APPENDIX 4

FINGAL C.C MEETING MINUTES
RESPONSE TO MULROY ENVIRONMENTAL'S DOCUMENT
(REF: 282.28.11.17)
MULROY'S CONSIDERATION OF
FCC/RPS NOTES OF MEETING 10-10-2017- REGARDING
TECHNICAL ASPECTS OF SITE INVESTIGATION AND
ENVIRONMENTAL RISK ASSESSMENT AT
BARNAGEERAGH
COVE, SKERRIES.
9-01-18

MULROY ENVIRONMENTALS'S RESPONSE TO
FINGAL C.C/RPS COMMENTS
9TH JANUARY 2018

NOTES OF MEETING REGARDING
PHASE II SITE INVESTIGATION/DQRA/GROUNDWATER
MONITORING
/LANDFILL GAS SURVEY RESIDENTIAL DEVELOPMENT
BARNAGEERAGH COVE, SKERRIES.
FINGAL COUNTY COUNCIL: COUNTY HALL, SWORDS,
COUNTY DUBLIN.
24/1/2018

DRAFT NOTES FROM MEETING ON ENVIRONMENTAL RISK
ASSESSMENT SITE INVESTIGATIONS IN BARNAGEERAGH
COVE, SKERRIES.
FINGAL COUNTY COUNCIL: COUNTY HALL, SWORDS,
COUNTY DUBLIN
21/03/2018

FOLLOW UP TO MINUTES OF BARNAGEERAGH COVE SITE
INVESTIGATIONS MINUTES ON 21/03/2018
(23/05/2018)

NOTES FROM MEETING ON ENVIRONMENTAL RISK ASSESSMENT–
SITE INVESTIGATIONS IN BARNAGEERAGH
COUNTY HALL, BLANCHARDSTOWN, DUBLIN 15
(08/11/2018)

Response to Mulroy Environmental's Document (Ref: 282.28.11.17); Mulroy's Consideration of FCC/RPS Notes of Meeting 10-10-2017- Regarding Technical Aspects of Site Investigation and Environmental Risk Assessment at Barnageeragh Cove, Skerries.

9-1-2017:

Introduction:

(1) The meeting of 10-10-2017 focused on technical aspects of Mulroy Environmental's interim report (Ref: 277.29.08.17) on Site Investigations in Barnageeragh Cove, Skerries, *Discussions focused on issues raised in RPS document (Ref:MDR0303Me5001) which was a consideration of site investigations to that date.* ***Relevant extracts are outlined below in green text.***

(2) The meeting notes recorded by (FCC & RPS) outlined an understanding of undertakings required of Mulroy Environmental, towards completing a site investigation and environmental risk assessment in line with the "Code of Practice for Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA, 2007)." ***These are outlined below in red text.***

(3) Mulroy Environmental's Responded to FCC/RPS understandings of undertakings through document (Ref:282.28.11.18). ***Their response is outlined below in Blue.***

(4) Outlined below in Bold and Black Italics under the heading "***FCC/RPS Comment***" is FCC/RPS Comment, further to (Ref: 282.28.11.18).

By way of general comment; at this stage a GANTT chart should be provided scheduling the proposed remaining tasks to close out the Site Investigation. An expected timeline for execution of mitigation measures once and if agreed to by appropriate regulators needs consideration. Consideration will need to be given to post site investigation / Environmental Risk Assessment monitoring regime.

BASIS FOR BUILDING THE BUILDINGS WHICH HAD PREVIOUSLY BEEN DELAYED

Action: *Mulroy Environmental to include a specific section in Site Investigation / Environmental Risk Assessment Report, explaining the basis upon which the two houses (which had previously been delayed) have been built and also the basis upon which the "pocket development", to the West of the site proceeded.*

With regard to the above, we would state the following:
Following the installation of groundwater and gas monitoring wells on the 14th June 2017 – 19th June 2017, the first landfill gas monitoring round was carried out on 23rd June 2017, this was followed by a second round of monitoring on the 12th July 2017. It should be noted that the landfill gas readings in shallow gas wells to the south / south-west indicated that methane levels were at 0% in all 4 shallow gas wells. Carbon dioxide levels were found to range from 0% - 1.2% in the 4 shallow wells across the first 2 monitoring rounds. Using the modified Card and Wilson classification system, a 'Very Low Risk' classification was attributed to the 4 wells. At that juncture the piling aspect of the foundations of houses Nos. 25 & 26 were complete. The results of the gas monitoring were communicated to Winsac Ltd, who were advised by Mulroy Environmental that the results indicated the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses. Mulroy Environmental advised that further gas monitoring was required to comply with CIRIA C665 and a further 4 monitoring rounds were required for this purpose. With regard to the newly constructed housing to the north west of the waste body, it is Mulroy Environmental's understanding that planning permission was acquired for this phase of the development. Following the low levels of methane and carbon dioxide levels identified in BH2 and the findings of the site investigation to the northwest of the cairn (i.e. no waste discovered in METP30 & METP33 with the extent of the waste body determined by archaeologist Eoin Halpin to cease at the

boundary of the Cairn, during slit trench excavation on the 2nd June 2017), it was determined that the risk from landfill gas from the waste body to the northwest residential phase was negligible.

FCC/RPS Comment:

- ***…"shallow wells to the south /south west"…should this be to the north / north west of waste body? – is this referring to "GS1-GS4"? If so should be explicitly stated in report.***
- ***Do monitoring rounds subsequent to first two monitoring rounds support advice given? Commentary to be put into Site Investigation / Environmental Risk Assessment Reports.***
- ***Clarify use of trial pits and archaeological slit trenching (provide details of slit trenching) as evidence in delineating waste body, as part of Landfill Gas Risk Assessment. Does archaeological data support the determination of the extent of the wastebody e.g. Slit Trench Logs?***
- ***Use of the term "negligible" ?– terminology from Wilson Card ERA more appropriate e.g. Very Low / Low Risk?***
- ***Need to address post site investigation monitoring programme and need for an emergency response procedure – should levels of LFG reach specified limits at specific boreholes?***

2.2.1 Waste & Groundwater Table

Borehole Log BH1: RPS were initially provided with a borehole log (via email on 31 July 2017) for BH1 which suggested that the base of the waste was at 11.2mbgl and the groundwater table was at 10.78mbgl, suggesting that the waste extended to a depth of approx. 0.42m below the water table. However, the borehole log for BH1 ithe Interim Report suggests that the waste extends to only 10.5mbgl and the groundwater level is at 10.78mbgl, suggesting that the waste terminates above the water table. Confirmation was sought from Mulroy's on which BH1 borehole log is correct.

Action: *Mulroy Environmental confirmed that the log presented in the Interim Report was the correct one and that the original borehole log was incorrect.*

With regard to the above, we would state the following:
Mulroy Environmental can confirm that Made Ground with timber and plastics was recorded to a depth of 8.0mBGL during the installation of BH1. Made Ground without timber and plastics (i.e. soil) was recorded to a depth of 10.5mBGL. On the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body and also delineate the overburden and depth to bedrock to the north and northeast of the waste body.

FCC/RPS Comment:

- ***Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.***
- ***Interpretation of BH1 Log is unclear. Depth of waste has been cited in text as 8.0mBGL but the borehole logs indicate made ground with plastics etc. to 9mBGL and made ground below this to 10.5mBGL. Needs clarification or correction.***
- ***Is Mulroy Environmental satisfied that the 'made ground' below 8mBGL (or 9mBGL) is not waste?***

2.2.2 Seasonal groundwater level variation:

Further to the previous point, the water level detailed on the borehole logs was measured in June 2017, which is obviously during the summer when groundwater levels will generally be lower. Groundwater levels will generally be higher in the winter months (when there is more recharge), thus dependent on season variation, even if the waste is above the groundwater level in June this may not be the case during the winter months. Another set of groundwater level measurements be collected from all the bores on-site. Ideally this would be undertaken during the late winter, when groundwater levels are generally at their highest.

Action: *This season variation in groundwater levels was acknowledged by Mulroy Environmental and they indicated that an additional programme of groundwater level monitoring was to be undertaken later the same*

week.

With regard to the above, we would state the following:

On the 15th November 2017, groundwater levels within each of the groundwater boreholes on site were taken. This included taking a groundwater level from BH14 (i.e. borehole installed on the 26th of October 2017, approximately 60m downgradient of the waste body). Table 1. compares the groundwater levels between the summer time monitoring round and levels taken on the 15th November 2017. As can be seen in Table 1 groundwater levels on the 15/11/17 had rose between 0.11m – 0.405m across the site. It should be noted that the groundwater level in BH1 had not risen above the waste body when taken on the 15/11/17, however it is envisaged that Mulroy Environmental will measure groundwater levels on all bores again in mid-December 2017.

FCC/RPS Comment:

- ***Need to consider 2017 Annual rainfall by comparison with previous years and provision for post site investigation Report monitoring to track seasonal groundwater level variation.***
- ***Table 1 identifies "July/August 2017" and "15th July 2017" as the dates for GW monitoring – we assume that is just a typo and that it should read "15th November 2017" rather than "15th July 2017"?***
- ***BH1 results from 15th November 2017 suggest that the groundwater level (10.54mBGL) is very close to the interpreted base of the "made ground" (10.5mBGL). The groundwater monitoring results from mid-December 2017 will be important to assessing whether the groundwater level reaches the inferred base of the "made ground" in BH1. The previous comment regarding whether the lower "made ground" horizon (marked as 9-10.5mBGL on the borehole log) is deemed waste is also of relevance and whether Mulroy Environmental is satisfied that the proximity of the groundwater table and the made ground/waste material is acceptable?***

2.2.3 Quantity of Waste below Groundwater Level

Following confirmation of borehole logs for BH1 and the seasonal position of the water table, consideration should be given in the report regarding: whether any waste exists below the water table (considering season water table variation), if any waste does exit below the water table then what percentage or volume of waste is predicted to exist below the water table and the remedial actions proposed to deal with the waste below the water table or why it is deemed appropriate that no remedial actions are required (considering that this is a breach of the Groundwater Regulations).

Action: Mulroy Environmental gave an undertaking to evaluate this.

With regard to the above, we would state the following:
As mentioned in Comment 2.2.1, on the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body. The outputs of this survey will be assessed to determine if any waste exists below the water table. Subsequently, if waste is identified below the water table an estimation of the quantity of this waste may be made.

FCC/RPS Comment:

- ***Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.***

2.2.4 Cross Section A-A':

The cross section suggests that the waste is underlain by approx. 4m of silty/clay, this does not appear consistent with the various borehole logs (including BH1 illustrated in the section) which generally suggest that the waste is directly underlain by sand and/or gravel. The cross section suggests that in BH1 the waste extends

below the water table, this should be confirmed and the section should be consistent with the findings of the aforementioned points.

Action: *Mulroy Environmental gave an undertaking to review and revise the cross section to deal with these inconsistencies.*

With regard to the above, we would state the following:
Mulroy Environmental will correct the cross-section drawings and include this in the final report.

FCC/RPS Comment:

- ***Noted, additional inconsistency referred to in 2.2.1 (FCC Comment; Second Bullet Point re. depth of made ground with plastics recorded on BH1 Log) – should be addressed here also.***

2.2.5 Groundwater Quality Results: Arsenic & Mercury:

The groundwater samples collected from the boreholes returned concentrations of arsenic (BH4) and mercury (BH1, BH3 and BH11) which exceed the Threshold Values stipulated in the Groundwater Regulations. Arsenic and mercury are deemed hazardous substances and as such the input of these substances into groundwater is prohibited under the Groundwater Regulations. It is also noted that BH4 and BH11 appear to be outside of the historical landfill area, thus they represent groundwater down-gradient of the waste body. The fact that these arsenic and mercury exceedances were detected is noted in the report in the results section; however, there is No further discussion of these results in the report. Some discussion about these results, the fact that hazardous substance exceedances have been detected should be addressed in the report with regards to how they are captured in the risk assessment, remedial strategy or why they are not considered significant. The report presents only one set of groundwater quality results. An additional round of groundwater quality monitoring should be undertaken in order to confirm the groundwater quality present on site.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater quality monitoring and do a Detailed Quantitative Risk Assessment to inform risks to groundwater. Mulroy Environmental gave an undertaking that this assessment would also include consideration of Waste Body Classification and how the proposed mitigation strategy is appropriate to the Hazardous classification of the waste body in 10 of forty soil samples taken.*

With regard to the above, we would state the following:
It should be noted that Mulroy Environmental carried out another round of groundwater quality monitoring on the 15th of November 2017 (see result Tables A2.1 & A2.5 in Appendix 2). This involved taking a groundwater sample from each of the 10 existing groundwater boreholes on site and from the more recently installed BH14. These results will be utilised in the development of a Detailed Quantitative Risk Assessment. It is proposed to use the Remedial Targets Methodology (RTM) and/or the RBCA methodology to assess the risk posed to groundwater. The RTM methodology was developed to specifically take account of the risk to groundwater from soil and groundwater contaminant sources. This approach will consider the arsenic and mercury concentration in the groundwater and elevated parameters in the 10 soil samples.

FCC/RPS Comment:

- ***Noted.***

2.2.6 "Recovering" Groundwater

The report states a number of times that the groundwater quality is "recovering" or "improving", yet there is No justification provided in the report to support this statement. It is on the basis of this Memorandum Page: 3 of 5 "improving condition of the groundwater" that no intrinsic remedial measures for groundwater are proposed. This statement should be supported in the report by either presenting a series of groundwater quality results (over time) which show a reducing contaminant level or detailed description as to why the current hydrochemistry supports the theory of improving water quality. Alternatively, this statement needs to be amended in the report and an alternative rationale behind the proposed remedial actions presented.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater monitoring (levels and quality) and to do a Detailed Quantitative Risk Assessment to inform assessment of risks to groundwater and evaluate if groundwater quality is "recovering".*

With regard to the above, we would state the following:
It is estimated that landfilling of the waste body commenced in the 1970's and ceased 1990's and as such the age of the waste is estimated to be approximately 30 – 50 years old. During the trial pit investigation putrescible waste (i.e. odour emanating waste) which has the potential to break down further through aerobic or anaerobic processes was not identified. It is the professional experience of Mulroy Environmental that waste bodies still posing a risk to underlying aquifers usually indicate the presence of putrescible waste and that this waste would normally be detected as landfill gases / H2S gas during intrusive site investigation works. Given the properties of the subsoil underlying the waste (i.e. predominantly Sands & Gravels), it is likely that organic and inorganic contaminants contained within the waste body have been significantly leached out over the lifespan of the waste body. However, in order to confirm that natural attenuation has occurred and is actively occurring on-site, Mulroy Environmental recommend further groundwater monitoring of the waste body and the land immediately to the north. Following the receipt of the second round of groundwater quality results, Mulroy Environmental will undertake a Detailed Quantitative Risk Assessment using the RTM/RBCA methodology. The groundwater models can be verified following the receipt of subsequent groundwater data.

FCC/RPS Comment:

- ***Noted that DQRA is being undertaken and will from part of Site Investigation and ERA.***
- ***Need to consider a post Site Investigation / ERA monitoring regime? Timeframe of regime?***

2.2.7 Groundwater Quality Migrating Off-Site;

As identified above, BH4 and BH11 appear to be outside of the historical landfill area but are still returning elevated metals concentrations in the groundwater samples collected. Installation of an additional groundwater monitoring borehole (or boreholes) further downgradient of the waste body (ideally along the downstream hydraulic gradient site boundary) would provide insight into contaminant concentrations in the groundwater further down hydraulic gradient of the waste (providing insight into contaminant concentration reduction with distance/travel time) and would also provide insight into the groundwater quality migrating off-site. As monitored attenuation may be a future proposed remedial strategy for the site an additional monitoring borehole(s) at the downgradient boundary may provide very important data for the future.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater level and quality monitoring, to install additional groundwater monitoring borehole(s) and to do a Detailed Quantitative Risk Assessment to inform risks to groundwater.*

With regard to the above, we would state the following:
As mentioned in Sections 2.2.2 & 2.2.5, BH14 was installed approx. 60m downgradient of the waste body on the 26th October 2017. A further round of groundwater quality samples was taken from all groundwater wells including BH14 on the 15th November 2017. This data will be utilised in the DQRA.

FCC/RPS Comment:

- **Noted.**

2.2.8 Groundwater Flow:

Section 4.7.2 Groundwater Flow is blank in the interim report and needs to be completed.

Action: *Mulroy Environmental gave an undertaking to complete the groundwater flow section.*

With regard to the above, we would state the following:
Mulroy Environmental will include a completed section in the final report detailing the direction of groundwater flow on site. This will include a groundwater contour map.

FCC/RPS Comment:

- ***Noted.***

2.2.9 Waste Delineation:
A thorough review of aerial photos and historical maps appears to have been undertaken, followed by a number of intrusive investigation programmes (including trial pitting and borehole drilling) in order to define the extent of the waste body which is illustrated in Figure 6. A critical aspect of the investigation is the position of the waste with respect to the housing development. Figure 6 appears to suggest there are no houses located (or proposed to be located) on the waste body itself, if this is indeed believed to be the case then this is a very important fact and should be specifically stated in the report.

Action: *Mulroy Environmental stated that, based on their site investigations, no houses were built on waste material. They will specifically reference this in report.*

With regard to the above, we would state the following:
Mulroy Environmental can confirm that no houses will be built on the area delineated as the waste body on Figure 6 of the interim report. With regard to the newly constructed houses to the north west of the waste body, Mulroy Environmental can confirm that the waste body did not extend past the cairn towards these houses. We estimate that the western boundary of the waste body is approximately 40m from the north west residential pocket development.
With regard to the residential development, it should be noted that Winsac Ltd. have had the foundations in these areas inspected by Homebond. A report detailing this information will be included in the final report. Mulroy Environmental will make specific reference to these details in the final report.

