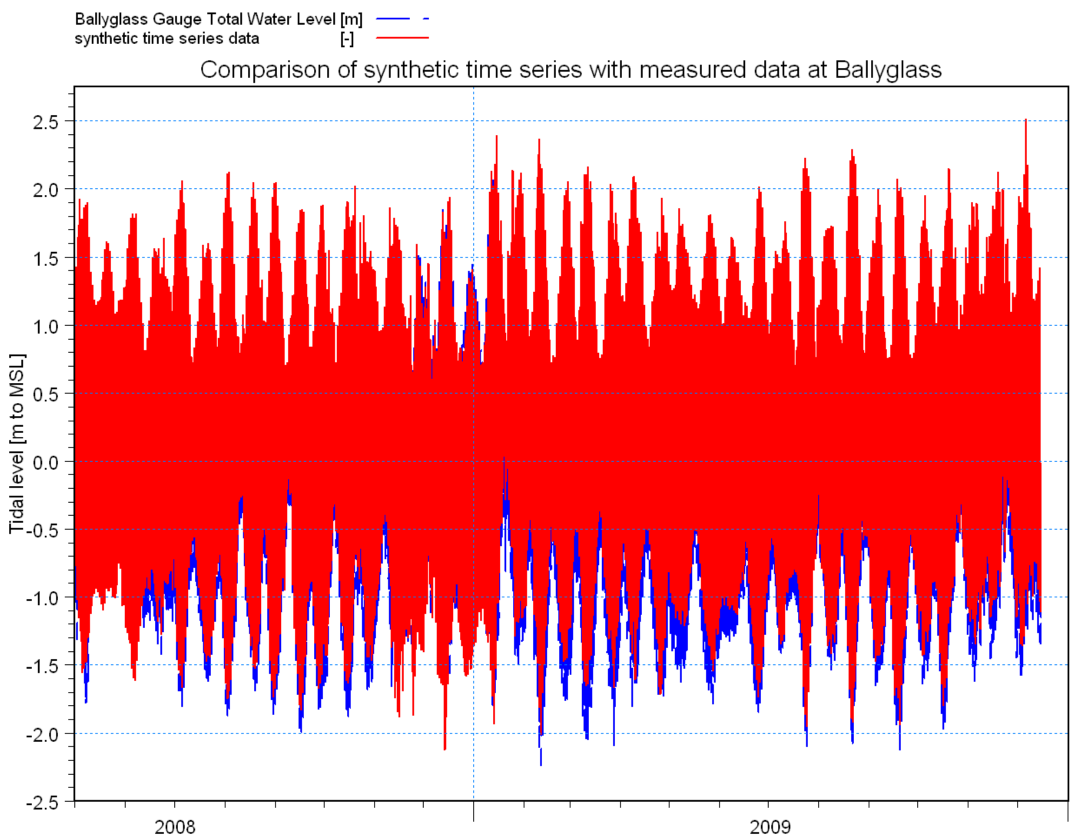


Figure 2 Comparison of the synthesized water levels and the measured water levels at Ballyglass for the period May 2008 to December 2009

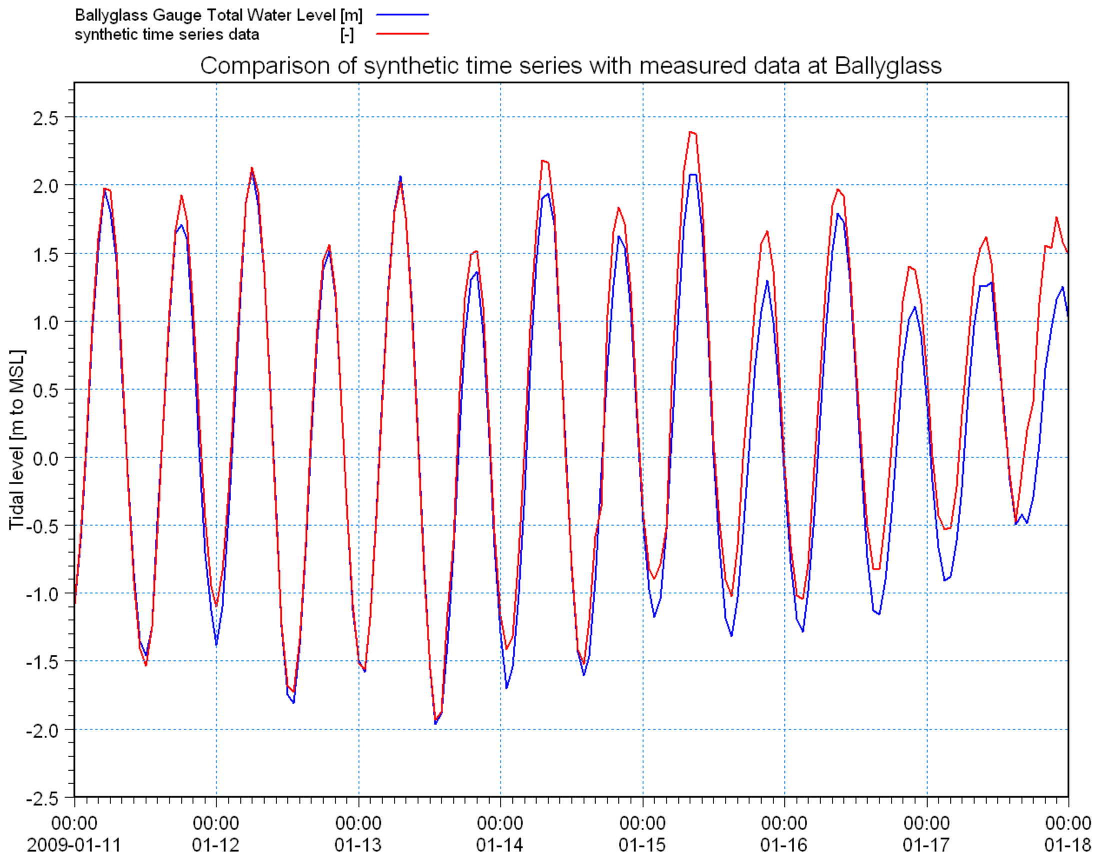


Figure 3 Comparison of the synthesized water levels and the measured water levels at Ballyglass for storm surge event January 2009

A similar validation exercise has been undertaken using the storm surge values from Malin so as to get a measure of the accuracy of using the Malin data when Killybegs storm surge residuals were not available. Figure 4 shows the comparison of the levels synthesized using the Malin surge residuals with the Ballyglass gauge measurements for the period May 2008 to July 2009. Figure 5 shows the data in more detail for the storm surge event in January 2009. It will be seen from these diagrams that the synthesized time series using the Malin surge residuals is a reasonably good match for the measured values. The results of the validation exercise indicate that the synthesized water level time series is likely to accord with or be slightly higher than the water levels which actually occurred during the period December 1996 to December 2009.

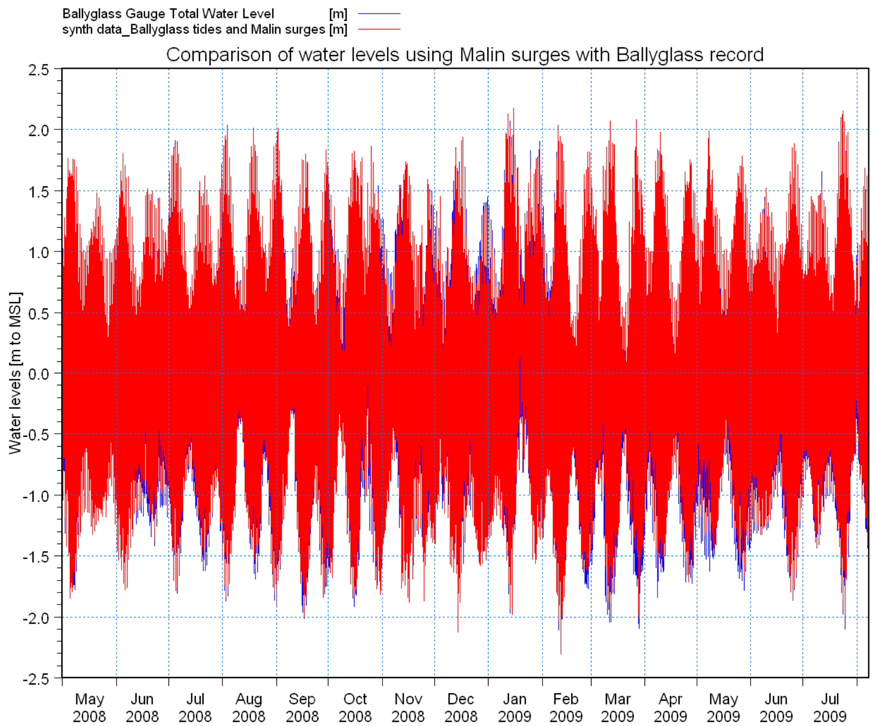


Figure 4 Comparison of the synthesized water levels using Malin surges with the measured water levels at Ballyglass for the period May 2008 to July 2009

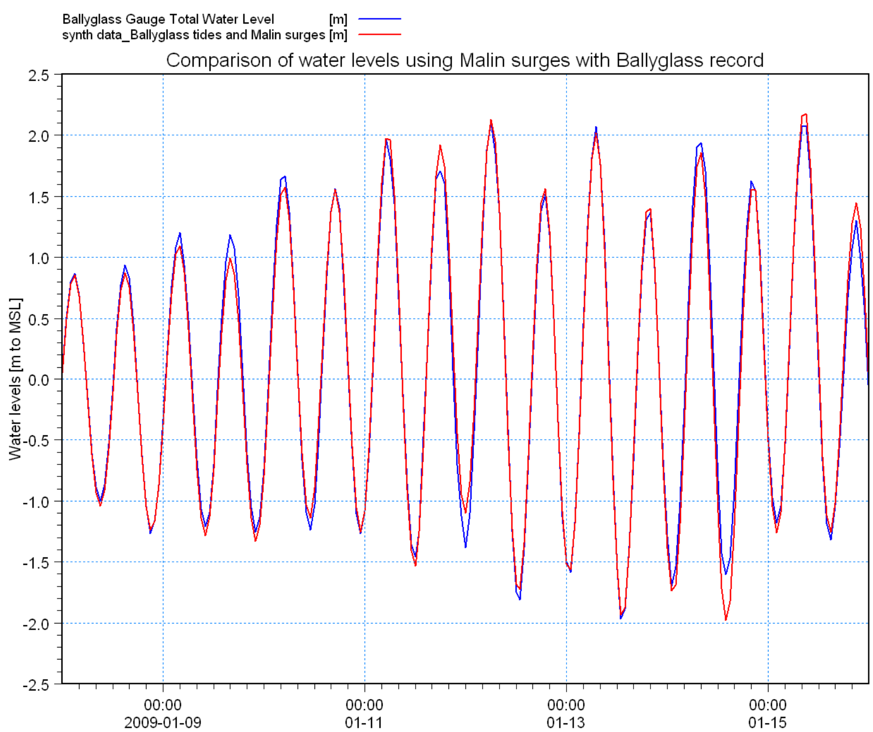


Figure 5 Comparison of the synthesized water levels using Malin surges and the measured water levels at Ballyglass for storm surge event January 2009

2.4 Statistical Analysis

The statistical analysis of the time series water levels was under taken using the Extreme Value Analysis tool in the MikeZero suite of coastal process modelling software developed by the Danish Hydraulics Institute. The EVA toolbox in MIKE Zero comprises a comprehensive suite of routines for performing extreme value analysis. These include