FCC/RPS Comment:

- ***Figures 1 -3 accompanying the email with "Reply to Technical Review Meeting Minutes 282.28.11.17" indicates a different delineation of waste body to Figure 6 of the Interim Report. The difference is significant in that GS1and GS2 are indicated as "in waste" on Figure 6 and out of waste in Figure 1. This appears to be inconsistent with the borehole log of GS1 and GS2. Clarification is required on this point – in Figures 2 and 3 the boundary of waste is noted as " drawn after site investigation". Additionally, Waste associated with METP01 appears to be now outside the boundary delineated in Figure 2. Can Mulroy Environmental confirm the boundary of the waste in this location?***

- ***There appears to be an inconsistency in the mapped locations of GS1-4 and BH3 between earlier and later maps e.g. (Figure 6 dated 8/8/17 and Figure 1 dated 27-11-17). For example GS2&3 are more distant from each other and BH3 is further north in the former than in the latter. It is also noted that the Logs for GAS03 and GAS04 have the same eastings and northings and that these grid references are incomplete.***

- ***The redrawn delineation of waste body should be elaborated upon in the text of the report and supported by reference to trial pits, borehole logs, slit trenching and any other evidence provided.***

- ***There may be a role for Geophysics results here in delineating waste body particularly in north west and western sides of site.***

- ***Can Mulroy Environmental confirm that no waste will exist within the curtilage of any properties developed on this site?***

2.2.10 Gas; Gas cut-off wall:
The detail on the drawing 13-157-C609 for the cut-off trench does not detail the vertical vents which are included in the sketch in the ME report (Plate 10). The use of a GCL in the vertical trench should be reconsidered. A more appropriate barrier would be HDPE or LLDPE. The depth of the trench needs to be considered. The detail in the drawing and report states the trench will be approx. 4m deep. With a waste body that is considerably deeper and a sand/gravel Memorandum Page: 4 of 5 layer underlying the site, the trench should probably extend to the summer GW level as a minimum or bedrock. In the CSM the trench is shown to terminate at the interface between the sand/gravel and bedrock.

Action: *Mulroy Environmental agreed GCL was not appropriate and will revise design accordingly. Details of vents and surface of trench to be reviewed. Depth of trench will be reconsidered by Mulroy Environmental in light of these comments.*

With regard to the above, we would state the following:
It is agreed that a HDPE or LLDPE barrier will be used in the cut off trench. Details of both horizontal and vertical venting will be provided as part of the proposed design for the landfill gas cut off trench. The trial pit investigation that was carried out on the 2nd June 2017 & 11th August 2017, indicated that the overburden in the vicinity of trialpits METP32 – METP34 & METP39 – METP47 (i.e. to the north of the waste body and builders compound) which are at approximately 15.9m AOD consists of the following:

As can be seen from Table 2 above, the groundwater table was identified at 2.60m BGL in BH13 (i.e. approximately 13.3m AOD). In order to intercept potential landfill gas migrating in a northerly direction, the proposed cut off trench will be extended to a depth of 4mBGL (11.9m AOD). It should be noted that landfill gas migration via overburden/subsoil is significantly higher than landfill gas migration via groundwater. As such, it is not necessary for the landfill gas cut off trench to extent to the depth of the underlying bedrock. Please note that a geophysical survey was carried out on 24th of November 2017. During the site investigation exercise the bedrock in the area proposed for commercial development was found at approximately 4.5m BGL. It is expected that a more accurate representation of the bedrock profile will be achieved following correlation between the site investigation findings and the geophysical survey. This information will be used to amend the cross-section drawings and CSM drawings if necessary.
With regard to the depth of the landfill gas cut off trench to the east and north east of the waste body, Mulroy Environmental have delineated the extent of this waste which correlates reasonably closely with the footprint of the former sand and gravel pit as per 25'' historical ordnance survey mapping. It is proposed that the landfill gas cut-off trench in this area is positioned at the edge of the former sand and gravel pit. It is proposed that the landfill gas cut off trench extends to 4.0m BGL into the indigenous soils which consists primarily of sands and gravels. It should be noted at this moment in time, 6 rounds of landfill gas monitoring have been carried out on the original boreholes that were installed in June 2017 (i.e. BH1 – BH7 & GAS01 – GAS04). For those wells located in closest proximity to the housing development (i.e. BH2, BH3 & BH5 which are located inside the waste body & GAS01 – GAS04 which are located outside the waste body & adjacent to the south / south-western boundary of residences No.25 – 34), it should be noted a concentration of 0.3% methane was recorded in BH2 on one occasion with 0% methane recorded across these 7 wells / 6 monitoring rounds on all other occasions (see Tables A3.1 & A3.2 in Appendix 3 & Figure 2). The landfill gas monitoring results obtained to date indicate that the risk posed by the north-western area of the waste body is at a lower level than that risk posed by the waste in the vicinity of BH1 and the waste to the south / south west of BH4. It is the opinion of Mulroy Environmental that the specification for the proposed landfill gas cut off trench (i.e. in particular the depth proposed) for the north-western area is proportionate given the results of the risk assessment to date.
It is proposed that further landfill gas monitoring wells are installed outside the north-western portion of the cut off trench. In order to determine if landfill gas is migrating under the cut off trench it is proposed that the depth of these landfill gas monitoring wells is at least 8mBGL. It is also proposed that these gas monitoring wells are spaced approximately 15m in distance apart.

FCC/RPS Comment:

- ***It is noted that the Geophysical Survey Results will be used to inform revision of the Cross Section Drawings and Conceptual Site Models.***
- ***It is not clear from the above what depth is being proposed for the PVT in the Northwestern / Western portion of the site.***

- ***It is noted that the details of the proposed PVT are still outstanding.***
- ***Re. BH4; there have been very high methane readings at this borehole, whereas there is very low methane readings in neighbouring boreholes. Does this suggest a localised source in this area? Will the geophysical survey help identify a localised source? If there is a localised pocket is there further mitigation measures to be considered in this area?***
- ***Has Mulroy Environmental an opinion on why BH4 has consistently shown elevated methane levels and with this consistency is Mulroy Environmental satisfied that the extent of the waste boundary in this area is correct?***
- ***Is Mulroy Environmental satisfied that 4m is sufficient depth in the north and northeast considering trial pit excavations terminated in waste material and before reaching indigenous soils in this area?***

2.2.11 Methane:

Fingal County Council stated that locating a petrol station adjacent to the waste body is a particular concern. Fingal County Council are concerned that although a petrol station would be ATEX rated, the likelihood of methane gases being above the LEL, is a key concern. Capping the waste body (which is passively venting) may force gas in other directions. The cut-off trench is not proposed on the western, southern or eastern sides of the waste body where there are houses planned (west), there is a foul main and railway line (south) and the WWTP is operational (east).

Action: *Mulroy Environmental are committed to extending the proposed length of the passive venting trench along the western side of the waste body where a pocket of houses are currently under construction. Additional landfill gas monitoring boreholes will be placed between the waste body and the pocket of houses under construction. There is a commitment to ongoing landfill gas monitoring. There will be a review of whether the Card Wilson risk assessment approach is appropriate to Barnageeragh and whether the proposed responses are adequate to deal with risks identified. Additionally, consideration needs to be given to extending passive venting trench south of the new houses (situated to SW of waste body) and parallel to the sewer line. A monitoring programme should be implemented to ensure that the mitigation measures are working.*

With regard to the above, we would state the following:
Please find attached Figure 1 which details the positioning of the proposed landfill gas cut off trench. Figure 1 illustrates the position of the cut off trench around the periphery of the landfill body. As can be seen from Figure 1, it is necessary to terminate the cut off trench 5m from the centre line of the rising sewer main in order to ensure that no damage occurs during the construction of the trench. Mulroy Environmental will continue to monitor the landfill gas in all boreholes on-site until a minimum of 6 gas monitoring rounds has been conducted on each well. At present 3 more rounds of monitoring are required for boreholes BH8 – BH13. This will require sampling rounds during times of high and low atmospheric pressure. In addition, gas monitoring during periods of low pressure is also required for wells BH1 – BH7 & GAS01 – GAS04. As stated in section 2.2.10, it is proposed that further landfill gas monitoring wells are installed outside the northwestern portion of the cut off trench. The purpose of these wells is to ensure the effectiveness of the landfill gas cut of trench intercepting any landfill gas which may be migrating from the waste body. It is proposed that wells are monitored for a certain time period after the installation of the cut off trench. It should be noted that it is also intended to monitor the vertical vent stacks within the landfill gas cut off trench and the radon sumps for each housing blocks to the northwest and the north of the waste body.

Mulroy Environmental will review the appropriateness of the Modified Wilson & Card Classification for the development. Mulroy Environmental will also review the NHBC classification (i.e. Situation B in Ciria C665) when developing the final risk assessment report. It should be noted that an underfloor ventilation void has been constructed for houses Nos. 25 & 26 (i.e. houses in closest proximity to waste body) and therefore the NHBC classification system is more appropriate when conducting a risk assessment for those houses in particular.

FCC/RPS Comment:

- ***Noted. See comments from 2.2.10 above.***
- ***Is Mulroy Environmental satisfied that no gas monitoring is required north of the PVT at BH10?***

2.2.12 H2S:

The monitoring only detected H2S on two occasions and to a maximum reading of 3ppm, albeit in the gas wells adjacent to the house. Below these levels there would possibly be an odour but nothing too concerning. If the venting trench is extended deep enough to capture fugitive emissions any H2S will vent with the other LFG to atmosphere for dispersal. They should not have any services passing through the waste body and/or manholes thereby reducing any risk of fugitive emissions. If H2S becomes an issue then other passive or active systems could be looked at to reduce the impact.

Action: *Design of passive venting trench to consider the above comments. Mulroy Environmental committed to further rounds of monitoring for this parameter. To include further monitoring in houses and services and to record and report results in report. These results to be included in Landfill Gas Risk Assessment. Mulroy undertook to establish if radon barrier / protection measures are in place in houses.*

With regard to the above, we would state the following:
Mulroy Environmental can confirm that H_2S gas will continue to be monitored in the deep boreholes, shallow gas wells, radon sumps, services and the landfill gas cut off trench vertical vent stacks during the subsequent gas monitoring rounds. It also proposed to carry out interior gas surveys off house Nos. 25, 26, 52 & 53 (i.e. houses in closest proximity to the landfill waste body). This will involve 28-day diffusion monitoring for speciated VOCs, H_2S, CH_4 and CO_2 at three locations within each residence. This data will be incorporated into the final risk assessment report. Mulroy Environmental understand that a Visqueen High Performance Radon Membrane™ was used in the construction of the houses at Barnageeragh Cove. It is understood that this specification of membrane is not equivalent to the specification provided by the Visqueen Gas Barrier or Visqueen Low Permeability Gas Membrane (see Appendix 4).

FCC/RPS Comment:

- ***Commitment to diffusion monitoring noted*** **- Is there a role for trace element analysis here? Are Mulroy Environmental satisfied that the number of houses being monitored and type of monitoring being undertaken; is sufficient.**
- **There should be Risk Assessment of the levels of H2S found in Boreholes / Houses / Sumps / Services. i.e. results have been presented but no interpretation or risk assessment provided for this parameter. To be included in SI and ERA report.**
- **Will services pass through pathway of proposed PVT? What measure to protect from providing a pathway for landfill gas prevention.**

2.2.13 Risk Assessment Table – Surface Water:

The risk assessments in the report detailing linkages without and then with mitigation measures in Tables 10 and 11, were discussed. It was observed that a number of "potentially complete" linkages remain even after the implementation of the proposed mitigation measures, with regard to some of these remaining "potentially complete" linkages the following issues were discussed: Table 11 (page 51) Direct surface water bodies to the north and east of the waste body: The report identifies that the linkage remains potentially complete as "impact on the stream is expected to be low and contact between landfill body and surface water body is not proven". It was recommended to collect surface water quality samples from the relevant surface water body (bodies), from locations both upstream and downstream of any groundwater baseflow contribution from the site, to provide data which might further clarify this potential linkage.

Action: *Mulroy Environmental committed to sampling surface water to clarify this.*

With regard to the above, we would state the following:
Mulroy Environmental will take surface water samples both upstream and downstream of the adjacent stream in order to assess the potentially complete pollutant linkage between the waste body (i.e. source) and stream (i.e. receptor). Please find attached Figure 3 which shows the location of the proposed upgradient and downgradient surface water monitoring points. It is proposed to take the upgradient sample to the south of the Belfast – Dublin railway line, 5 – 10m to the south of the where the stream is culverted underneath the railway line. It is proposed to take 2 downgradient samples.

One sample will be taken from a storm water manhole to the north east of the site with the other downgradient surface water sample taken from a storm water manhole to the north west of the site.

FCC/RPS Comment: Noted.

2.2.14 Risk Assessment Table – Landfill Gas:

Table 11 (page 53) Residents of newly built residences to northwest, north and north of road: The report identifies that the linkage remains potentially complete as "no underground services in proximity of waste body with exception of foul rising main running to the south and north". This suggests that the foul rising main remains a potential migration pathway for gas. This remaining potential linkage appears significant and should be considered further regarding potential additional mitigation measures. Table 11 (page 53) Operatives on WWTP to the southeast of the site: The report identifies that the linkage remains potentially complete and that this should be "investigated further in consultation with Fingal CC". The statement that something requires further investigation obviously suggests that further work is required to close this out, this should be closed out as part of this report. We understand that Fingal CC have provided details of the engineering design of the pipeline and the associated gas protection put in place to Mulroy, which may assist with progressing this aspect.

Action: *Mulroy Environmental committed to reviewing this information and revising risk assessment, if appropriate – See also 11.*

With regard to the above, we would state the following:
In order to determine if the foul rising main is acting as a pathway (ie. a path of least resistance) for landfill gas migrating from the waste body in either a north western (i.e. towards the residence) or in a south-eastern direction (i.e. towards the Waste Water Treatment Plant (WWTP)) it is proposed to carryout a local gas probe survey within a 5m buffer of the foul rising main. This gas probe survey will entail the drilling of shallow boreholes (i.e. 1-inch diameter and 1.2m in depth) using an electric Hilti drill. Following this, 0.75-inch perforated uPVC piping is inserted into each borehole with the end sealed until measurement is carried out. These holes will be assessed for landfill gas levels approximately 2 hours after their installation. Mulroy Environmental will review gas protection measures put in place during the construction of the pipeline.

FCC/RPS Comment: Noted.

WINSAC LTD.,

PHASE II SITE INVESTIGATION/DQRA/

GROUNDWATER MONITORING/LANDFILL GAS SURVEY

RESIDENTIAL DEVELOPMENT,

BARNAGEERAGH COVE, SKERRIES

MULROY ENVIRONMENTAL'S RESPONSE TO FINGAL COCO / RPS COMMENTS DATED 09TH JANUARY 2018

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1. INTRODUCTION

On the 10th of November 2017, Mortimer Loftus, James Walls and Brian Reynolds of Fingal County Council, Conrad Wilson and Paul Heaney of RPS Consulting Engineers and Padraic Mulroy and Patrick McCabe of Mulroy Environmental attended a technical review meeting at County Hall, Swords, Co. Dublin to discuss the contents of Mulroy Environmental's Phase II Site Investigation Interim Report (277.29.08.17) which was submitted on the 29th August 2017.

Following this meeting, the minutes were compiled by Mortimer Loftus with a copy furnished to Mulroy Environmental on the 23rd of October 2017. Mulroy Environmental reviewed the contents of the minutes including the actions outlined within and responded with their client's comments and commitments (Ref: 282.28.11.17). On the 9th January 2018, Fingal County Council / RPS responded with further comments.

This document is a reply prepared on behalf of Winsac Ltd. by Mulroy Environmental to the aforementioned further comments. For reasons of clarity, each item discussed / action required is dealt with by section with:

- Relevant extracts of the RPS document (Ref MDR0303Me5001) which commented on Mulroy Environmental's Interim Site Investigation Report (Ref. 277.29.08.17) are outlined in green text;
- Actions required following the technical meeting between Mulroy Environmental, Fingal C.C and RPS on the 10th October 2017 in relation to the Interim Report are outlined in red text;
- Mulroy Environmental's response to the Fingal C.C / RPS meeting minutes and required actions are outlined in blue text;
- Fingal C.C / RPS further comments in relation to Mulroy Environmental's response are outlined in purple text; and
- Mulroy Environmental's response to Fingal C.C / RPS comments on the 9th January 2018 are outlined in this document in black bold text.

As part of the Fingal C.C / RPS response on the 9th of January 2018, it was requested that a GANTT chart should be produced scheduling the proposed remaining tasks associated with the site investigation, an expected timeline for execution of mitigation measures and post site investigation monitoring regime. A copy of this GANNT chart is included in Appendix 1 of this document.

2. MEETING ACTIONS / COMMENTS

2.1 Basis For Building The Buildings Which Had Previously Been Delayed

***Action:** Mulroy Environmental to include a specific section in Site Investigation / Environmental Risk Assessment Report, explaining the basis upon which the two houses (which had previously been delayed) have been built and also the basis upon which the "pocket development", to the West of the site proceeded.*

With regard to the above, we would state the following:

Following the installation of groundwater and gas monitoring wells on the 14th June 2017 – 19th June 2017, the first landfill gas monitoring round was carried out on 23rd June 2017, this was followed by a second round of monitoring on the 12th July 2017. It should be noted that the landfill gas readings in shallow gas wells to the south / south-west indicated that methane levels were at 0% in all 4 shallow gas wells. Carbon dioxide levels were found to range from 0% - 1.2% in the 4 shallow wells across the first 2 monitoring rounds. Using the modified Card and Wilson classification system, a 'Very Low Risk' classification was attributed to the 4 wells.