- A pre-processing facility for extraction of the extreme value series from the record of observations.
- Support of two different extreme value models, the annual maximum series model and the partial duration series model.
- Support of a large number of probability distributions, including exponential, generalised Pareto, Gumbel, generalized extreme value, Weibull, Frechét, gamma, Pearson Type 3, Log-Pearson Type 3, log-normal, and square-root exponential distributions.
- Three different estimation methods: method of moments, maximum likelihood method, and method of L-moments.
- Three validation tests for independence and homogeneity of the extreme value series.
- Calculation of five different goodness-of-fit statistics.
- Support of two different methods for uncertainty analysis, Monte Carlo simulation and Jackknife resampling.
- Comprehensive graphical tools, including histogram and probability plots

A partial duration series model was used for the analysis of the extreme water levels for Broadhaven Bay. Although each tidal cycle is an independent event, storm surges can last over several tidal cycles thus a time period of 72 hours was set as the minimum period between peak tidal levels in the analysis. The threshold for the data extract was adjusted so that the analysis was undertaken for the equivalent to an average annual number of exceedances of about 5 which is equivalent to about 65 to 70 events. A Truncated Gumble distribution with a threshold level of 2.05m was found to give a good fit to the water level data. Figure 6 shows the probability distribution derived for the analysis of extreme water levels. The diagram shows the best fit line and the 95% confidence values.

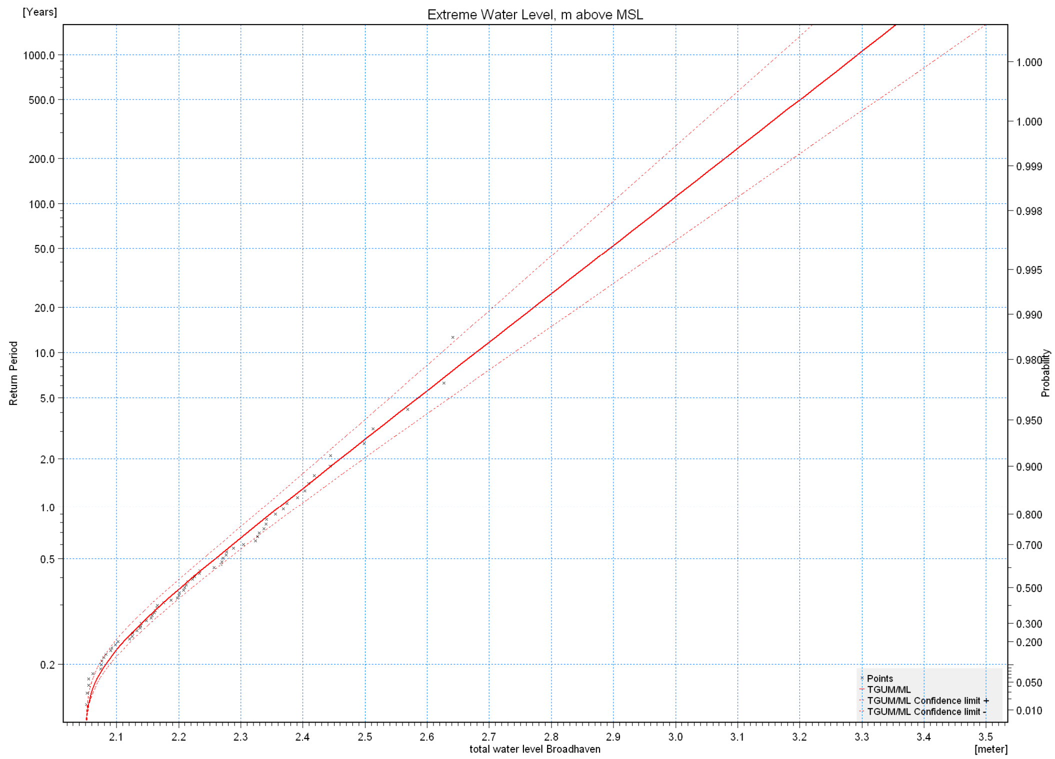


Figure 6 Probability distribution from the extreme value analysis of the water levels relative to MSL at Broadhaven Bay.

As a check on the results of the extreme water levels analysis, calculations were undertaken using the techniques outlined in the UK Department of Energy's Offshore Installations: Guidance on design, construction and certification document 1990(2). Section 11.5 of this document sets out a method of estimating the extreme water levels based on the surge residual values. Thus a statistical analysis was also undertaken on the time series of the surge residual. The technique outlined in the UK Department of Energy document relates to using the 1 in 50 year return period surge with the mean spring amplitude to derive a total 1 in 50 year return period water level which equals an extreme water level constant (E_{50}) x (spring tide amplitude + 50 year positive storm surge elevation). In the analysis the E_{50} value for Broadhaven Bay was taken to be the same as that at Malin with a value of 1.04. This value is relatively constant along the west coasts of Britain and Ireland being 1.05 at Stornoway and 1.07 at Newlyn. The document gives a relationship for transforming the 50 year return period water level value to give the 1 in 200 and 1 in 1000 year return period levels.

Figure 7 shows this time series for the surges and Figure 8 shows the probability distribution derived from the analysis of the top 65 surge events in the time series which has been used to derive the surge data for the analysis.

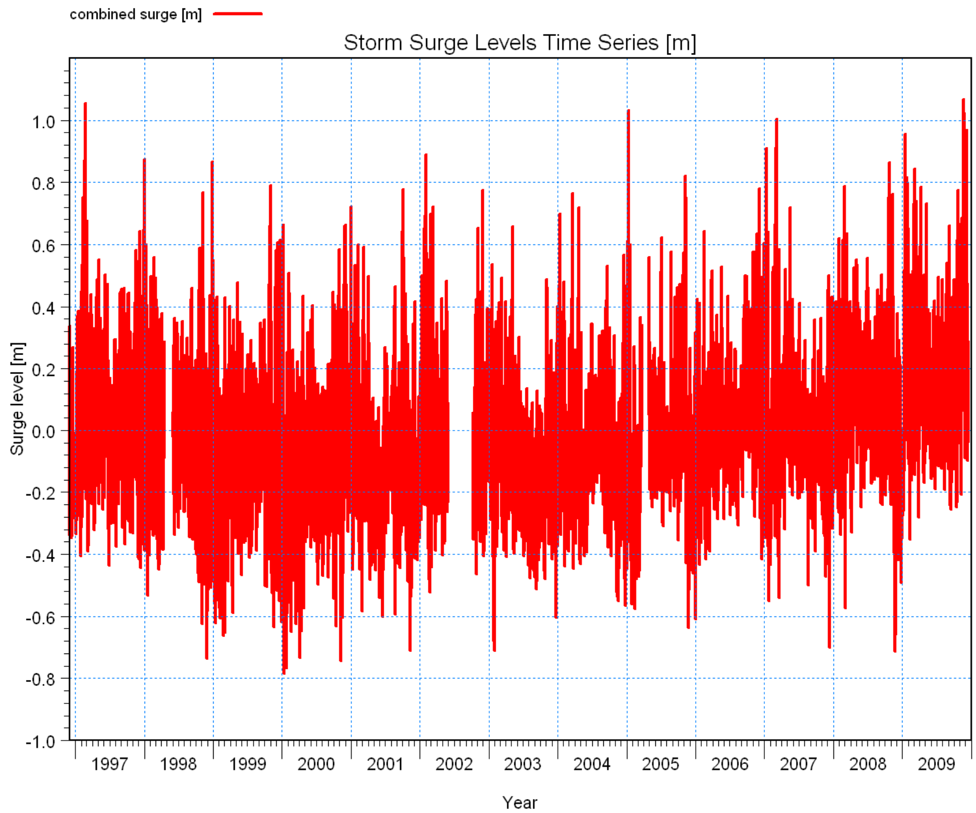


Figure 7 Surge elevation time series derived for Broadhaven Bay.

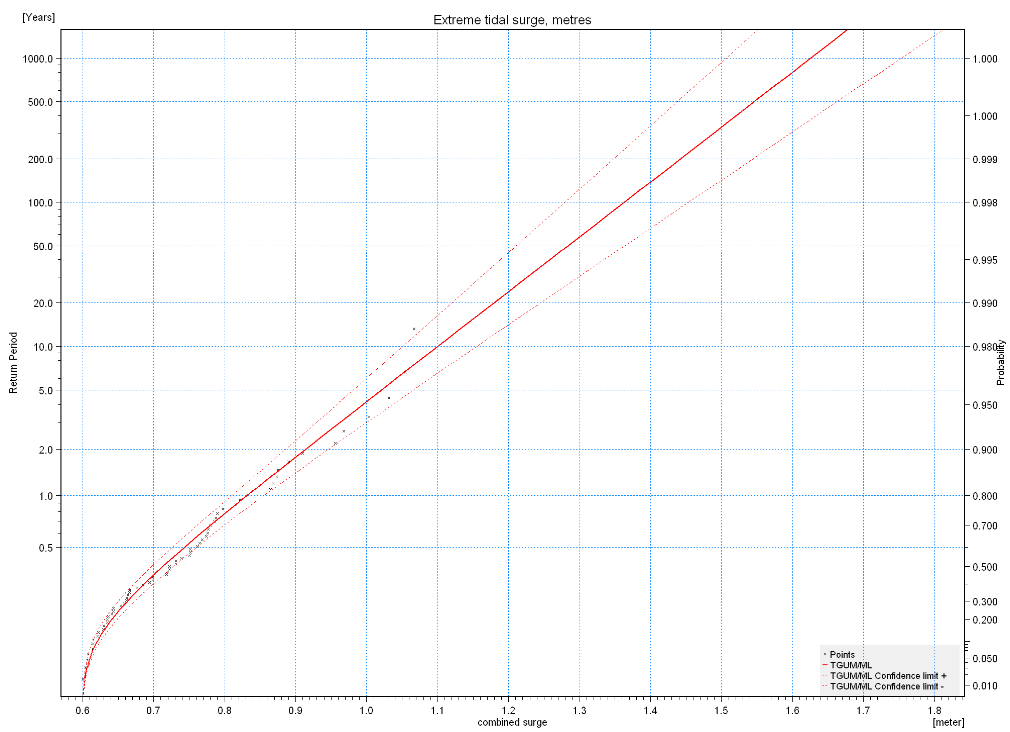


Figure 8 Probability distribution from the extreme value analysis of the storm surge elevation at Broadhaven Bay.

2.5 Modelling of variation water levels around Sruwaddacon Bay

The results of the statistical analysis of extreme water levels are applicable to the water levels in and around the tide gauge site and other parts of Broadhaven Bay which have a similar hydraulic regime. However the water levels in Sruwaddacon Bay will be influenced by its local bathymetry and the effect of the water being pushed up into the bay by strong onshore winds which can accompany storm surge events.

Computational model studies were used to assess the increase in extreme water levels in the Bay due to the influence of its bathymetry and onshore winds. The modelling was undertaken using a Mike21 FM model of Broadhaven Bay and its adjoining waters. This flexible mesh model is a sub model of the RPS storm surge model of the Western Atlantic and Irish Coastal waters. This large model is being used for the Irish Coastal Protection project and is also used to provide storm surge forecasts for the OPW. The extent of the Irish coastal waters model is shown in Figure 9 and the area of the sub model of Broadhaven Bay is shown in Figure 10.