At that juncture the piling aspect of the foundations of houses Nos. 25 & 26 were complete. The results of the gas monitoring were communicated to Winsac Ltd, who were advised by Mulroy Environmental that the results indicated the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses. Mulroy Environmental advised that further gas monitoring was required to comply with CIRIA C665 and a further 4 monitoring rounds were required for this purpose.

With regard to the newly constructed housing to the north west of the waste body, it is Mulroy Environmental's understanding that planning permission was acquired for this phase of the development. Following the low levels of methane and carbon dioxide levels identified in BH2 and the findings of the site investigation to the northwest of the cairn (i.e. no waste discovered in METP30 & METP33 with the extent of the waste body determined by archaeologist Eoin Halpin to cease at the boundary of the Cairn, during slit trench excavation on the 2nd June 2017), it was determined that the risk from landfill gas from the waste body to the northwest residential phase was negligible.

FCC/RPS Comment:

- …''shallow wells to the south / south west''… should this be to the north / north west of waste body? – is this referring to ''GS1 – GS4''? If so should be explicitly stated in the report.
- Do monitoring rounds subsequent to first two monitoring rounds support advice given? Commentary to be put into Site Investigation / Environmental Risk Assessment Reports.
- Clarify use of trial pits and archaeological slit trenching (provide details of slit trenching) as evidence in delineating waste body, as part of Landfill Gas Risk Assessment. Does archaeological data support the determination of the extent of the waste body e.g. Slit Trench Logs?

- Use of the term ''negligible''? terminology from Wilson Card ERA more appropriate e.g. Very Low / Low Risk?
- Need to address post site investigation monitoring programme and need for an emergency response procedure – should levels of LFG reach specified limits at specific boreholes?

Mulroy Environmental / Winsac Ltd Response:

- **Mulroy Environmental can confirm that 'GS1 – GS4' refers to the shallow wells to the north / north east of the waste body and to the south / south west of residence Nos. 25 – 34;**
- **The results of the gas monitoring (i.e. Rounds 1 & 2) were communicated to Winsac Ltd, who were advised by Mulroy Environmental that the results, at that juncture, indicated the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses. Mulroy Environmental advised that further gas monitoring was required to comply with CIRIA C665 and a further 4 monitoring rounds were required for this purpose;**
- **A log detailing the slit trench excavated on the 2nd June 2017 under the supervision of Eoin Halpin will be included in the final site investigation / risk assessment report;**
- **Mulroy Environmental will use terminology consistent with CIRIA C665 throughout the final risk assessment report; and**
- **Mulroy Environmental will include a section in the final site investigation / risk assessment report detailing the post site investigation monitoring programme (i.e. landfill gas and groundwater monitoring) and emergency response procedure outlining the actions to be taken should elevated landfill gas concentrations be detected in specific boreholes (i.e. GAS01 – GAS04);**

2.2 Waste & Groundwater Table

Borehole Log BH1: RPS were initially provided with a borehole log (via email on 31 July 2017) for BH1 which suggested that the base of the waste was at 11.2mbgl and the groundwater table was at 10.78mbgl, suggesting that the waste extended to a depth of approx. 0.42m below the water table. However, the borehole log for BH1 in the Interim Report suggests that the waste extends to only 10.5mbgl and the groundwater level is at 10.78mbgl, suggesting that the waste terminates above the water table. Confirmation was sought from Mulroy's on which BH1 borehole log is correct.

Action: *Mulroy Environmental confirmed that the log presented in the Interim Report was the correct one and that the original borehole log was incorrect.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that Made Ground with timber and plastics was recorded to a depth of 8.0mBGL during the installation of BH1. Made Ground without timber and plastics (i.e. soil) was recorded to a depth of 10.5mBGL. On the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body and also delineate the overburden and depth to bedrock to the north and northeast of the waste body.

FCC/RPS Comment:

- Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.
- Interpretation of BH1 Log is unclear. Depth of waste has been cited in text as 8.0m BGL but borehole logs indicate made ground with plastics etc. to 9m BGL and made ground below this to 10.5m BGL. Needs clarification or correction.
- Is Mulroy Environmental satisfied that the 'made ground' below 8m BGL (or 9m BGL) is not waste?

Mulroy Environmental / Winsac Ltd Response:

- **To clarify made ground with plastics was recorded in BH1 to a depth of 9m BGL as indicated on the BH Log. The text should have read made ground with plastic and timber recorded to a depth of 8m BGL with made ground containing plastics (i.e. no timber recorded) to a depth of 9m BGL; and**
- **During the logging of BH1, no plastics / timber was recorded at a depth below 9m BGL. Upon preliminary review of the geophysical survey report, domestic waste would appear to extend to a depth to 9m BGL (14m AOD) in the vicinity of BH1. However, the geophysical survey report indicates that domestic waste extends to depths of approximately 12m BGL (11.5m AOD) in the vicinity of BH6 (see geophysical survey in Appendix 2).**

2.3 Seasonal groundwater level variation:

Further to the previous point, the water level detailed on the borehole logs was measured in June 2017, which is obviously during the summer when groundwater levels will generally be lower. Groundwater levels will generally be higher in the winter months (when there is more recharge), thus dependent on season variation, even if the waste is above the groundwater level in June this may not be the case during the winter months. Another set of groundwater level measurements be collected from all the bores on-site. Ideally this would be undertaken during the late winter, when groundwater levels are generally at their highest.

Action: *This season variation in groundwater levels was acknowledged by Mulroy Environmental and they indicated that an additional programme of groundwater level monitoring was to be undertaken later the same week.*

With regard to the above, we would state the following:

On the 15th November 2017, groundwater levels within each of the groundwater boreholes on site were taken. This included taking a groundwater level from BH14 (i.e. borehole installed on the 26th of October 2017, approximately 60m downgradient of the waste body). Table 1. compares the groundwater levels between the summer time monitoring round and levels taken on the 15th November 2017. As can be seen in Table 1 groundwater levels on the 15/11/17 had rose between 0.11m – 0.405m across the site. It should be noted that the

groundwater level in BH1 had not risen above the waste body when taken on the 15/11/17, however it is envisaged that Mulroy Environmental will measure groundwater levels on all bores again in mid-December 2017.

FCC/RPS Comment:

- Need to consider 2017 Annual rainfall by comparison with previous years and provision for post site investigation Report monitoring to track seasonal groundwater level variation.
- Table 1 identifies ''July/August 2017'' and ''15th July 2017'' as the dates for GW monitoring – we assume that is just a typo and that it should read '15th November 2017'' rather than ''15th July 2017''?
- BH1 results from 15th November 2017 suggest that the groundwater level (10.54m BGL) is very close to the interpreted base of the ''made ground'' (10.5m BGL). The groundwater monitoring results from mid-December 2017 will be important to assessing whether the groundwater level reaches the inferred base of the 'made ground' in BH1. The previous comment regarding whether the lower ''made ground'' horizon (marked as 9 – 10.5m BGL on the borehole log) is deemed waste is also of relevance and whether Mulroy Environmental is satisfied that the proximity of the groundwater table and the made ground/waste material is acceptable?

Mulroy Environmental / Winsac Ltd Response:

- **Mulroy Environmental will consider the 2017 annual rainfall by comparison with previous years to ascertain if groundwater levels are likely to have been higher in previous years than those recorded in 2017. As stated in section 2.1, the final site investigation / risk assessment report will include a section detailing the post site investigation monitoring programme. This programme will include seasonal groundwater level monitoring in 2018. In addition, a pressure transducer has been in place in BH14 since 6th December 2017. On the 11th January 2018, this transducer was relocated to BH1. A second transducer will be installed in a BH yet to be determined on 22nd January 2018;**
- **Mulroy Environmental can confirm that the groundwater dates included in Table 1 of document 282.28.11.17 should read ''July/August 2017'' and ''15th November 2017''**
- **Please note that Mulroy Environmental carried out the additional round of winter groundwater level monitoring on the 11th of January 2018 (see Appendix 3); and**
- **Please see Section 2.2 for Mulroy Environmental's comment on the depths of waste on-site.**

2.4 Quantity of Waste below Groundwater Level:

Following confirmation of borehole logs for BH1 and the seasonal position of the water table, consideration should be given in the report regarding: whether any waste exists below the water table (considering season water table variation), if any waste does exit below the water table then what percentage or volume of waste is predicted to exist below the water table, and the remedial actions proposed to deal with the waste below the water table or why it is deemed appropriate that no remedial actions are required (considering that this is a breach of the Groundwater Regulations).

Action: Mulroy Environmental gave an undertaking to evaluate this.

With regard to the above, we would state the following:

As mentioned in Comment 2.2.1, on the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body. The outputs of this survey will be assessed to determine if any waste exists below the water table. Subsequently, if waste is identified below the water table an estimation of the quantity of this waste may be made.

FCC/RPS Comment:

- Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

2.5 Cross Section A-A':

The cross section suggests that the waste is underlain by approx. 4m of silty/clay, this does not appear consistent with the various borehole logs (including BH1 illustrated in the section) which generally suggest that the waste is directly underlain by sand and/or gravel. The cross section suggests that in BH1 the waste extends below the water table, this should be confirmed and the section should be consistent with the findings of the aforementioned points.

Action: *Mulroy Environmental gave an undertaking to review and revise the cross section to deal with these inconsistencies.*

With regard to the above, we would state the following:

Mulroy Environmental will correct the cross-section drawings and include this in the final report.

FCC/RPS Comment:

- Noted, additional inconsistency referred to in 2.2.1 (FCC Comment; Second Bullet Point re. depth of made ground with plastics recorded on BH1 Log) – should be addressed here also.

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

2.6 Groundwater Quality Results: Arsenic & Mercury:

The groundwater samples collected from the boreholes returned concentrations of arsenic (BH4) and mercury (BH1, BH3 and BH11) which exceed the Threshold Values stipulated in the Groundwater Regulations. Arsenic and mercury are deemed hazardous substances and as such the input of these substances into groundwater is

prohibited under the Groundwater Regulations. It is also noted that BH4 and BH11 appear to be outside of the historical landfill area, thus they represent groundwater down-gradient of the waste body. The fact that these arsenic and mercury exceedances were detected is noted in the report in the results section; however, there is no further discussion of these results in the report. Some discussion about these results, the fact that hazardous substance exceedances have been detected should be addressed in the report with regards to how they are captured in the risk assessment, remedial strategy or why they are not considered significant. The report presents only one set of groundwater quality results. An additional round of groundwater quality monitoring should be undertaken in order to confirm the groundwater quality present on site.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater quality monitoring and do a Detailed Quantitative Risk Assessment to inform risks to groundwater. Mulroy Environmental gave an undertaking that this assessment would also include consideration of Waste Body Classification and how the proposed mitigation strategy is appropriate to the Hazardous classification of the waste body in 10 of forty soil samples taken.*

With regard to the above, we would state the following:

It should be noted that Mulroy Environmental carried out another round of groundwater quality monitoring on the 15th of November 2017 (see result Tables A2.1 & A2.5 in Appendix 3). This involved taking a groundwater sample from each of the 10 existing groundwater boreholes on site and from the more recently installed BH14. These results will be utilised in the development of a Detailed Quantitative Risk Assessment. It is proposed to use the Remedial Targets Methodology (RTM) and/or the RBCA methodology to assess the risk posed to groundwater. The RTM methodology was developed to specifically take account of the risk to groundwater from soil and groundwater contaminant sources. This approach will consider the arsenic and mercury concentration in the groundwater and elevated parameters in the 10 soil samples.

FCC/RPS Comment:

- Noted.

Mulroy Environmental / Winsac Ltd Response:

- **Please note that Mulroy Environmental / Winsac Ltd. have subcontracted Peter Conroy EurGeol, PGeo of Hidrigeolaíocht Uí Chonaire Teo. to aid in the development of the Detailed Quantitative Risk Assessment. It is proposed to use ConSim modeling software to assess the risk posed to groundwater and it is proposed to use the RBCA Model to assess the human risk.**

2.7 "Recovering" Groundwater

The report states a number of times that the groundwater quality is "recovering" or "improving", yet there is no justification provided in the report to support this statement. It is on the basis of this Memorandum Page: 3 of 5 "improving condition of the groundwater" that no intrinsic remedial measures for groundwater are proposed. This statement should be supported in the report by either presenting a series of groundwater quality results (over

time) which show a reducing contaminant level or detailed description as to why the current hydrochemistry supports the theory of improving water quality. Alternatively, this statement needs to be amended in the report and an alternative rationale behind the proposed remedial actions presented.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater monitoring (levels and quality) and to do a Detailed Quantitative Risk Assessment to inform assessment of risks to groundwater and evaluate if groundwater quality is "recovering".*

With regard to the above, we would state the following:

It is estimated that landfilling of the waste body commenced in the 1970's and ceased 1990's and as such the age of the waste is estimated to be approximately 30 – 50 years old. During the trial pit investigation putrescible waste (i.e. odour emanating waste) which has the potential to break down further through aerobic or anaerobic processes was not identified. It is the professional experience of Mulroy Environmental that waste bodies still posing a risk to underlying aquifers usually indicate the presence of putrescible waste and that this waste would normally be detected as landfill gases / H2S gas during intrusive site investigation works. Given the properties of the subsoil underlying the waste (i.e. predominantly Sands & Gravels), it is likely that organic and inorganic contaminants contained within the waste body have been significantly leached out over the lifespan of the waste body.

However, in order to confirm that natural attenuation has occurred and is actively occurring on-site, Mulroy Environmental recommend further groundwater monitoring of the waste body and the land immediately to the north. Following the receipt of the second round of groundwater quality results, Mulroy Environmental will undertake a Detailed Quantitative Risk Assessment using the RTM/RBCA methodology. The groundwater models can be verified following the receipt of subsequent groundwater data.

FCC/RPS Comment:

- Noted that DQRA is being undertaken and will form part of Site Investigation and ERA.
- Need to consider a post Site Investigation / ERA monitoring regime? Timeframe of regime?

Mulroy Environmental / Winsac Ltd Response:

- **As mentioned previously a section detailing the post site investigation / ERA monitoring regime will be included in the final report. This will include a timeframe of the monitoring regime.**

2.8 Groundwater Quality Migrating Off-Site;

As identified above, BH4 and BH11 appear to be outside of the historical landfill area but are still returning elevated metals concentrations in the groundwater samples collected. Installation of an additional groundwater monitoring borehole (or boreholes) further downgradient of the waste body (ideally along the downstream hydraulic gradient site boundary) would provide insight into contaminant concentrations in the groundwater further down hydraulic gradient of the waste (providing insight into contaminant concentration reduction with distance/travel time) and would also provide insight into the groundwater quality migrating off-site. As monitored

attenuation may be a future proposed remedial strategy for the site an additional monitoring borehole(s) at the downgradient boundary may provide very important data for the future.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater level and quality monitoring, to install additional groundwater monitoring borehole(s) and to do a Detailed Quantitative Risk Assessment to inform risks to groundwater.*

With regard to the above, we would state the following:

As mentioned in Sections 2.2.2 & 2.2.5, BH14 was installed approx. 60m downgradient of the waste body on the 26th October 2017. A further round of groundwater quality samples was taken from all groundwater wells including BH14 on the 15th November 2017. This data will be utilised in the DQRA.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted**

2.9 Groundwater Flow:

Section 4.7.2 Groundwater Flow is blank in the interim report and needs to be completed.

Action: *Mulroy Environmental gave an undertaking to complete the groundwater flow section.*

With regard to the above, we would state the following:

Mulroy Environmental will include a completed section in the final report detailing the direction of groundwater flow on site. This will include a groundwater contour map.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted**

2.10 Waste Delineation:

A thorough review of aerial photos and historical maps appears to have been undertaken, followed by a number of intrusive investigation programmes (including trial pitting and borehole drilling) in order to define the extent of the waste body which is illustrated in Figure 6. A critical aspect of the investigation is the position of the waste with respect to the housing development. Figure 6 appears to suggest there are no houses located (or proposed to be located) on the waste body itself, if this is indeed believed to be the case then this is a very important fact and should be specifically stated in the report.

Action: *Mulroy Environmental stated that, based on their site investigations, no houses were built on waste material. They will specifically reference this in report.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that no houses will be built on the area delineated as the waste body on Figure 6 of the interim report.

With regard to the newly constructed houses to the north west of the waste body, Mulroy Environmental can confirm that the waste body did not extend past the cairn towards these houses. We estimate that the western boundary of the waste body is approximately 40m from the north west residential pocket development.

With regard to house Nos. 25 – 34, it should be noted that Winsac Ltd. have had the foundations in this area inspected by Homebond. A report detailing this information will be included in the final report.

Mulroy Environmental will make specific reference to these details in the final report.

FCC/RPS Comment:

- Figures 1 – 3 accompanying the email with ''Reply to technical Review Meeting Minutes 282.28.11.17'' indicates a different delineation of waste body to Figure 6 of the Interim Report. The difference is significant in that GS1 and GS2 are indicated as ''in waste'' on Figure 6 and out of waste in Figure 1. This appears to be inconsistent with the borehole log of GS1 and GS2. Clarification is required on this point – in Figures 2 & 3 the boundary of the waste is noted as ''drawn after site investigation''. Additionally, Waste associated with METP01 appears to be now outside the boundary delineated in Figure 2. Can Mulroy Environmental confirm the boundary of the waste in this location?