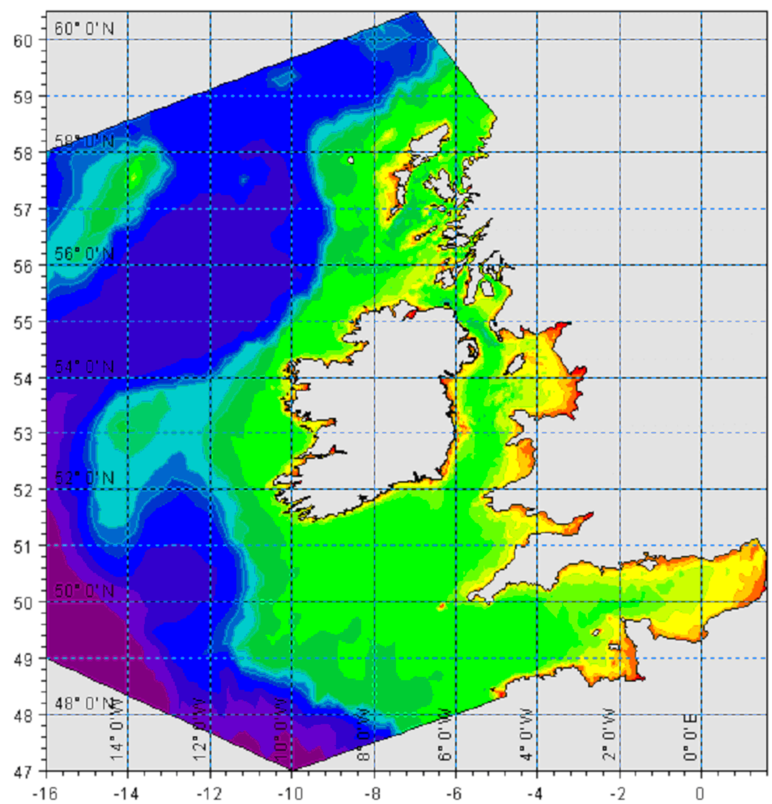


Figure 9 Extent of RPS's Storm surge model for Irish Coastal Waters

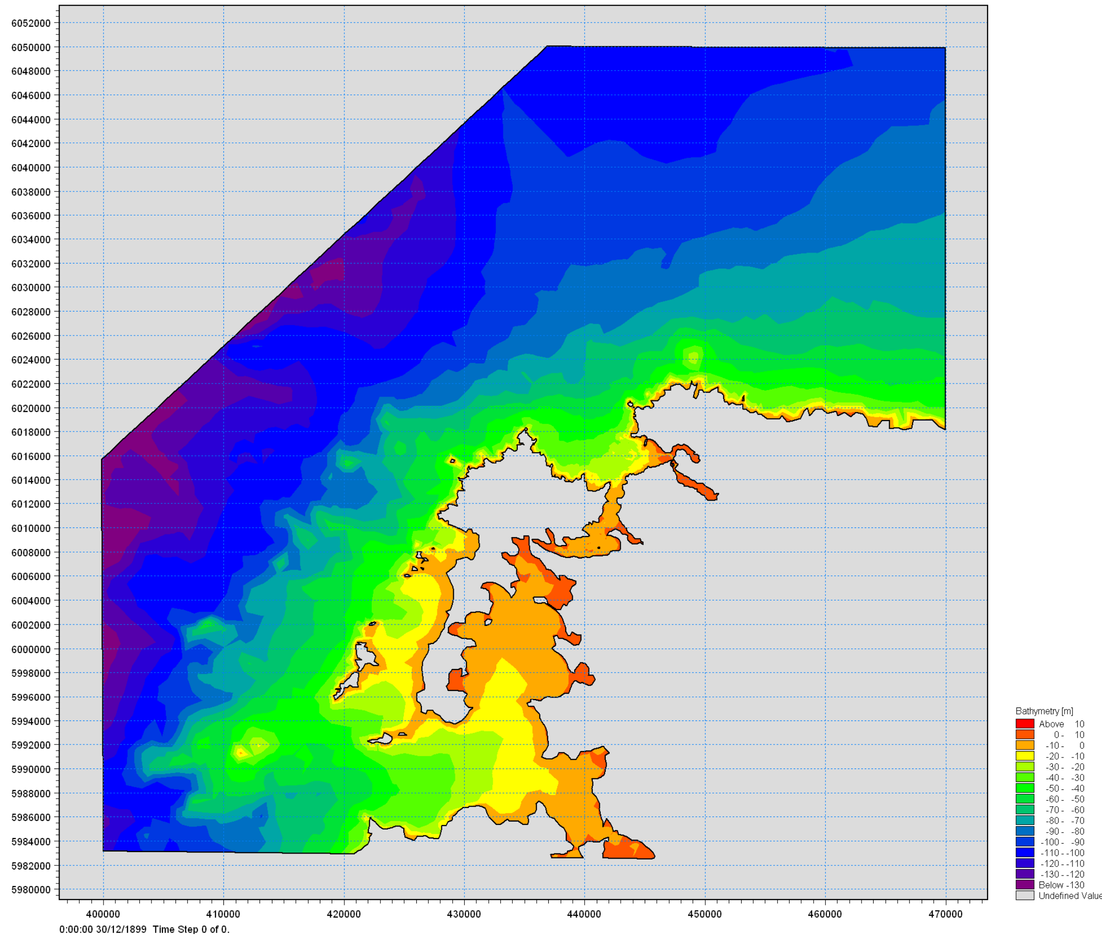


Figure 10 Extent of Broadhaven Bay tidal and storm surge sub model

The Broadhaven Bay model was run for a period of high spring tides with a storm surge of about 1 metre which results in water levels which are approximately the same as a 1 in 200 year return period event. In addition wind forcing equivalent to 25 m/s mean wind speed from a west north west direction was applied to the model to simulate the conditions when storm surges are accompanied by strong onshore winds.

The results of the model simulations was used to derive the increase in water levels in and around Sruwaddacon Bay over those derived from the statistical analysis for the Ballyglass area.

3.0 RESULTS AND CONCLUSIONS

3.1 Results of the statistical analysis of water levels and surges

The statistical analysis of the extreme water levels derived from the synthesized water level time series for Broadhaven Bay gave the extreme levels set out in Table 10.1below.

Return period event	Water level to MSL	Water level to OD Malin
1 in 200 year	3.079m	2.929m
1 in 1000 year	3.293m	3.143m

Table 10.1 Extreme water level values derived for Ballyglass, Broadhaven Bay

The above figures are the best fit values and the 95% confidence limits were +/- 0.106m for the 1 in 200 return period event and +/- 0.132m for the 1 in 1000 year event.

The results of the surge residual analysis gave values of 1.442m and 1.625m for the 1 in 200 and 1 in 1000 year return period events respectively. The 1 in 50 year return period surge residual value was 1.283m. Using this value in the formula for estimating the extreme water levels in the UK Department of Energy offshore installation guidance document resulted in predicted extreme water levels of 3.088m and 3.208m above MSL for the 1 in 200 and 1 in 1000 return period events respectively. These values are consistent with figures given in Table 10.1 above and give confidence in the values shown in Table 10.1

3.2 Modelling of the change in water levels in Sruwaddacon Bay

Figure 11 shows the time series of surface elevation of the water at Ballyglass, the entrance to Sruwaddacon Bay and at the inland end of Sruwaddacon Bay during the simulated 1 in 200 year return period storm event. The distribution of the water levels around Boadhaven Bay at the time of peak water levels is shown in Figure 12.

It will be seen from the diagrams that the water levels at the entrance to Sruwaddacon bay are some 0.1m higher than at Ballyglass while the levels at the inland head of the Bay are some 0.36m above Ballyglass. The equivalent increases for a 1 in 1000 year return period event are estimated to be 0.104m and 0.386m for the entrance area and the head of the bay respectively.

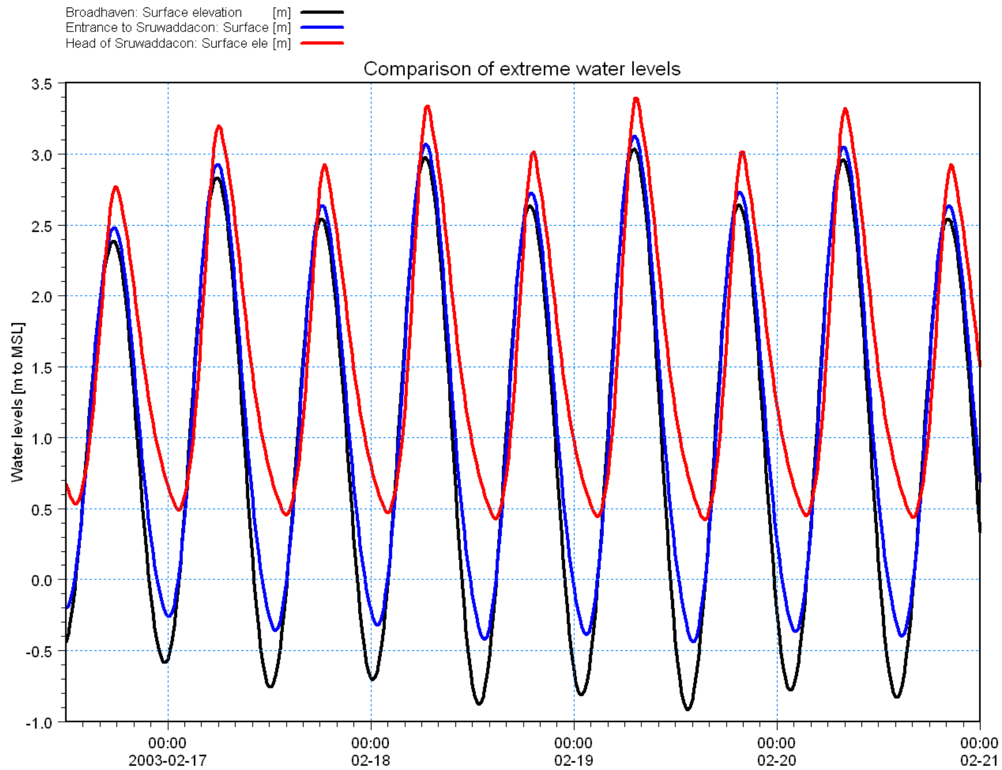


Figure 11 Time series of water levels during 1 in 200 year simulated event with strong onshore winds