- There appears to be an inconsistency in the mapped locations of GS1-4 and BH3 between earlier and later maps e.g. (Figure 6 dated 8/8/17 and Figure 1 dated 27-11-17). For example, GS2 & 3 are more distant from each other and BH3 is further north in the former than in the later. It is also noted that the Logs for GAS03 and GAS04 have the same eastings and northings and that these grid references are incomplete.

- The redrawn delineation of waste body should be elaborated upon in the text of the report and supported by reference to trial pits, borehole logs, slit trenching and any other evidence provided.
- There may be a role for Geophysics results here in delineating waste body particularly in north west and western sides of the site.
- Can Mulroy Environmental confirm that no waste will exist within the curtilage of any properties developed on this site?

Mulroy Environmental / Winsac Ltd Response:

- **On further review of the BH log for GAS01 and accompanying digital photographs (see Appendix 4), made ground was identified up to 4m BGL. It should be noted that the material identified in the made ground was dominated, for the most part by inert construction and demolition type waste up to 3m BGL. However, charred domestic waste was identified from 3.0m – 4.0m BGL. As such it is the opinion of Mulroy Environmental that GS01 is at the edge of the waste body. On further review of the TP log for TP1, this waste was found to be a mixture of domestic and construction and demolition waste. For clarification purposes, please see Figure 1 Rev. A attached, which has the correct delineation of the waste body and is consistent with Figure 6 of Mulroy Environmental's Interim Report. Please note, that gas well GAS02 is not within the waste body as indigenous soils were encountered at a depth of 0.2m BGL during its installation (see Appendix 5). It should be noted that it is intended to carry out further geophysical runs to the south of residence Nos. 25 – 34 and to the east of residence Nos. 25 & 26 (i.e. along the access road). It is anticipated that the findings of this additional geophysical work will clarify the extent of made ground and / or domestic waste within the vicinity of these residences;**
- **Please be advised that the locations of the gas wells and boreholes on the most recent drawing (i.e. Figure 1 dated 27-11-17) is correct. The location of the wells on Figure 6 dated 08/08/17 was provisional only and marked up prior to the topographical survey being completed. Figure 6 dated 20-08-17 which was included in Mulroy Environmental's Interim Report (277.29.09.17) is consistent with Figure 1 dated 27-11-17. The coordinates for gas wells GAS03 & GAS04 are located in Appendix 5. Mulroy Environmental will correct the coordinates for GAS03 & GAS04 in the final report also; and**
- **Mulroy Environmental can confirm that no residences will be or have been developed on waste within the site. Please find a letter from Homebond Building Control Ltd. in relation to the foundation inspections at residences Nos. 27 – 35, Hamilton Hill, Barnageeragh Cove, Skerries (see Appendix 6). The document states *'The ground encountered was sand clay with no foreign material observed'*. In addition, please find a letter in Appendix 6 from Duffy Chartered Engineers (DCE) in relation to residences Nos. 25 & 26 stating *'No foreign material was observed on the footprint of these houses. The piles where installed into a sand / clay material.''***

2.11 Gas; Gas cut-off wall:

The detail on the drawing 13-157-C609 for the cut-off trench does not detail the vertical vents which are included in the sketch in the ME report (Plate 10). The use of a GCL in the vertical trench should be reconsidered. A more appropriate barrier would be HDPE or LLDPE. The depth of the trench needs to be considered. The detail in the drawing and report states the trench will be approx. 4m deep. With a waste body that is considerably deeper and a sand/gravel Memorandum Page: 4 of 5 layer underlying the site, the trench should probably extend to the summer GW level as a minimum or bedrock. In the CSM the trench is shown to terminate at the interface between the sand/gravel and bedrock.

Action: *Mulroy Environmental agreed GCL was not appropriate and will revise design accordingly. Details of vents and surface of trench to be reviewed. Depth of trench will be reconsidered by Mulroy Environmental in light of these comments.*

With regard to the above, we would state the following:

It is agreed that a HDPE or LLDPE barrier will be used in the cut off trench. Details of both horizontal and vertical venting will be provided as part of the proposed design for the landfill gas cut off trench.

The trial pit investigation that was carried out on the 2nd June 2017 & 11th August 2017, indicated that the overburden in the vicinity of trialpits METP32 – METP34 & METP39 – METP47 (i.e. to the north of the waste body and builders compound) which are at approximately 15.9m AOD consists of the following:

As can be seen from Table 2 above, the groundwater table was identified at 2.60m BGL in BH13 (i.e. approximately 13.3m AOD). In order to intercept potential landfill gas migrating in a northerly direction, the proposed cut off trench will be extended to a depth of 4mBGL (11.9m AOD). It should be noted that landfill gas migration via overburden/subsoil is significantly higher than landfill gas migration via groundwater. As such, it is not necessary for the landfill gas cut off trench to extent to the depth of the underlying bedrock. Please note that a geophysical survey was carried out on 24th of November 2017. During the site investigation exercise the bedrock in the area proposed for commercial development was found at approximately 4.5m BGL. It is expected that a more accurate representation of the bedrock profile will be achieved following correlation between the site investigation findings and the geophysical survey. This information will be used to amend the cross-section drawings and CSM drawings if necessary.

With regard to the depth of the landfill gas cut off trench to the east and north east of the waste body, Mulroy Environmental have delineated the extent of this waste which correlates reasonably closely with the footprint of the former sand and gravel pit as per 25'' historical ordnance survey mapping. It is proposed that the landfill gas cut-off trench in this area is positioned at the edge of the former sand and gravel pit. It is proposed that the landfill gas cut off trench extends to 4.0m BGL into the indigenous soils which consists primarily of sands and gravels. It should be noted at this moment in time, 6 rounds of landfill gas monitoring have been carried out on the original boreholes that were installed in June 2017 (i.e. BH1 – BH7 & GAS01 – GAS04). For those wells located in closest proximity to the housing development (i.e. BH2, BH3 & BH5 which are located inside the waste body & GAS01

– GAS04 which are located outside the waste body & adjacent to the south / south-western boundary of residences No.25 – 34), it should be noted a concentration of 0.3% methane was recorded in BH2 on one occasion with 0% methane recorded across these 7 wells / 6 monitoring rounds on all other occasions (see Tables A3.1 & A3.2 in Appendix 3 & Figure 2). The landfill gas monitoring results obtained to date indicate that the risk posed by the north-western area of the waste body is at a lower level than that risk posed by the waste in the vicinity of BH1 and the waste to the south / south west of BH4. It is the opinion of Mulroy Environmental that the specification for the proposed landfill gas cut off trench (i.e. in particular the depth proposed) for the north-western area is proportionate given the results of the risk assessment to date.

It is proposed that further landfill gas monitoring wells are installed outside the north-western portion of the cut off trench. In order to determine if landfill gas is migrating under the cut off trench it is proposed that the depth of these landfill gas monitoring wells is at least 8mBGL. It is also proposed that these gas monitoring wells are spaced approximately 15m in distance apart.

FCC/RPS Comment:

- It is noted that the Geophysical Survey Results will be used to inform revision of the Cross Section Drawings and Conceptual Site Models.
- It is not clear from the above what depth is being proposed for the PVT in the Northwestern / western portion of the site.
- It is noted that the details of the proposed PVT are still outstanding.
- Re. BH4; there have been very high methane readings at this borehole, whereas there is very low methane readings in neighbouring boreholes. Does this suggest a localized source in this area? Will the geophysical survey help identify a localized source? If there is a localized pocket is there further mitigation measures to be considered in this area?
- Has Mulroy Environmental an opinion on why BH4 has consistently shown elevated methane levels and with this consistency is Mulroy Environmental satisfied that the extent of the waste boundary in this area is correct?
- Is Mulroy Environmental satisfied that 4m is sufficient depth in the north and northeast considering trial pit excavations terminated in waste material and before reaching indigenous soils in this area?

Mulroy Environmental / Winsac Ltd Response:

- **It is plausible that a localized source is contributing to the elevated methane levels in BH4. The geophysical survey indicates that domestic waste extends to a depth of 7.5m BGL (11.5m AOD) in the construction compound area (see resistivity profile R4 in geophysical survey). This domestic waste type material does not appear to extend as far as BH4. However, it is the understanding of Mulroy Environmental that the toilets located within the site compound were discharging to an on-site septic tank. It is understood that the contents of the septic tank were removed in December 2017 and the septic tank was decommissioned. To date a minimum of 6 rounds of landfill gas monitoring has been conducted for each well on site as is consistent with CIRIA C665 (see final 3 gas monitoring rounds in Appendix 7). However, Mulroy Environmental propose to carry out**

additional rounds of gas monitoring on BH4 over the coming weeks to ascertain if the decommissioning of the septic tank has resulted in a reduction in the CH_4 levels in the borehole;

- **Mulroy Environmental are satisfied that the position of the northern waste boundary delineated on Figure 1 dated 27-11-17 is the correct boundary for the waste body. In addition, the resistivity profiles (R3 & R4) from the geophysical survey indicate an absence of municipal waste with high organic and / or metallic content in the area to the north of the site compound and within the vicinity of BH4, BH 8 – BH12; and**
- **Trialpits TP24, TP25, TP26 & TP27 were excavated to the north / north east of the waste boundary / construction compound. Each of these trialpits were excavated to 3.5m – 3.6m BGL with no waste identified within. In addition, the resistivity profile R3 contained within the geophysical survey indicates that municipal waste with high organic and/or metallic content was not present to the north / north eastern waste boundary.**

2.12 Methane:

Fingal County Council stated that locating a petrol station adjacent to the waste body is a particular concern. Fingal County Council are concerned that although a petrol station would be ATEX rated, the likelihood of methane gases being above the LEL, is a key concern. Capping the waste body (which is passively venting) may force gas in other directions. The cut-off trench is not proposed on the western, southern or eastern sides of the waste body where there are houses planned (west), there is a foul main and railway line (south) and the WWTP is operational (east).

Action: *Mulroy Environmental are committed to extending the proposed length of the passive venting trench along the western side of the waste body where a pocket of houses are currently under construction. Additional landfill gas monitoring boreholes will be placed between the waste body and the pocket of houses under construction. There is a commitment to ongoing landfill gas monitoring. There will be a review of whether the Card Wilson risk assessment approach is appropriate to Barnageeragh and whether the proposed responses are adequate to deal with risks identified. Additionally, consideration needs to be given to extending passive venting trench south of the new houses (situated to SW of waste body) and parallel to the sewer line. A monitoring programme should be implemented to ensure that the mitigation measures are working.*

With regard to the above, we would state the following:

Please find attached Figure 1 which details the positioning of the proposed landfill gas cut off trench. Figure 1 illustrates the position of the cut off trench around the periphery of the landfill body. As can be seen from Figure 1, it is necessary to terminate the cut off trench 5m from the centre line of the rising sewer main in order to ensure that no damage occurs during the construction of the trench.

Mulroy Environmental will continue to monitor the landfill gas in all boreholes on-site until a minimum of 6 gas monitoring rounds has been conducted on each well. At present 3 more rounds of monitoring are required for boreholes BH8 – BH13. This will require sampling rounds during times of high and low atmospheric pressure. In addition, gas monitoring during periods of low pressure is also required for wells BH1 – BH7 & GAS01 – GAS04.

As stated in section 2.2.10, it is proposed that further landfill gas monitoring wells are installed outside the north-western portion of the cut off trench. The purpose of these wells is to ensure the effectiveness of the landfill gas cut of trench intercepting any landfill gas which may be migrating from the waste body. It is proposed that wells are monitored for a certain time period after the installation of the cut off trench. It should be noted that it is also intended to monitor the vertical vent stacks within the landfill gas cut off trench and the radon sumps for each housing blocks to the northwest and the north of the waste body.

Mulroy Environmental will review the appropriateness of the Modified Wilson & Card Classification for the development. Mulroy Environmental will also review the NHBC classification (i.e. Situation B in Ciria C665) when developing the final risk assessment report. It should be noted that an underfloor ventilation void has been constructed for houses Nos. 25 & 26 (i.e. houses in closest proximity to waste body) and therefore the NHBC classification system is more appropriate when conducting a risk assessment for those houses in particular.

FCC/RPS Comment:

- Noted. See comments from 2.2.10 above.
- Is Mulroy Environmental satisfied that no gas monitoring is required north of the PVT at BH10?

Mulroy Environmental / Winsac Ltd Response:

- **It is proposed that a number of shallow landfill gas wells will be installed to the northeast of the PVT (i.e. following its completion). The purpose of these wells is to confirm the effectiveness of the PVT in preventing landfill gas migrating in a north easterly direction towards the commercial zoned area and in a north-westerly direction towards the residences (i.e. Nos 25 & 26).**

2.13 H2S:

The monitoring only detected H2S on two occasions and to a maximum reading of 3ppm, albeit in the gas wells adjacent to the house. Below these levels there would possibly be an odour but nothing too concerning. If the venting trench is extended deep enough to capture fugitive emissions any H2S will vent with the other LFG to atmosphere for dispersal. They should not have any services passing through the waste body and/or manholes thereby reducing any risk of fugitive emissions. If H2S becomes an issue then other passive or active systems could be looked at to reduce the impact.

Action: *Design of passive venting trench to consider the above comments. Mulroy Environmental committed to further rounds of monitoring for this parameter. To include further monitoring in houses and services and to record and report results in report. These results to be included in Landfill Gas Risk Assessment. Mulroy undertook to establish if radon barrier / protection measures are in place in houses.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that H_2S gas will continue to be monitored in the deep boreholes, shallow gas wells, radon sumps, services and the landfill gas cut off trench vertical vent stacks during the subsequent gas

monitoring rounds. It also proposed to carry out interior gas surveys off house Nos. 25, 26, 52 & 53 (i.e. houses in closest proximity to the landfill waste body). This will involve 28-day diffusion monitoring for speciated VOCs, H_2S, CH_4 and CO_2 at three locations within each residence. This data will be incorporated into the final risk assessment report.

Mulroy Environmental understand that a Visqueen High Performance Radon Membrane™ was used in the construction of the houses at Barnageeragh Cove. It is understood that this specification of membrane is not equivalent to the specification provided by the Visqueen Gas Barrier or Visqueen Low Permeability Gas Membrane (see Appendix 4).

FCC/RPS Comment:

- Commitment to diffusion monitoring noted – Is there a role for trace element analysis here? Are Mulroy Environmental satisfied that the number of houses being monitored, and type of monitoring being undertaken: is sufficient.
- There should be Risk Assessment of the levels of H2S found in Boreholes / Houses / Sumps / Services. i.e. results have been presented but no interpretation or risk assessment provided for this parameter. To be included in SI and ERA report.
- Will services pass through pathway of proposed PVT? What measure to protect from providing a pathway for landfill gas prevention.

Mulroy Environmental / Winsac Ltd Response:

- **During the initial indoor gas assessment, four houses were selected given their proximity to the waste (i.e. residence Nos. 25, 26, 52 & 53). Please note that residence No. 26 was not surveyed with the other 3 houses on the 15th, due to a bereavement within the family on the morning of the survey.**
- **Please note that both arsenic and mercury have been analysed by Odour Monitoring Ireland in residence Nos. 25, 52 & 53 during the indoor gas survey;**
- **Please note, that a primary purpose of the indoor gas survey is to assess the risk from H_2S to residences in an indoor environment (i.e. receptors); and**
- **Please note that there are storm water sewers which will intersect with the proposed PVT (see location on Figure 4). It is proposed that where the storm water sewers intersect the PVT, that sealing is put in place to prevent the transfer of any landfill gas outside the PVT along the route of the storm sewers (i.e. landfill gas migrating along the fill material as a preferential pathway).**

2.14 Risk Assessment Table – Surface Water:

The risk assessments in the report detailing linkages without and then with mitigation measures in Tables 10 and 11, were discussed. It was observed that a number of "potentially complete" linkages remain even after the implementation of the proposed mitigation measures, with regard to some of these remaining "potentially complete" linkages the following issues were discussed: Table 11 (page 51) Direct surface water bodies to the north and east of the waste body: The report identifies that the linkage remains potentially complete as "impact on the stream is expected to be low and contact between landfill body and surface water body is not proven". It was recommended to collect surface water quality samples from the relevant surface water body (bodies), from

locations both upstream and downstream of any groundwater baseflow contribution from the site, to provide data which might further clarify this potential linkage.

Action: *Mulroy Environmental committed to sampling surface water to clarify this.*

With regard to the above, we would state the following:

Mulroy Environmental will take surface water samples both upstream and downstream of the adjacent stream in order to assess the potentially complete pollutant linkage between the waste body (i.e. source) and stream (i.e. receptor). Please find attached Figure 3 which shows the location of the proposed upgradient and downgradient surface water monitoring points. It is proposed to take the upgradient sample to the south of the Belfast – Dublin railway line, 5 – 10m to the south of the where the stream is culverted underneath the railway line. It is proposed to take 2 downgradient samples. One sample will be taken from a storm water manhole to the north east of the site with the other downgradient surface water sample taken from a storm water manhole to the north west of the site.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Please note that Mulroy Environmental carried out the surface water monitoring at the 3 sampling locations mentioned previously, on the 11th of January 2018. We are currently awaiting the results of this analysis.**

2.15 Risk Assessment Table – Landfill Gas:

Table 11 (page 53) Residents of newly built residences to northwest, north and north of road: The report identifies that the linkage remains potentially complete as "no underground services in proximity of waste body with exception of foul rising main running to the south and north". This suggests that the foul rising main remains a potential migration pathway for gas. This remaining potential linkage appears significant and should be considered further regarding potential additional mitigation measures. Table 11 (page 53) Operatives on WWTP to the southeast of the site: The report identifies that the linkage remains potentially complete and that this should be "investigated further in consultation with Fingal CC". The statement that something requires further investigation obviously suggests that further work is required to close this out, this should be closed out as part of this report. We understand that Fingal CC have provided details of the engineering design of the pipeline and the associated gas protection put in place to Mulroy, which may assist with progressing this aspect.