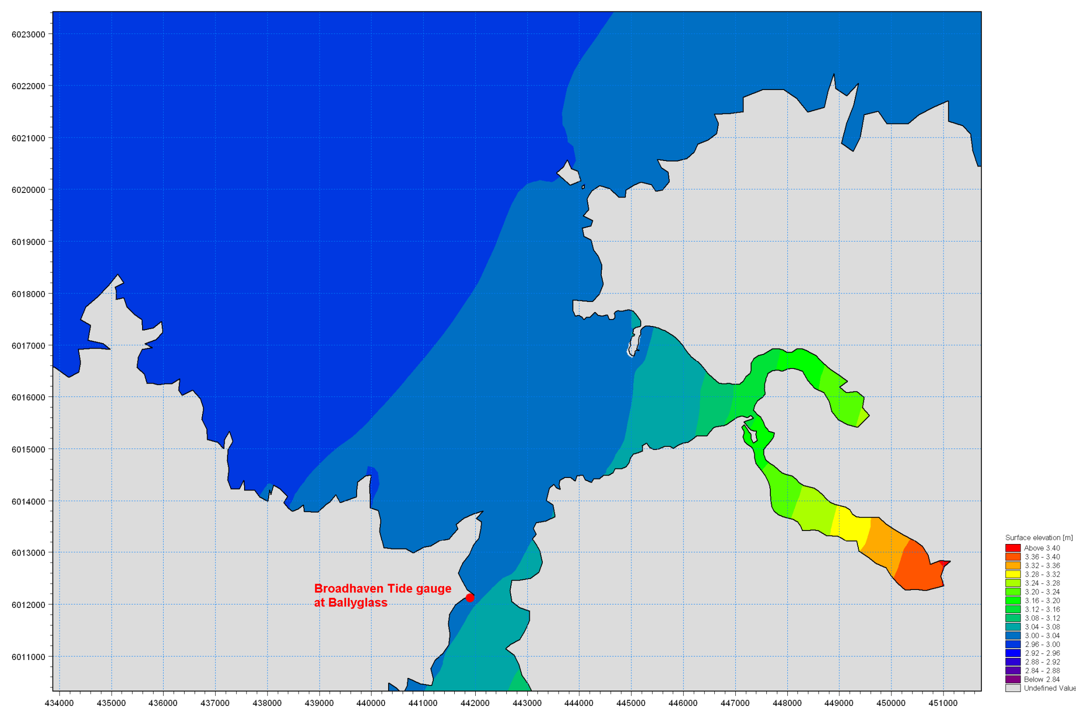


Figure 12 Distribution of water levels at peak tide for 1 in 200 year return period event with strong onshore winds

3.3 Conclusions

The results of the analysis and modelling give the following extreme water levels:

1 in 200 year return period storm

Ballyglass Pier	+3.079m to MSL	+2.929m OD Malin
Entrance to Sruwaddacon Bay	+3.179m to MSL	+3.029m OD Malin
Head of Sruwaddacon Bay	+3.439m to MSL	+3.289m OD Malin

1 in 1000 year return period storm

Ballyglass Pier	+3.293m to MSL	+3.143m OD Malin
Entrance to Sruwaddacon Bay	+3.397m to MSL	+3.247m OD Malin
Head of Sruwaddacon Bay	+3.579m to MSL	+3.429m OD Malin

The extreme still water levels at the Landfall Valve location will be the similar to the values at the entrance to Sruwaddacon Bay.

4.0 REFERENCES

(1) Office of Public Works, Dublin, Ireland. – "Irish Coastal Protection Strategy Study - A Strategic Assessment of Coastal Flooding and Erosion Extents" A report being undertaken in various stages by RPS Consulting Engineers on behalf of the OPW. Phase 4 Extreme water levels on the west coast of Ireland (in production).

(2) Department of Energy UK – "Offshore Installations: Guidance on design, construction and certification - Section 11 Environmental considerations" Fourth edition 1990.