Action: *Mulroy Environmental committed to reviewing this information and revising risk assessment, if appropriate – See also 11.*

With regard to the above, we would state the following:

In order to determine if the foul rising main is acting as a pathway (i.e. a path of least resistance) for landfill gas migrating from the waste body in either a north western (i.e. towards the residence) or in a south-eastern direction (i.e. towards the Waste Water Treatment Plant (WWTP)) it is proposed to carryout a local gas probe survey within a 5m buffer of the foul rising main. This gas probe survey will entail the drilling of shallow boreholes (i.e. 1-inch diameter and 1.2m in depth) using an electric Hilti drill. Following this, 0.75-inch perforated uPVC piping is inserted into each borehole with the end sealed until measurement is carried out. These holes will be assessed for landfill gas levels approximately 2 hours after their installation. Mulroy Environmental will review gas protection measures put in place during the construction of the pipeline.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

If you have any questions or require clarification with regard to any item of this report, Mulroy Environmental can be contacted at 042-9384750.

Yours sincerely,

Patrick McCabe

Patrick McCabe
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Staff Scientist

Padraic Mulroy

Padraic Mulroy
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Managing Director
Mulroy Environmental

Notes of Meeting Regarding; Phase II Site Investigation / DQRA / Groundwater Monitoring /Landfill Gas Survey Residential Development Barbageeragh Cove, Skerries.

Location: Fingal County Council: County Hall, Swords, County Dublin.

Date and Time: 24/1/2018; 3pm-5pm.

In Attendance: Gilbert Power (GP) and Mortimer Loftus (ML), (Fingal County Council; FCC); Conrad Wilson (CW) and Paul Heaney (PH), (RPS); Padraic Mulroy (PM) and Patrick McCabe (PMc), (Mulroy Environmental; ME); Bernie Carroll (BC) and Malachy Clarke (MC), (Winsac Ltd).

1. **Background:**

On the 10th of October 2017, Mortimer Loftus, James Walls and Brian Reynolds of Fingal County Council, Conrad Wilson and Paul Heaney of RPS Consulting Engineers and Padraic Mulroy and Patrick McCabe of Mulroy Environmental attended a technical review meeting at County Hall, Swords, Co. Dublin to discuss the contents of Mulroy Environmental's Phase II Site Investigation Interim Report on Barnageeragh (277.29.08.17) which was submitted on the 29th August 2017.

Following this meeting, the minutes were compiled by Mortimer Loftus with a copy furnished to Mulroy Environmental on the 23rd of October 2017. Mulroy Environmental reviewed the contents of the minutes including the actions outlined within and responded with their client's comments and commitments (Ref: 282.28.11.17). On the 9th January 2018, Fingal County Council / RPS responded with further comments. On 23/1/2018, a reply prepared on behalf of Winsac Ltd. was prepared by Mulroy Environmental to the aforementioned (Ref:293.23.01.18)(Appendix 1) and sent to Fingal County Council /RPS in advance of Meeting dated for 24/01/2018. These are the notes of meeting of 24-01-2018.

1.1 Introduction:

GP opened the meeting and outlined that the purpose of the meeting was to get an update on progress of Site Investigations and to address issues raised to date through meeting of 10/10/2018, minutes and subsequent responses arising. As with previous meeting, it was said that other agencies may have a significant input into issues arising from Site Investigations / ERA.

GP queried the inclusion of mercury and arsenic as part of the diffuse monitoring discussed in Section 2.13. Mulroy Environmental advised that mercury and arsenic had been added to the odour monitoring suite only for completeness sake, as elevated concentrations of these two compounds had previously been detected in the groundwater, and that there was no other reason for their inclusion in the monitoring suite. Mulroy Environmental (ME) advised that other trace elements have been analysed also and final results are awaited. GP requested that the final report from Odour Monitoring Ireland, with interpretation of results, be forwarded to Fingal County Council.

PM provided a broad outline of progress in Site Investigations since the last meeting and advised that the deadline for their final report was 21st February 2018.

ACTION: Mulroy Environmental committed to circulate diffuse monitoring report of Odour Monitoring Ireland, with interpretation. Proceed with Site Investigations / ERA with a view to completion on 21st / 2 / 2018.

2.1 Basis For Building The Buildings Which Had Previously Been Delayed.

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

Mulroy Environmental advised that further gas monitoring was undertaken to comply with CIRIA C665 (six rounds). They advised that results of the gas monitoring to date, which were communicated to Winsac Ltd, that the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses (nine rounds to date).

Action: Mulroy Environmental committed to provide a log detailing the slit trench excavated on the 2nd June 2017 under the supervision of Eoin Halpin in the final site investigation / risk assessment report;

Mulroy Environmental committed to use terminology consistent with CIRIA C665 throughout the final risk assessment report;

and

Mulroy Environmental will include a section in the final site investigation / risk assessment report detailing the post site investigation monitoring programme (i.e. landfill gas and groundwater monitoring) and emergency response procedure outlining the actions to be taken should elevated landfill gas concentrations be detected in specific boreholes (i.e. GAS01 – GAS04).

2.2 Waste & Groundwater Table

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18) and the commitments provided therein are noted and still apply – in addition to the Action Items below.

Mulroy Environmental advised that based on the recent groundwater table measurements and the inferred depth of waste (from borehole logging previously completed and recent geophysical survey work), that it appeared that waste material did exist below the groundwater table in the BH1/BH6 area.

Mulroy Environmental advised that additional geophysics would be undertaken in order to provide more insight into the depth of waste. There appeared to be some inconsistencies in the interpretations of depth of waste around BH6 between different geophysics cross sections, which needs clarification.

There was joint discussion regarding the implications of the fact that the waste appeared to exist below the groundwater table and that this was not permitted under the groundwater regulations. It was mutually agreed that the appropriate way to progress was to complete the proposed DQRA to evaluate the consequences of this and evaluate the potential risk. It was acknowledged by all, that while this may not in any way impact the site residents that this would be a key point of consideration for the EPA.

Discussion that clarity required on the use of terminology in borehole / trial pit and gas logs e.g. "made ground" and environmental significance of such terminology vis a vis GW directive and nature of connection between waste and groundwater..

Action: Mulroy Environmental committed to clarifying depth of waste / groundwater table in the vicinity of BH1/BH6 – through consultation with Geophysics Surveyors (APEX) on existing survey and further Runs / Geophysics Survey. Clarify and standardise use of strata terms throughout site investigation reports.

2.3 Seasonal groundwater level variations:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

Mulroy Environmental advised that hydraulic testing was to be completed in order assess the hydraulic conductivity of the strata across the site.

Mulroy Environmental advised that Peter Conroy had been commissioned by Mulroy to complete the DQRA assessment.

FCC enquired as to whether the DQRA was purely groundwater focussed and did it also consider gas. Mulroy advised that the DQRA was purely groundwater related but that a human health risk assessment was also being undertaken and that this would consider the gas element.

Mulroy Environmental advised that Peter Conroy had started to look at the groundwater data and had indicated that the groundwater levels and flow directions were very complex across the site and that there was a potential link in with surface water drainage.

Mulroy Environmental advised that groundwater flow direction was not only in a north-easterly direction towards the coast, but potentially there was also flow in a south-easterly direction towards the railway. FCC enquired, if this were the case, then was BH14 (the new downgradient borehole) in an appropriate location; Mulroy advised that they believed it was. RPS raised the question that if groundwater levels/flow were more complex than initially envisaged, then was there sufficient data points to provide an appropriately level of certainty with regards groundwater flow directions (both within the site and migration off-site). RPS raised the question was there now a significant data gap in the south east corner of the site, if groundwater was migrating off-site in this direction.

Mulroy Environmental advised that this was a work in progress and that Peter Conroy was still evaluating all the data.

It will be very important that Peter Conroy's initial assessment of all the data Mulroy Environmental has collected considers whether there is sufficient groundwater and surface water related data, from across the site, to complete the DQRA to an appropriate level of certainty.

Action: Mulroy Environmental committed to clarify seasonal groundwater level variations, groundwater levels and flow directions through DQRA. Identify data gaps, if any, and obtain data as necessary.

2.4 Quantity of waste below groundwater table:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

Mulroy Environmental advised that as discussed previously additional geophysical survey work was to be undertaken and that this would confirm the quantity of waste below the water table.

Action: Mulroy Environmental committed to clarify depth of waste / groundwater table in the BH1/BH6 area – through consultation with Geophysics Surveyors (APEX) on existing survey and further Geophysics Survey.

2.5 Cross Section A-A': Waste and Other strata.

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

The cross section suggests that the waste is underlain by approx. 4m of silty/clay, this does not appear consistent with the various borehole logs (including BH1 illustrated in the section) which generally suggest that the waste is directly underlain by sand and/or gravel. The cross section suggests that in BH1 the waste extends below the water table, this should be confirmed and the section should be consistent with the findings of the aforementioned points.

Action: Mulroy Environmental to clarify depth of waste/groundwater table in the BH1/BH6 area – through consultation with Geophysics Surveyors (APEX) on existing survey and further Geophysics Survey. Cross-sections to be consistent with findings of trial pits, borehole logs and geophysics. Terminology used (Made Ground, Fill Material, C&D) should be explained through glossary and be consistent across all the reports comprising the site investigations (e.g. consistency between descriptions of strata in borehole logs, cross sectional drawings and geophysics reports.)

2.6 Groundwater quality results: Arsenic and Mercury

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

Joint discussion on the arsenic and mercury results from 15th November 2017 groundwater monitoring round; discussions of the fact that the November 2017 results showed generally lower concentrations of both arsenic and mercury, although now mercury was detected above guidelines in BH10 where it was previously below the guideline value.

Mulroy Environmental had conducted two rounds of GW monitoring. Is this a sufficient to conduct DQRA?

Mulroy Environmental stated that they had appointed P Conroy to conduct DQRA. They proposed to use ConSim modeling software to assess the risk posed to groundwater (Developed by GOLDERS – for unlined historical landfills) and to use the RBCA Model to assess the human risk.

Mulroy Environmental to conduct GW pump trials in coming week to provide modelling data.

Action: Mulroy Environmental / P Conroy to evaluate these parameters (amongst others required of GW directive) through DQRA. Identify data gaps, if any, and obtain data as necessary. Also, as indicated, to assess risk to human health.

2.7 "Recovering" Groundwater

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

Action: Mulroy Environmental / P Conroy to evaluate these parameters (amongst others required of GW directive) through DQRA. Evaluate if natural attenuation is occurring. Identify data gaps, if any, and obtain data as necessary. Proposal for Post site investigation / ERA monitoring regime to be included in the final report. This will include a timeframe of the monitoring regime.

2.8 Groundwater Quality Migration Off-site:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

Previously discussed, in part, under Section 2.3. Further information required from Mulroy on groundwater flow direction and gradients across the site and confirmation of details of off-site groundwater migration.

Groundwater flows described by Mulroy as "complex" and "linked in with surface water drainage" raises uncertainty.

Groundwater flow directions and hydraulic gradients are fundamental to the DQRA assessment and there will need to be sufficient confidence in both these aspects to undertake a robust DQRA.

Action: Mulroy Environmental / P Conroy to evaluate groundwater flows and hydraulic gradients and provide sufficient confidence in these aspects to undertake a robust DQRA. Evaluate if new GW borehole "BH14", given the above, is an optimal down-gradient borehole. Evaluate if there is sufficient coverage of GW monitoring boreholes to complete a robust DQRA.

2.9 Groundwater Flow:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

Previously discussed under Section 2.3. 2.7 & 2.8 Still awaiting information from Mulroy on groundwater flow direction and gradients across the site and confirmation of details of off-site groundwater migration. Need for GW direction maps asap underlined.

ACTION: Mulroy Environmental committed to including a completed section in the final report detailing the direction of groundwater flow on site. This will include a groundwater contour map.

2.10 Waste Delineation:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

Discussion on evidence of where waste body ends near residences e.g. Borehole logs GAS01 identifies waste to 4ms BGL – but does not evidence that this is the end of the waste body. Some discussion of foundation and piling inspections as supporting evidence. Further runs of geophysics in this area mentioned.

Discussion also on the delineation of the waste body as being to the south of BH9, contradicting Geophysics Maps (See R4). Need to clarify this.

Mulroy Environmental will include additional Geophysics runs north of 29-34 and east of 25 & 26 to clarify the nature of the strata in the vicinity of these residences. Mulroy Environmental to consult Geophysics surveyors re interpretation of strata in the vicinity of BH9. Mulroy Environmental will correct the waste delineation maps accordingly.

As with section 2.5. terminology used in describing waste body in cross section the same applies in representing waste body in plan; (e.g. Made Ground, Fill Material, Domestic Waste, C&D etc.) should be explained through glossary and be consistent across all the reports comprising the site investigations (e.g. consistency between descriptions of strata in borehole logs, cross sectional drawings and geophysics reports.)

Careful review of trial pit logs and borehole logs needed to inform delineation of waste boundary (plan and cross sections).

2.11 Gas; Gas cut-off wall:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18).

The position, depth and design of gas cut-off wall discussed. It was suggested that further consideration needs to be given to the design of same, including intersection with services. Discussion on source of Methane around BH4 – source removed – and Methane readings appear to be subsiding.

ACTION Mulroy Environmental will re-consider design details, including depth and location, of gas cut off wall and whether specialist expertise is required Mulroy Environmental to keep FCC/RPS updated on landfill gas readings at BH4.

2.12 Methane:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

This item was discussed and ties in with 2.11 above. It ties in with the location of the proposed cut off trench to the north of the waste body, to the south of 29-34 and to the east of 52-53. It also discussed monitoring arrangements post installation of cut off trench, if agreed.

ACTION: Mulroy Environmental will re-consider design details of gas cut off wall and whether specialist expertise is required. Details of monitoring programme post completion of cut off wall (if agreed) will be incorporated into report.

2.13 H2S:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

The trace element analysis (diffuse monitoring) conducted by Odour Monitoring Ireland was discussed. GP queried the inclusion of mercury and arsenic as part of the diffuse monitoring discussed in Section 2.13. Mulroy Environmental advised that mercury and arsenic had been added to the odour monitoring suite only for completeness sake, as elevated concentrations of these two compounds had previously been detected in the groundwater. Mulroy Environmental (ME) advised that other trace elements have been analysed also and final results are awaited. GP requested that the final report from Odour Monitoring Ireland, with interpretation of results, be forwarded to Fingal County Council.

ACTION: Mulroy Environmental committed to circulate diffuse monitoring report of Odour Monitoring Ireland, with interpretation to FCC.

2.14 Risk Assessment – Surface Water:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply – in addition to the Action Items below.

Mulroy advised that they had received the surface water results and that there was no guideline exceedances, except nitrates in the upgradient sample location.

There was some discussion regarding the pathway of the storm water trenches. The first point related to whether the storm water pipes drained the waste body in which they were laid. Mulroy Environmental advised that they did not drain the waste, but are solid storm water pipes which act as a conduit for storm water from the development.

FCC advised that adjacent coastal area was designated as a shellfish protection area and that this should be addressed in the Mulroy report.

ACTION: Mulroy Environmental to incorporate sw results into Site Investigations / ERA. Evaluate SW/GW results in the context of adjacent coastal waters being designated as a shellfish protection area.

2.15 Risk Assessment Table – Landfill Gas:

Mulroy Environmental discussed this issue as outlined in their correspondence (Ref:293.23.01.18). The commitments provided therein are noted and still apply.

3.0 Close:

Mulroy Environmental advised that the DQRA was due for completion 13th February and that potentially we could be provided with a copy after this date.

A provisional date of 22nd February was discussed for a follow on meeting which is to be confirmed.

APPENDIX I.

WINSAC LTD.,

PHASE II SITE INVESTIGATION/DQRA/

GROUNDWATER MONITORING/LANDFILL GAS SURVEY

RESIDENTIAL DEVELOPMENT,

BARNAGEERAGH COVE, SKERRIES

MULROY ENVIRONMENTAL'S RESPONSE TO FINGAL COCO / RPS COMMENTS DATED 09TH JANUARY 2018

293.23.01.18

23rd January 2018

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PROJECT MANAGER	Padraic Mulroy	Project Director	Padraic Mulroy	23/01/18

1. INTRODUCTION

On the 10th of November 2017, Mortimer Loftus, James Walls and Brian Reynolds of Fingal County Council, Conrad Wilson and Paul Heaney of RPS Consulting Engineers and Padraic Mulroy and Patrick McCabe of Mulroy Environmental attended a technical review meeting at County Hall, Swords, Co. Dublin to discuss the contents of Mulroy Environmental's Phase II Site Investigation Interim Report (277.29.08.17) which was submitted on the 29th August 2017.

Following this meeting, the minutes were compiled by Mortimer Loftus with a copy furnished to Mulroy Environmental on the 23rd of October 2017. Mulroy Environmental reviewed the contents of the minutes including the actions outlined within and responded with their client's comments and commitments (Ref: 282.28.11.17). On the 9th January 2018, Fingal County Council / RPS responded with further comments.

This document is a reply prepared on behalf of Winsac Ltd. by Mulroy Environmental to the aforementioned further comments. For reasons of clarity, each item discussed / action required is dealt with by section with:

- Relevant extracts of the RPS document (Ref MDR0303Me5001) which commented on Mulroy Environmental's Interim Site Investigation Report (Ref. 277.29.08.17) are outlined in green text;
- Actions required following the technical meeting between Mulroy Environmental, Fingal C.C and RPS on the 10th October 2017 in relation to the Interim Report are outlined in red text;
- Mulroy Environmental's response to the Fingal C.C / RPS meeting minutes and required actions are outlined in blue text;
- Fingal C.C / RPS further comments in relation to Mulroy Environmental's response are outlined in purple text; and
- Mulroy Environmental's response to Fingal C.C / RPS comments on the 9th January 2018 are outlined in this document in black bold text.

As part of the Fingal C.C / RPS response on the 9th of January 2018, it was requested that a GANTT chart should be produced scheduling the proposed remaining tasks associated with the site investigation, an expected timeline for execution of mitigation measures and post site investigation monitoring regime. A copy of this GANNT chart is included in Appendix 1 of this document.

2. MEETING ACTIONS / COMMENTS

2.1 Basis For Building The Buildings Which Had Previously Been Delayed

***Action:** Mulroy Environmental to include a specific section in Site Investigation / Environmental Risk Assessment Report, explaining the basis upon which the two houses (which had previously been delayed) have been built and also the basis upon which the "pocket development", to the West of the site proceeded.*

With regard to the above, we would state the following:

Following the installation of groundwater and gas monitoring wells on the 14th June 2017 – 19th June 2017, the first landfill gas monitoring round was carried out on 23rd June 2017, this was followed by a second round of monitoring on the 12th July 2017. It should be noted that the landfill gas readings in shallow gas wells to the south / south-west indicated that methane levels were at 0% in all 4 shallow gas wells. Carbon dioxide levels were found to range from 0% - 1.2% in the 4 shallow wells across the first 2 monitoring rounds. Using the modified Card and Wilson classification system, a 'Very Low Risk' classification was attributed to the 4 wells.

At that juncture the piling aspect of the foundations of houses Nos. 25 & 26 were complete. The results of the gas monitoring were communicated to Winsac Ltd, who were advised by Mulroy Environmental that the results indicated the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses. Mulroy Environmental advised that further gas monitoring was required to comply with CIRIA C665 and a further 4 monitoring rounds were required for this purpose.

With regard to the newly constructed housing to the north west of the waste body, it is Mulroy Environmental's understanding that planning permission was acquired for this phase of the development. Following the low levels of methane and carbon dioxide levels identified in BH2 and the findings of the site investigation to the northwest of the cairn (i.e. no waste discovered in METP30 & METP33 with the extent of the waste body determined by archaeologist Eoin Halpin to cease at the boundary of the Cairn, during slit trench excavation on the 2nd June 2017), it was determined that the risk from landfill gas from the waste body to the northwest residential phase was negligible.

FCC/RPS Comment:

- …''shallow wells to the south / south west''… should this be to the north / north west of waste body? – is this referring to ''GS1 – GS4''? If so should be explicitly stated in the report.
- Do monitoring rounds subsequent to first two monitoring rounds support advice given? Commentary to be put into Site Investigation / Environmental Risk Assessment Reports.
- Clarify use of trial pits and archaeological slit trenching (provide details of slit trenching) as evidence in delineating waste body, as part of Landfill Gas Risk Assessment. Does archaeological data support the determination of the extent of the waste body e.g. Slit Trench Logs?

- Use of the term ''negligible''? terminology from Wilson Card ERA more appropriate e.g. Very Low / Low Risk?
- Need to address post site investigation monitoring programme and need for an emergency response procedure – should levels of LFG reach specified limits at specific boreholes?

Mulroy Environmental / Winsac Ltd Response:

- **Mulroy Environmental can confirm that 'GS1 – GS4' refers to the shallow wells to the north / north east of the waste body and to the south / south west of residence Nos. 25 – 34;**
- **The results of the gas monitoring (i.e. Rounds 1 & 2) were communicated to Winsac Ltd, who were advised by Mulroy Environmental that the results, at that juncture, indicated the risks from landfill gas appeared to be 'Very Low' based on the results of the 4 shallow gas wells to the south / south west of the houses. Mulroy Environmental advised that further gas monitoring was required to comply with CIRIA C665 and a further 4 monitoring rounds were required for this purpose;**
- **A log detailing the slit trench excavated on the 2nd June 2017 under the supervision of Eoin Halpin will be included in the final site investigation / risk assessment report;**
- **Mulroy Environmental will use terminology consistent with CIRIA C665 throughout the final risk assessment report; and**
- **Mulroy Environmental will include a section in the final site investigation / risk assessment report detailing the post site investigation monitoring programme (i.e. landfill gas and groundwater monitoring) and emergency response procedure outlining the actions to be taken should elevated landfill gas concentrations be detected in specific boreholes (i.e. GAS01 – GAS04);**

2.2 Waste & Groundwater Table

Borehole Log BH1: RPS were initially provided with a borehole log (via email on 31 July 2017) for BH1 which suggested that the base of the waste was at 11.2mbgl and the groundwater table was at 10.78mbgl, suggesting that the waste extended to a depth of approx. 0.42m below the water table. However, the borehole log for BH1 in the Interim Report suggests that the waste extends to only 10.5mbgl and the groundwater level is at 10.78mbgl, suggesting that the waste terminates above the water table. Confirmation was sought from Mulroy's on which BH1 borehole log is correct.

Action: *Mulroy Environmental confirmed that the log presented in the Interim Report was the correct one and that the original borehole log was incorrect.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that Made Ground with timber and plastics was recorded to a depth of 8.0mBGL during the installation of BH1. Made Ground without timber and plastics (i.e. soil) was recorded to a depth of 10.5mBGL. On the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body and also delineate the overburden and depth to bedrock to the north and northeast of the waste body.

FCC/RPS Comment:

- Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.
- Interpretation of BH1 Log is unclear. Depth of waste has been cited in text as 8.0m BGL but borehole logs indicate made ground with plastics etc. to 9m BGL and made ground below this to 10.5m BGL. Needs clarification or correction.
- Is Mulroy Environmental satisfied that the 'made ground' below 8m BGL (or 9m BGL) is not waste?

Mulroy Environmental / Winsac Ltd Response:

- **To clarify made ground with plastics was recorded in BH1 to a depth of 9m BGL as indicated on the BH Log. The text should have read made ground with plastic and timber recorded to a depth of 8m BGL with made ground containing plastics (i.e. no timber recorded) to a depth of 9m BGL; and**
- **During the logging of BH1, no plastics / timber was recorded at a depth below 9m BGL. Upon preliminary review of the geophysical survey report, domestic waste would appear to extend to a depth to 9m BGL (14m AOD) in the vicinity of BH1. However, the geophysical survey report indicates that domestic waste extends to depths of approximately 12m BGL (11.5m AOD) in the vicinity of BH6 (see geophysical survey in Appendix 2).**

2.3 Seasonal groundwater level variation:

Further to the previous point, the water level detailed on the borehole logs was measured in June 2017, which is obviously during the summer when groundwater levels will generally be lower. Groundwater levels will generally be higher in the winter months (when there is more recharge), thus dependent on season variation, even if the waste is above the groundwater level in June this may not be the case during the winter months. Another set of groundwater level measurements be collected from all the bores on-site. Ideally this would be undertaken during the late winter, when groundwater levels are generally at their highest.

Action: *This season variation in groundwater levels was acknowledged by Mulroy Environmental and they indicated that an additional programme of groundwater level monitoring was to be undertaken later the same week.*

With regard to the above, we would state the following:

On the 15th November 2017, groundwater levels within each of the groundwater boreholes on site were taken. This included taking a groundwater level from BH14 (i.e. borehole installed on the 26th of October 2017, approximately 60m downgradient of the waste body). Table 1. compares the groundwater levels between the summer time monitoring round and levels taken on the 15th November 2017. As can be seen in Table 1 groundwater levels on the 15/11/17 had rose between 0.11m – 0.405m across the site. It should be noted that the

groundwater level in BH1 had not risen above the waste body when taken on the 15/11/17, however it is envisaged that Mulroy Environmental will measure groundwater levels on all bores again in mid-December 2017.

FCC/RPS Comment:

- Need to consider 2017 Annual rainfall by comparison with previous years and provision for post site investigation Report monitoring to track seasonal groundwater level variation.
- Table 1 identifies ''July/August 2017'' and ''15th July 2017'' as the dates for GW monitoring – we assume that is just a typo and that it should read '15th November 2017'' rather than ''15th July 2017''?
- BH1 results from 15th November 2017 suggest that the groundwater level (10.54m BGL) is very close to the interpreted base of the ''made ground'' (10.5m BGL). The groundwater monitoring results from mid-December 2017 will be important to assessing whether the groundwater level reaches the inferred base of the 'made ground' in BH1. The previous comment regarding whether the lower ''made ground'' horizon (marked as 9 – 10.5m BGL on the borehole log) is deemed waste is also of relevance and whether Mulroy Environmental is satisfied that the proximity of the groundwater table and the made ground/waste material is acceptable?

Mulroy Environmental / Winsac Ltd Response:

- **Mulroy Environmental will consider the 2017 annual rainfall by comparison with previous years to ascertain if groundwater levels are likely to have been higher in previous years than those recorded in 2017. As stated in section 2.1, the final site investigation / risk assessment report will include a section detailing the post site investigation monitoring programme. This programme will include seasonal groundwater level monitoring in 2018. In addition, a pressure transducer has been in place in BH14 since 6th December 2017. On the 11th January 2018, this transducer was relocated to BH1. A second transducer will be installed in a BH yet to be determined on 22nd January 2018;**
- **Mulroy Environmental can confirm that the groundwater dates included in Table 1 of document 282.28.11.17 should read ''July/August 2017'' and ''15th November 2017''**
- **Please note that Mulroy Environmental carried out the additional round of winter groundwater level monitoring on the 11th of January 2018 (see Appendix 3); and**
- **Please see Section 2.2 for Mulroy Environmental's comment on the depths of waste on-site.**

2.4 Quantity of Waste below Groundwater Level:

Following confirmation of borehole logs for BH1 and the seasonal position of the water table, consideration should be given in the report regarding: whether any waste exists below the water table (considering season water table variation), if any waste does exit below the water table then what percentage or volume of waste is predicted to exist below the water table, and the remedial actions proposed to deal with the waste below the water table or why it is deemed appropriate that no remedial actions are required (considering that this is a breach of the Groundwater Regulations).

Action: Mulroy Environmental gave an undertaking to evaluate this.

With regard to the above, we would state the following:

As mentioned in Comment 2.2.1, on the 24th November 2017, Apex Geoservices conducted a geophysical survey of the site in order to further delineate the depths of waste within the waste body. The outputs of this survey will be assessed to determine if any waste exists below the water table. Subsequently, if waste is identified below the water table an estimation of the quantity of this waste may be made.

FCC/RPS Comment:

- Need to consider Geophysical Survey of the Site to delineate depths of waste / depth of overburden and depth to bedrock is noted. Need to incorporate results into The Site Investigation and Environmental Risk Assessment is noted.

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

2.5 Cross Section A-A':

The cross section suggests that the waste is underlain by approx. 4m of silty/clay, this does not appear consistent with the various borehole logs (including BH1 illustrated in the section) which generally suggest that the waste is directly underlain by sand and/or gravel. The cross section suggests that in BH1 the waste extends below the water table, this should be confirmed and the section should be consistent with the findings of the aforementioned points.

Action: *Mulroy Environmental gave an undertaking to review and revise the cross section to deal with these inconsistencies.*

With regard to the above, we would state the following:

Mulroy Environmental will correct the cross-section drawings and include this in the final report.

FCC/RPS Comment:

- Noted, additional inconsistency referred to in 2.2.1 (FCC Comment; Second Bullet Point re. depth of made ground with plastics recorded on BH1 Log) – should be addressed here also.

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

2.6 Groundwater Quality Results: Arsenic & Mercury:

The groundwater samples collected from the boreholes returned concentrations of arsenic (BH4) and mercury (BH1, BH3 and BH11) which exceed the Threshold Values stipulated in the Groundwater Regulations. Arsenic and mercury are deemed hazardous substances and as such the input of these substances into groundwater is

prohibited under the Groundwater Regulations. It is also noted that BH4 and BH11 appear to be outside of the historical landfill area, thus they represent groundwater down-gradient of the waste body. The fact that these arsenic and mercury exceedances were detected is noted in the report in the results section; however, there is no further discussion of these results in the report. Some discussion about these results, the fact that hazardous substance exceedances have been detected should be addressed in the report with regards to how they are captured in the risk assessment, remedial strategy or why they are not considered significant. The report presents only one set of groundwater quality results. An additional round of groundwater quality monitoring should be undertaken in order to confirm the groundwater quality present on site.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater quality monitoring and do a Detailed Quantitative Risk Assessment to inform risks to groundwater. Mulroy Environmental gave an undertaking that this assessment would also include consideration of Waste Body Classification and how the proposed mitigation strategy is appropriate to the Hazardous classification of the waste body in 10 of forty soil samples taken.*

With regard to the above, we would state the following:

It should be noted that Mulroy Environmental carried out another round of groundwater quality monitoring on the 15th of November 2017 (see result Tables A2.1 & A2.5 in Appendix 3). This involved taking a groundwater sample from each of the 10 existing groundwater boreholes on site and from the more recently installed BH14. These results will be utilised in the development of a Detailed Quantitative Risk Assessment. It is proposed to use the Remedial Targets Methodology (RTM) and/or the RBCA methodology to assess the risk posed to groundwater. The RTM methodology was developed to specifically take account of the risk to groundwater from soil and groundwater contaminant sources. This approach will consider the arsenic and mercury concentration in the groundwater and elevated parameters in the 10 soil samples.

FCC/RPS Comment:

- Noted.

Mulroy Environmental / Winsac Ltd Response:

- **Please note that Mulroy Environmental / Winsac Ltd. have subcontracted Peter Conroy EurGeol, PGeo of Hidrigeolaíocht Uí Chonaire Teo. to aid in the development of the Detailed Quantitative Risk Assessment. It is proposed to use ConSim modeling software to assess the risk posed to groundwater and it is proposed to use the RBCA Model to assess the human risk.**

2.7 "Recovering" Groundwater

The report states a number of times that the groundwater quality is "recovering" or "improving", yet there is no justification provided in the report to support this statement. It is on the basis of this Memorandum Page: 3 of 5 "improving condition of the groundwater" that no intrinsic remedial measures for groundwater are proposed. This statement should be supported in the report by either presenting a series of groundwater quality results (over

time) which show a reducing contaminant level or detailed description as to why the current hydrochemistry supports the theory of improving water quality. Alternatively, this statement needs to be amended in the report and an alternative rationale behind the proposed remedial actions presented.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater monitoring (levels and quality) and to do a Detailed Quantitative Risk Assessment to inform assessment of risks to groundwater and evaluate if groundwater quality is "recovering".*

With regard to the above, we would state the following:

It is estimated that landfilling of the waste body commenced in the 1970's and ceased 1990's and as such the age of the waste is estimated to be approximately 30 – 50 years old. During the trial pit investigation putrescible waste (i.e. odour emanating waste) which has the potential to break down further through aerobic or anaerobic processes was not identified. It is the professional experience of Mulroy Environmental that waste bodies still posing a risk to underlying aquifers usually indicate the presence of putrescible waste and that this waste would normally be detected as landfill gases / H2S gas during intrusive site investigation works. Given the properties of the subsoil underlying the waste (i.e. predominantly Sands & Gravels), it is likely that organic and inorganic contaminants contained within the waste body have been significantly leached out over the lifespan of the waste body.

However, in order to confirm that natural attenuation has occurred and is actively occurring on-site, Mulroy Environmental recommend further groundwater monitoring of the waste body and the land immediately to the north. Following the receipt of the second round of groundwater quality results, Mulroy Environmental will undertake a Detailed Quantitative Risk Assessment using the RTM/RBCA methodology. The groundwater models can be verified following the receipt of subsequent groundwater data.

FCC/RPS Comment:

- Noted that DQRA is being undertaken and will form part of Site Investigation and ERA.
- Need to consider a post Site Investigation / ERA monitoring regime? Timeframe of regime?

Mulroy Environmental / Winsac Ltd Response:

- **As mentioned previously a section detailing the post site investigation / ERA monitoring regime will be included in the final report. This will include a timeframe of the monitoring regime.**

2.8 Groundwater Quality Migrating Off-Site;

As identified above, BH4 and BH11 appear to be outside of the historical landfill area but are still returning elevated metals concentrations in the groundwater samples collected. Installation of an additional groundwater monitoring borehole (or boreholes) further downgradient of the waste body (ideally along the downstream hydraulic gradient site boundary) would provide insight into contaminant concentrations in the groundwater further down hydraulic gradient of the waste (providing insight into contaminant concentration reduction with distance/travel time) and would also provide insight into the groundwater quality migrating off-site. As monitored

attenuation may be a future proposed remedial strategy for the site an additional monitoring borehole(s) at the downgradient boundary may provide very important data for the future.

Action: *Mulroy Environmental gave an undertaking to do additional rounds of groundwater level and quality monitoring, to install additional groundwater monitoring borehole(s) and to do a Detailed Quantitative Risk Assessment to inform risks to groundwater.*

With regard to the above, we would state the following:

As mentioned in Sections 2.2.2 & 2.2.5, BH14 was installed approx. 60m downgradient of the waste body on the 26th October 2017. A further round of groundwater quality samples was taken from all groundwater wells including BH14 on the 15th November 2017. This data will be utilised in the DQRA.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted**

2.9 Groundwater Flow:

Section 4.7.2 Groundwater Flow is blank in the interim report and needs to be completed.