APPENDIX G

Revised Appendix Q6.3 Figures

1. **Figures 5.3, 5.4 & 5.5**

2. **Attachment Q6.3 B - Figure B3.2 – H-01.03a**

Figure 5.3: Consequence Example

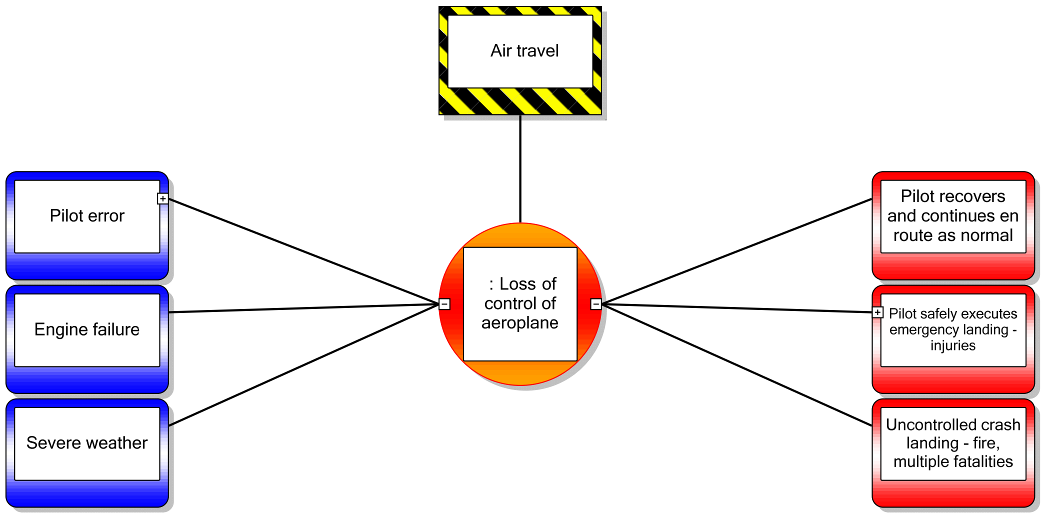


Figure 5.4: Controls Example

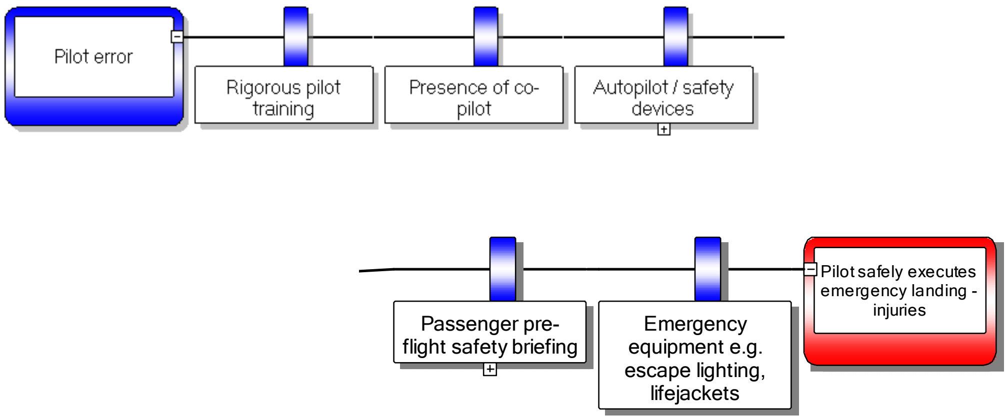
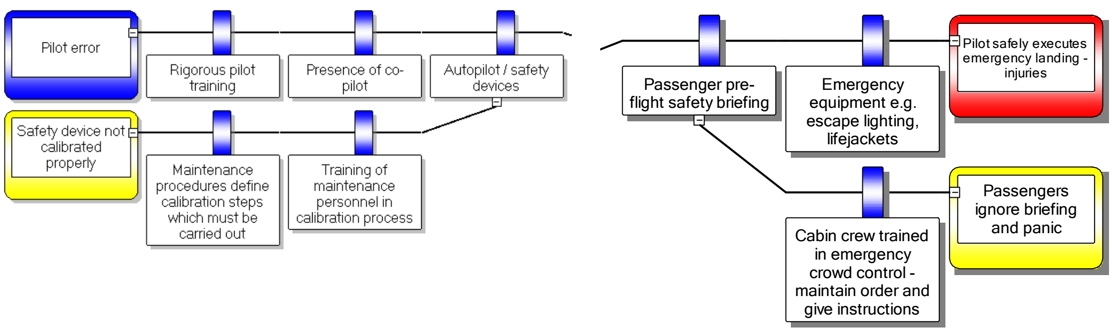
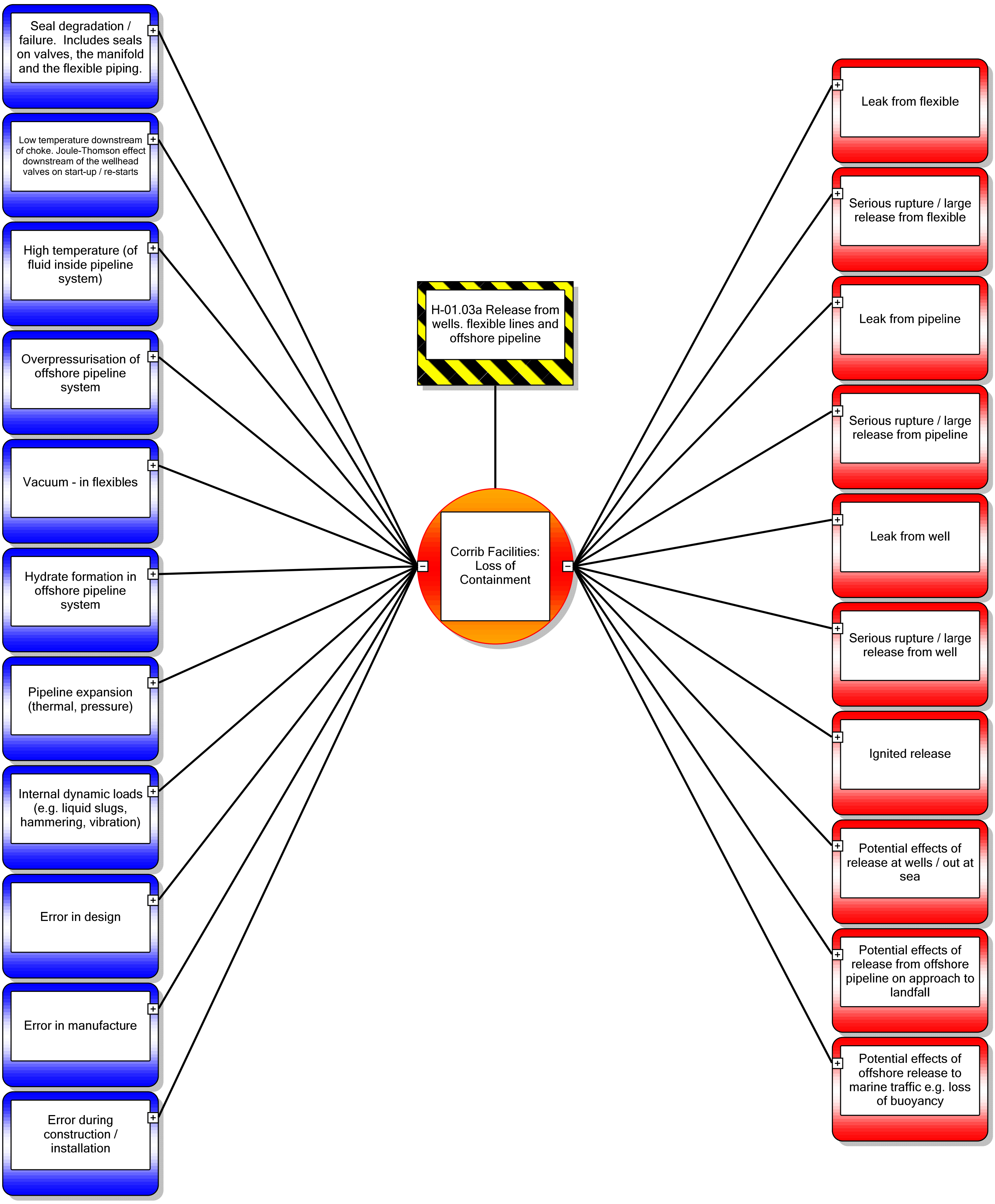


Figure 5.5: Escalation Factor Example



Appendix Q, Attachment B

Figure B3.2 – H-01.03a Release from Wells, Flexible Lines and Offshore Pipeline Overview of Threats and Consequences (continued)



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