Action: *Mulroy Environmental gave an undertaking to complete the groundwater flow section.*

With regard to the above, we would state the following:

Mulroy Environmental will include a completed section in the final report detailing the direction of groundwater flow on site. This will include a groundwater contour map.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted**

2.10 Waste Delineation:

A thorough review of aerial photos and historical maps appears to have been undertaken, followed by a number of intrusive investigation programmes (including trial pitting and borehole drilling) in order to define the extent of the waste body which is illustrated in Figure 6. A critical aspect of the investigation is the position of the waste with respect to the housing development. Figure 6 appears to suggest there are no houses located (or proposed to be located) on the waste body itself, if this is indeed believed to be the case then this is a very important fact and should be specifically stated in the report.

Action: *Mulroy Environmental stated that, based on their site investigations, no houses were built on waste material. They will specifically reference this in report.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that no houses will be built on the area delineated as the waste body on Figure 6 of the interim report.

With regard to the newly constructed houses to the north west of the waste body, Mulroy Environmental can confirm that the waste body did not extend past the cairn towards these houses. We estimate that the western boundary of the waste body is approximately 40m from the north west residential pocket development.

With regard to house Nos. 25 – 34, it should be noted that Winsac Ltd. have had the foundations in this area inspected by Homebond. A report detailing this information will be included in the final report.

Mulroy Environmental will make specific reference to these details in the final report.

FCC/RPS Comment:

- Figures 1 – 3 accompanying the email with ''Reply to technical Review Meeting Minutes 282.28.11.17'' indicates a different delineation of waste body to Figure 6 of the Interim Report. The difference is significant in that GS1 and GS2 are indicated as ''in waste'' on Figure 6 and out of waste in Figure 1. This appears to be inconsistent with the borehole log of GS1 and GS2. Clarification is required on this point – in Figures 2 & 3 the boundary of the waste is noted as ''drawn after site investigation''. Additionally, Waste associated with METP01 appears to be now outside the boundary delineated in Figure 2. Can Mulroy Environmental confirm the boundary of the waste in this location?

- There appears to be an inconsistency in the mapped locations of GS1-4 and BH3 between earlier and later maps e.g. (Figure 6 dated 8/8/17 and Figure 1 dated 27-11-17). For example, GS2 & 3 are more distant from each other and BH3 is further north in the former than in the later. It is also noted that the Logs for GAS03 and GAS04 have the same eastings and northings and that these grid references are incomplete.

- The redrawn delineation of waste body should be elaborated upon in the text of the report and supported by reference to trial pits, borehole logs, slit trenching and any other evidence provided.
- There may be a role for Geophysics results here in delineating waste body particularly in north west and western sides of the site.
- Can Mulroy Environmental confirm that no waste will exist within the curtilage of any properties developed on this site?

Mulroy Environmental / Winsac Ltd Response:

- **On further review of the BH log for GAS01 and accompanying digital photographs (see Appendix 4), made ground was identified up to 4m BGL. It should be noted that the material identified in the made ground was dominated, for the most part by inert construction and demolition type waste up to 3m BGL. However, charred domestic waste was identified from 3.0m – 4.0m BGL. As such it is the opinion of Mulroy Environmental that GS01 is at the edge of the waste body. On further review of the TP log for TP1, this waste was found to be a mixture of domestic and construction and demolition waste. For clarification purposes, please see Figure 1 Rev. A attached, which has the correct delineation of the waste body and is consistent with Figure 6 of Mulroy Environmental's Interim Report. Please note, that gas well GAS02 is not within the waste body as indigenous soils were encountered at a depth of 0.2m BGL during its installation (see Appendix 5). It should be noted that it is intended to carry out further geophysical runs to the south of residence Nos. 25 – 34 and to the east of residence Nos. 25 & 26 (i.e. along the access road). It is anticipated that the findings of this additional geophysical work will clarify the extent of made ground and / or domestic waste within the vicinity of these residences;**
- **Please be advised that the locations of the gas wells and boreholes on the most recent drawing (i.e. Figure 1 dated 27-11-17) is correct. The location of the wells on Figure 6 dated 08/08/17 was provisional only and marked up prior to the topographical survey being completed. Figure 6 dated 20-08-17 which was included in Mulroy Environmental's Interim Report (277.29.09.17) is consistent with Figure 1 dated 27-11-17. The coordinates for gas wells GAS03 & GAS04 are located in Appendix 5. Mulroy Environmental will correct the coordinates for GAS03 & GAS04 in the final report also; and**
- **Mulroy Environmental can confirm that no residences will be or have been developed on waste within the site. Please find a letter from Homebond Building Control Ltd. in relation to the foundation inspections at residences Nos. 27 – 35, Hamilton Hill, Barnageeragh Cove, Skerries (see Appendix 6). The document states *'The ground encountered was sand clay with no foreign material observed'*. In addition, please find a letter in Appendix 6 from Duffy Chartered Engineers (DCE) in relation to residences Nos. 25 & 26 stating *'No foreign material was observed on the footprint of these houses. The piles where installed into a sand / clay material.''***

2.11 Gas; Gas cut-off wall:

The detail on the drawing 13-157-C609 for the cut-off trench does not detail the vertical vents which are included in the sketch in the ME report (Plate 10). The use of a GCL in the vertical trench should be reconsidered. A more appropriate barrier would be HDPE or LLDPE. The depth of the trench needs to be considered. The detail in the drawing and report states the trench will be approx. 4m deep. With a waste body that is considerably deeper and a sand/gravel Memorandum Page: 4 of 5 layer underlying the site, the trench should probably extend to the summer GW level as a minimum or bedrock. In the CSM the trench is shown to terminate at the interface between the sand/gravel and bedrock.

Action: *Mulroy Environmental agreed GCL was not appropriate and will revise design accordingly. Details of vents and surface of trench to be reviewed. Depth of trench will be reconsidered by Mulroy Environmental in light of these comments.*

With regard to the above, we would state the following:

It is agreed that a HDPE or LLDPE barrier will be used in the cut off trench. Details of both horizontal and vertical venting will be provided as part of the proposed design for the landfill gas cut off trench.

The trial pit investigation that was carried out on the 2nd June 2017 & 11th August 2017, indicated that the overburden in the vicinity of trialpits METP32 – METP34 & METP39 – METP47 (i.e. to the north of the waste body and builders compound) which are at approximately 15.9m AOD consists of the following:

As can be seen from Table 2 above, the groundwater table was identified at 2.60m BGL in BH13 (i.e. approximately 13.3m AOD). In order to intercept potential landfill gas migrating in a northerly direction, the proposed cut off trench will be extended to a depth of 4mBGL (11.9m AOD). It should be noted that landfill gas migration via overburden/subsoil is significantly higher than landfill gas migration via groundwater. As such, it is not necessary for the landfill gas cut off trench to extent to the depth of the underlying bedrock. Please note that a geophysical survey was carried out on 24th of November 2017. During the site investigation exercise the bedrock in the area proposed for commercial development was found at approximately 4.5m BGL. It is expected that a more accurate representation of the bedrock profile will be achieved following correlation between the site investigation findings and the geophysical survey. This information will be used to amend the cross-section drawings and CSM drawings if necessary.

With regard to the depth of the landfill gas cut off trench to the east and north east of the waste body, Mulroy Environmental have delineated the extent of this waste which correlates reasonably closely with the footprint of the former sand and gravel pit as per 25'' historical ordnance survey mapping. It is proposed that the landfill gas cut-off trench in this area is positioned at the edge of the former sand and gravel pit. It is proposed that the landfill gas cut off trench extends to 4.0m BGL into the indigenous soils which consists primarily of sands and gravels. It should be noted at this moment in time, 6 rounds of landfill gas monitoring have been carried out on the original boreholes that were installed in June 2017 (i.e. BH1 – BH7 & GAS01 – GAS04). For those wells located in closest proximity to the housing development (i.e. BH2, BH3 & BH5 which are located inside the waste body & GAS01

– GAS04 which are located outside the waste body & adjacent to the south / south-western boundary of residences No.25 – 34), it should be noted a concentration of 0.3% methane was recorded in BH2 on one occasion with 0% methane recorded across these 7 wells / 6 monitoring rounds on all other occasions (see Tables A3.1 & A3.2 in Appendix 3 & Figure 2). The landfill gas monitoring results obtained to date indicate that the risk posed by the north-western area of the waste body is at a lower level than that risk posed by the waste in the vicinity of BH1 and the waste to the south / south west of BH4. It is the opinion of Mulroy Environmental that the specification for the proposed landfill gas cut off trench (i.e. in particular the depth proposed) for the north-western area is proportionate given the results of the risk assessment to date.

It is proposed that further landfill gas monitoring wells are installed outside the north-western portion of the cut off trench. In order to determine if landfill gas is migrating under the cut off trench it is proposed that the depth of these landfill gas monitoring wells is at least 8mBGL. It is also proposed that these gas monitoring wells are spaced approximately 15m in distance apart.

FCC/RPS Comment:

- It is noted that the Geophysical Survey Results will be used to inform revision of the Cross Section Drawings and Conceptual Site Models.
- It is not clear from the above what depth is being proposed for the PVT in the Northwestern / western portion of the site.
- It is noted that the details of the proposed PVT are still outstanding.
- Re. BH4; there have been very high methane readings at this borehole, whereas there is very low methane readings in neighbouring boreholes. Does this suggest a localized source in this area? Will the geophysical survey help identify a localized source? If there is a localized pocket is there further mitigation measures to be considered in this area?
- Has Mulroy Environmental an opinion on why BH4 has consistently shown elevated methane levels and with this consistency is Mulroy Environmental satisfied that the extent of the waste boundary in this area is correct?
- Is Mulroy Environmental satisfied that 4m is sufficient depth in the north and northeast considering trial pit excavations terminated in waste material and before reaching indigenous soils in this area?

Mulroy Environmental / Winsac Ltd Response:

- **It is plausible that a localized source is contributing to the elevated methane levels in BH4. The geophysical survey indicates that domestic waste extends to a depth of 7.5m BGL (11.5m AOD) in the construction compound area (see resistivity profile R4 in geophysical survey). This domestic waste type material does not appear to extend as far as BH4. However, it is the understanding of Mulroy Environmental that the toilets located within the site compound were discharging to an on-site septic tank. It is understood that the contents of the septic tank were removed in December 2017 and the septic tank was decommissioned. To date a minimum of 6 rounds of landfill gas monitoring has been conducted for each well on site as is consistent with CIRIA C665 (see final 3 gas monitoring rounds in Appendix 7). However, Mulroy Environmental propose to carry out**

additional rounds of gas monitoring on BH4 over the coming weeks to ascertain if the decommissioning of the septic tank has resulted in a reduction in the CH_4 levels in the borehole;

- **Mulroy Environmental are satisfied that the position of the northern waste boundary delineated on Figure 1 dated 27-11-17 is the correct boundary for the waste body. In addition, the resistivity profiles (R3 & R4) from the geophysical survey indicate an absence of municipal waste with high organic and / or metallic content in the area to the north of the site compound and within the vicinity of BH4, BH 8 – BH12; and**
- **Trialpits TP24, TP25, TP26 & TP27 were excavated to the north / north east of the waste boundary / construction compound. Each of these trialpits were excavated to 3.5m – 3.6m BGL with no waste identified within. In addition, the resistivity profile R3 contained within the geophysical survey indicates that municipal waste with high organic and/or metallic content was not present to the north / north eastern waste boundary.**

2.12 Methane:

Fingal County Council stated that locating a petrol station adjacent to the waste body is a particular concern. Fingal County Council are concerned that although a petrol station would be ATEX rated, the likelihood of methane gases being above the LEL, is a key concern. Capping the waste body (which is passively venting) may force gas in other directions. The cut-off trench is not proposed on the western, southern or eastern sides of the waste body where there are houses planned (west), there is a foul main and railway line (south) and the WWTP is operational (east).

Action: *Mulroy Environmental are committed to extending the proposed length of the passive venting trench along the western side of the waste body where a pocket of houses are currently under construction. Additional landfill gas monitoring boreholes will be placed between the waste body and the pocket of houses under construction. There is a commitment to ongoing landfill gas monitoring. There will be a review of whether the Card Wilson risk assessment approach is appropriate to Barnageeragh and whether the proposed responses are adequate to deal with risks identified. Additionally, consideration needs to be given to extending passive venting trench south of the new houses (situated to SW of waste body) and parallel to the sewer line. A monitoring programme should be implemented to ensure that the mitigation measures are working.*

With regard to the above, we would state the following:

Please find attached Figure 1 which details the positioning of the proposed landfill gas cut off trench. Figure 1 illustrates the position of the cut off trench around the periphery of the landfill body. As can be seen from Figure 1, it is necessary to terminate the cut off trench 5m from the centre line of the rising sewer main in order to ensure that no damage occurs during the construction of the trench.

Mulroy Environmental will continue to monitor the landfill gas in all boreholes on-site until a minimum of 6 gas monitoring rounds has been conducted on each well. At present 3 more rounds of monitoring are required for boreholes BH8 – BH13. This will require sampling rounds during times of high and low atmospheric pressure. In addition, gas monitoring during periods of low pressure is also required for wells BH1 – BH7 & GAS01 – GAS04.

As stated in section 2.2.10, it is proposed that further landfill gas monitoring wells are installed outside the north-western portion of the cut off trench. The purpose of these wells is to ensure the effectiveness of the landfill gas cut of trench intercepting any landfill gas which may be migrating from the waste body. It is proposed that wells are monitored for a certain time period after the installation of the cut off trench. It should be noted that it is also intended to monitor the vertical vent stacks within the landfill gas cut off trench and the radon sumps for each housing blocks to the northwest and the north of the waste body.

Mulroy Environmental will review the appropriateness of the Modified Wilson & Card Classification for the development. Mulroy Environmental will also review the NHBC classification (i.e. Situation B in Ciria C665) when developing the final risk assessment report. It should be noted that an underfloor ventilation void has been constructed for houses Nos. 25 & 26 (i.e. houses in closest proximity to waste body) and therefore the NHBC classification system is more appropriate when conducting a risk assessment for those houses in particular.

FCC/RPS Comment:

- Noted. See comments from 2.2.10 above.
- Is Mulroy Environmental satisfied that no gas monitoring is required north of the PVT at BH10?

Mulroy Environmental / Winsac Ltd Response:

- **It is proposed that a number of shallow landfill gas wells will be installed to the northeast of the PVT (i.e. following its completion). The purpose of these wells is to confirm the effectiveness of the PVT in preventing landfill gas migrating in a north easterly direction towards the commercial zoned area and in a north-westerly direction towards the residences (i.e. Nos 25 & 26).**

2.13 H2S:

The monitoring only detected H2S on two occasions and to a maximum reading of 3ppm, albeit in the gas wells adjacent to the house. Below these levels there would possibly be an odour but nothing too concerning. If the venting trench is extended deep enough to capture fugitive emissions any H2S will vent with the other LFG to atmosphere for dispersal. They should not have any services passing through the waste body and/or manholes thereby reducing any risk of fugitive emissions. If H2S becomes an issue then other passive or active systems could be looked at to reduce the impact.

Action: *Design of passive venting trench to consider the above comments. Mulroy Environmental committed to further rounds of monitoring for this parameter. To include further monitoring in houses and services and to record and report results in report. These results to be included in Landfill Gas Risk Assessment. Mulroy undertook to establish if radon barrier / protection measures are in place in houses.*

With regard to the above, we would state the following:

Mulroy Environmental can confirm that H_2S gas will continue to be monitored in the deep boreholes, shallow gas wells, radon sumps, services and the landfill gas cut off trench vertical vent stacks during the subsequent gas

monitoring rounds. It also proposed to carry out interior gas surveys off house Nos. 25, 26, 52 & 53 (i.e. houses in closest proximity to the landfill waste body). This will involve 28-day diffusion monitoring for speciated VOCs, H_2S, CH_4 and CO_2 at three locations within each residence. This data will be incorporated into the final risk assessment report.

Mulroy Environmental understand that a Visqueen High Performance Radon Membrane™ was used in the construction of the houses at Barnageeragh Cove. It is understood that this specification of membrane is not equivalent to the specification provided by the Visqueen Gas Barrier or Visqueen Low Permeability Gas Membrane (see Appendix 4).

FCC/RPS Comment:

- Commitment to diffusion monitoring noted – Is there a role for trace element analysis here? Are Mulroy Environmental satisfied that the number of houses being monitored, and type of monitoring being undertaken: is sufficient.
- There should be Risk Assessment of the levels of H2S found in Boreholes / Houses / Sumps / Services. i.e. results have been presented but no interpretation or risk assessment provided for this parameter. To be included in SI and ERA report.
- Will services pass through pathway of proposed PVT? What measure to protect from providing a pathway for landfill gas prevention.

Mulroy Environmental / Winsac Ltd Response:

- **During the initial indoor gas assessment, four houses were selected given their proximity to the waste (i.e. residence Nos. 25, 26, 52 & 53). Please note that residence No. 26 was not surveyed with the other 3 houses on the 15th, due to a bereavement within the family on the morning of the survey.**
- **Please note that both arsenic and mercury have been analysed by Odour Monitoring Ireland in residence Nos. 25, 52 & 53 during the indoor gas survey;**
- **Please note, that a primary purpose of the indoor gas survey is to assess the risk from H_2S to residences in an indoor environment (i.e. receptors); and**
- **Please note that there are storm water sewers which will intersect with the proposed PVT (see location on Figure 4). It is proposed that where the storm water sewers intersect the PVT, that sealing is put in place to prevent the transfer of any landfill gas outside the PVT along the route of the storm sewers (i.e. landfill gas migrating along the fill material as a preferential pathway).**

2.14 Risk Assessment Table – Surface Water:

The risk assessments in the report detailing linkages without and then with mitigation measures in Tables 10 and 11, were discussed. It was observed that a number of "potentially complete" linkages remain even after the implementation of the proposed mitigation measures, with regard to some of these remaining "potentially complete" linkages the following issues were discussed: Table 11 (page 51) Direct surface water bodies to the north and east of the waste body: The report identifies that the linkage remains potentially complete as "impact on the stream is expected to be low and contact between landfill body and surface water body is not proven". It was recommended to collect surface water quality samples from the relevant surface water body (bodies), from

locations both upstream and downstream of any groundwater baseflow contribution from the site, to provide data which might further clarify this potential linkage.

Action: *Mulroy Environmental committed to sampling surface water to clarify this.*

With regard to the above, we would state the following:

Mulroy Environmental will take surface water samples both upstream and downstream of the adjacent stream in order to assess the potentially complete pollutant linkage between the waste body (i.e. source) and stream (i.e. receptor). Please find attached Figure 3 which shows the location of the proposed upgradient and downgradient surface water monitoring points. It is proposed to take the upgradient sample to the south of the Belfast – Dublin railway line, 5 – 10m to the south of the where the stream is culverted underneath the railway line. It is proposed to take 2 downgradient samples. One sample will be taken from a storm water manhole to the north east of the site with the other downgradient surface water sample taken from a storm water manhole to the north west of the site.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Please note that Mulroy Environmental carried out the surface water monitoring at the 3 sampling locations mentioned previously, on the 11th of January 2018. We are currently awaiting the results of this analysis.**

2.15 Risk Assessment Table – Landfill Gas:

Table 11 (page 53) Residents of newly built residences to northwest, north and north of road: The report identifies that the linkage remains potentially complete as "no underground services in proximity of waste body with exception of foul rising main running to the south and north". This suggests that the foul rising main remains a potential migration pathway for gas. This remaining potential linkage appears significant and should be considered further regarding potential additional mitigation measures. Table 11 (page 53) Operatives on WWTP to the southeast of the site: The report identifies that the linkage remains potentially complete and that this should be "investigated further in consultation with Fingal CC". The statement that something requires further investigation obviously suggests that further work is required to close this out, this should be closed out as part of this report. We understand that Fingal CC have provided details of the engineering design of the pipeline and the associated gas protection put in place to Mulroy, which may assist with progressing this aspect.

Action: *Mulroy Environmental committed to reviewing this information and revising risk assessment, if appropriate – See also 11.*

With regard to the above, we would state the following:

In order to determine if the foul rising main is acting as a pathway (i.e. a path of least resistance) for landfill gas migrating from the waste body in either a north western (i.e. towards the residence) or in a south-eastern direction (i.e. towards the Waste Water Treatment Plant (WWTP)) it is proposed to carryout a local gas probe survey within a 5m buffer of the foul rising main. This gas probe survey will entail the drilling of shallow boreholes (i.e. 1-inch diameter and 1.2m in depth) using an electric Hilti drill. Following this, 0.75-inch perforated uPVC piping is inserted into each borehole with the end sealed until measurement is carried out. These holes will be assessed for landfill gas levels approximately 2 hours after their installation. Mulroy Environmental will review gas protection measures put in place during the construction of the pipeline.

FCC/RPS Comment:

- Noted

Mulroy Environmental / Winsac Ltd Response:

- **Noted.**

If you have any questions or require clarification with regard to any item of this report, Mulroy Environmental can be contacted at 042-9384750.

Yours sincerely,

Patrick McCabe

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Draft Notes from Meeting on Environmental Risk Assessment – Site Investigations in Barnageeragh.

Location: Room 2A2, County Hall, Swords, County Dublin.

Date and Time: 21/03/2018; 14:00-17:00.

In Attendance:

Fingal County Council (FCC): Gilbert Power (GP), John Daly (JD), James Walls (JW) and Mortimer Loftus (ML).

RPS: Conrad Wilson (CW) and Paul Heaney (PH).

Mulroy Environmental (ME): Padraic Mulroy (PM) and Patrick McCabe (PMc).

HUCT: Peter Conroy (PC).

Winsac Ltd: (WL): Bernie Carroll (BC) and Malachy Clarke (MC).

1. Background:

On the 10th of October 2017, representatives of Fingal County Council, RPS Consulting Engineers and Mulroy Environmental attended a technical review meeting at County Hall, Swords, Co. Dublin to discuss the contents of Mulroy Environmental's Phase II Site Investigation Interim Report on Barnageeragh (277.29.08.17) which was submitted on the 29th August 2017.

Following this meeting, minutes were compiled by FCC and circulated to attendees on the 23rd of October 2017. Mulroy Environmental reviewed the contents of the minutes including the actions outlined within and responded with their client's (Winsac Limited) comments and commitments (Ref: 282.28.11.17).

On the 9th January 2018, Fingal County Council / RPS responded with further comments. On 23/1/2018, a reply prepared on behalf of Winsac Ltd. was prepared by Mulroy Environmental to the aforementioned (Ref:293.23.01.18) and sent to Fingal County Council /RPS in advance of Meeting dated for 24/01/2018. The notes of meeting of 24-01-2018 – were circulated on 7/2/2018 - which included a series of actions required to progress site investigations.

Following further progress in site investigations a meeting was convened on 21/3/2018 in County Hall to review progress towards completion of Site Investigations / Environmental Risk Assessment. These are the notes from that meeting.

1.1 Introduction:

GP opened meeting and outlined that the purpose of the meeting was to get an update on progress of Site Investigations and to address issues raised to date through meeting of 24/01/2018.

He outlined that the format of the meeting would be as follows; (a) Groundwater, Detailed Quantitative Risk Assessment (b) Landfill Gas, trace element analysis and update on borehole monitoring (c) Surface Water (d) Waste / Soil, risk assessment (e) review of previous minutes and actions arising (f) Further work and Scheduling of next meeting.

GP invited PC to discuss the DQRA.

2.1 Groundwater.

PC gave a detailed account of the DQRA report *(Detailed Quantitative Risk Assessment of Barnageeragh Cove Landfill –February 2018)* which he authored. Initially he outlined the history of his appointment, the datasets which he was given by ME to develop his conceptual model and run the DQRA model Software (CONSIM). He described the details given to him to model the site's landfill (Source), the geology and quaternary geology (Pathway) and the Stream and Groundwater resource (Receptor).

He described the selection of substances of concern (SOC) and the modelling of trends in concentrations of (SOCs) over time frames 0.10 – 1,000 years at sensitive receptors. PC referenced the representativeness of the model by comparing modelled with actual results –concluding a reasonable agreement.

He described recommendations involving further monitoring to provide information to refine model and to test model over longer timeframe – Monitored Natural Attenuation (MNA).

PH led the discussions after PC's presentation and focused on the need to develop a case for MNA as being the most appropriate course of action for Barnageeragh (if PC believed this to be the most appropriate course of action moving forward, based on the model results) – to draw those elements together from the model, real site investigative results, GW Directive, national context etc. Actions outlined below were identified.

ACTIONS:

Without prejudice to what further / additional mitigation measures might be required. It was discussed at the meeting that PC would review the interim DQRA report provided, specifically with regards to the following aspects:

1. The stream surrounding the site has been identified as the primary receptor for the DQRA. It would be beneficial to include a cross section in the conceptual model section of the report to illustrate this and if possible to include some actual elevations (both groundwater and surface water) to demonstrate a hydraulic gradient from the groundwater to the surface water (i.e. demonstrate that they are in hydraulic continuity in both summer and winter; and that the stream is not perched above groundwater).
2. Consider inclusion within the report of a specific section which provides a compelling case (as articulated during meeting) to support the proposed MNA proposal (if you believe appropriate).
    a. In particular, address the issues which may conflict with an MNA approach (e.g. existence of waste below the groundwater table, direct discharge to groundwater,

hazardous substances, above EQS/DW standards, effect on receptors, long timescales, long duration period of monitoring, etc.).

b. Discuss why other remedial options are not justified or required.

3. Consider inclusion within the report comments regarding the predicted impact on groundwater quality on a more regional aquifer basis (as articulated in the meeting) e.g. with regard to the status of the groundwater body etc.
4. Consider including commentary in the report regarding the nature of the substances of concern. At the meeting it was articulated that these "contaminants" were not that harmful (i.e. not heavy hydrocarbons, etc.). Providing some more context around the toxicity of the predicted SOC may be beneficial in support of an MNA approach.
5. On numerous instances throughout the meeting it was articulated that the work which was completed was "worst case", "conservative" or would "over-estimate concentration". Where appropriate in the report it would be good to highlight this fact.
6. Consider taking this study to the next level. Now that the model has provided predictive concentrations in groundwater discharging to the identified surface water receptors, consider assessing:
    a. the loadings discharging to the receptors and
    b. the assimilative capacity of these receptors.

    Then based on these results comment on the implications…again, does this support an MNA approach or mean that an alternative remedial measure is required.
7. The surface water receptors ultimately discharge to the sea not far from the site, consider assessing the risk to the marine environment from the discharge of these streams to the sea. In order to demonstrate that this has been considered and (if appropriate) then dismissed as "no impact"…again supporting the MNA case.
8. Consider deriving target values and/or target observations for the proposed MNA approach, so that it can be "objectives based" and "measurable" (i.e. to demonstrate/confirm that in the future we are seeing results which are consistent with predicted concentrations, water quality is improving, there is no unexpected increase in substances of concern, there are no new substances of concern, etc.).
9. Review the need for any additional monitoring boreholes – particularly along the southern and south-eastern site boundaries [between BH2 and BH1; and between BH1 and BH7(no data); and between BH7(no data) and BH12]. If (as articulated at the meeting), that there is no access in this area and no space between the waste and the site boundary to install extra boreholes then comment on this in the report….as this may be something which would be identified as a gap in the future. If (as articulated at the meeting), that while there are a limited number of boreholes in these locations, it is believed that the groundwater migrating to the south and southeast of the waste body would be no different in water quality to that migrating northwards (as defined by the boreholes north of the waste body), then consider including this comment in the report and provide back-up support for this conclusion (e.g. trial pitting results, waste all very similar, waste not expected to be any different, etc.).
10. The report evaluates water quality at a representative location (BH4) which is approx. 10m from the boundary of the waste. There does not appear to be any comment in the report regarding groundwater quality at further away locations. It was articulated in the meeting that groundwater quality would improve further from the waste body, due to natural

attenuation, if this is the belief then inclusion of this comment in the report may be beneficial.

11. There were discussions regarding whether it may be beneficial to also look at modelling sulphate, as it had previously been detected at elevated concentrations. Although it was discussed that it may have a very similar Kd to the chloride which was modelled.

2.2 Landfill Gas.

Trace Element Analysis.

PM of ME gave an account of Odour Monitoring Irelands report ***"Occupational Monitoring of Headspace Air Within House No. 25, 26, 52 & 53 and Headspace Monitoring of Gas Well 1, Gas Well 2, Gas Well 3 and Gas Well 4 Located in Barnageeragh Cove, Skerries, Co. Dublin." – March 2018.***

Broadly speaking PM reported that there was no exceedances of Occupational Exposure Limits(OELs) for any parameters measured in any of the houses or Gas Wells monitored. There were measurements above the Level of Detection (LOD) for a number of parameters – but these were well below the OELs for these compounds.

PM advised that the parameter's measured above LOD were largely associated with finishings of the houses (paints, adhesives, plastic piping etc. and would reduce with time).

ML pointed out that Formaldehyde was the parameter that appeared at levels closest to it's OEL and contributed the highest scoring to the Examination of additive / cumulative effects. There was an error in the calculation of the "Examination of additive / cumulative effect" for Formaldehyde at House 26 Location 2 (Page 18) and the lab result for this parameter at House 26 Location 1 was mis-transcribed into table 3.8. An error was also noticed for calculation of Benzene concentration in Table 3.8. These errors have significant effects on the "Examination of additive / cumulative effect" score and need to be corrected and assessed in terms of Risk Assessment to Human Health.

JD along with CW and ML queried the use of OELs for residential buildings and also suggested referring to the literature on background levels for the parameters for which there were hits (E.G. Literature reviews by WHO etc.), to provide context for these readings.

CW and JD suggested follow up monitoring (25 & 26) and also choosing houses on site more distant from waste body for results comparison.

ACTION: ME to arrange for Corrections of Errors in Report, Include reference to Scientific literature on parameters where there were detections above LOD for context, arrange additional monitoring as discussed above.

ACTION: RPS review OMI report. (Note: At time of writing - RPS have reviewed OMI report and have made comments which should be considered – These are attached as an addendum to this document. ME can contact CW of RPS directly if they need further clarification on these comments).

Borehole Landfill Gas Monitoring.

PM and PMc provided an account of the Landfill gas monitoring on Gas Wells GS01-GS04 and BH1-BH14 from June 2017 – March 2018. High Methane readings at BH4, BH9, BH12, BH10, BH1 , BH8, BH7 and BH6 persist particularly at BH4, BH1, BH6 & BH7. However those boreholes closest to residences consistently return low methane values. The Card Wilson and Traffic Light Systems of Risk Classification have been assigned to each borehole. It was underlined that the report would need to elaborate on these two Risk Assessment methodologies and ties them into mitigation measures being proposed.

Discussion focused on mitigation measures (PM and PMC) proposed installation of deep passive venting wells (as had been installed in Churchtown Landfill Co. Donegal) adjacent to Methane Hotspots to see if they mitigate Methane Levels. Pictures and details circulated by PM (325mm Bore, 150mm pea gravel pack to 2.5m bgl. Backfill to 1m bgl, Bentonite grout 0-1m bgl and venting cowl. MC stated that access around these installations could be restricted. Following some discussion it was broadly agreed that this would be worth pursuing – without prejudice to what further / additional mitigation measures might be required.

ACTION: ME to continue monitoring., to elaborate on these two Risk Assessment methodologies and tie them into mitigation measures being proposed. ME to progress mitigation measures re Methane Hotspots – as discussed.

Landfill Gas Probe Survey.

PM and PMc provided an account of their Landfill Gas Probe Survey at temporary Monitoring Points (LF1-LF14) adjacent to Foul Sewer Rising Main to determine if the utility provided a preferential pathway for landfill gas migration along its corridor rendering the housing in the north west of site vulnerable to landfill gas migration. Results indicate no such pathway exists.

2.3 Surface Water:

As discussed under Groundwater – Given that the stream to north of site is considered the primary receptor in the groundwater DQRA it was agreed that further Surface Water Monitoring should be undertaken, to provide evidence in support of MNA proposal. Consideration to be given to results in the context of adjacent coastal waters as being designated as a Shellfish Protected Area.

ACTION: ME to consider whether SW1 is truly reflective of an "upstream" monitoring location or whether an alternative location can be selected which may be upstream of groundwater contribution to the south of the site. ME to complete additional monitoring round (SW1-3), results to be incorporated into DQRA (PC) and support for MNA proposal (if results apply). Consideration to be given to results in the context of adjacent coastal waters as being designated as a Shellfish Protected Area.

2.4 Soil / Waste Matrix:

ML said that a Risk Assessment should be conducted on soil/waste matrix as trial pit lab results had indicated hazardous levels of some parameters in approx. 10 of 40 samples taken. Risk Assessment to take into account Health Impacts of dermal contact and/or ingestion and propose corrective / mitigation measures.

ACTION: ME undertook to model this, Risk Assess and propose mitigation measures, where appropriate.

3.1 Notes from Meeting of 24/1/2018 and review of actions arising.

GP reviewed aloud the notes from previous meeting of 24/1/2018 – focusing on actions arising. Most actions arising from these notes had been addressed during the meeting. The following items, *inter alia*, need to be addressed in compiled ERA / SI report.

2.1 Basis For Building The Buildings Which Had Previously Been Delayed.

Action: (1) Mulroy Environmental committed to provide a log detailing the slit trench excavated on the 2nd June 2017 under the supervision of Eoin Halpin in the final site investigation / risk assessment report;

and

(2) Mulroy Environmental will include a section in the final site investigation / risk assessment report detailing the post site investigation monitoring programme (i.e. landfill gas and groundwater monitoring) and emergency response procedure outlining the actions to be taken should elevated landfill gas concentrations be detected in specific boreholes (i.e. GAS01 – GAS04).

2.2 Waste & Groundwater Table

It is noted that Further Geophysics survey report circulated just before meeting 21/03/2018 which needs appraisal.

Action: Mulroy Environmental committed to clarifying depth of waste / groundwater table in the vicinity of BH1/BH6 – through consultation with Geophysics Surveyors (APEX) on existing survey and further Runs / Geophysics Survey. Clarify and standardise use of strata terms throughout site investigation reports.

2.3 Seasonal groundwater level variations:

Action: Mulroy Environmental committed to clarify seasonal groundwater level variations, groundwater levels and flow directions through DQRA. Identify data gaps, if any, and obtain data as necessary.

2.4 Quantity of waste below groundwater table:

Action: Mulroy Environmental committed to clarify depth of waste / groundwater table in the BH1/BH6 area – through consultation with Geophysics Surveyors (APEX) on existing survey and further

Geophysics Survey.

2.5 Cross Section A-A': Waste and Other strata.
It is noted that revised AA Cross Section supplied before meeting 21/03/2018 but not in time for review. To be appraised.

Action: Mulroy Environmental to clarify depth of waste/groundwater table in the BH1/BH6 area – through consultation with Geophysics Surveyors (APEX) on existing survey and further Geophysics Survey. Cross-sections to be consistent with findings of trial pits, borehole logs and geophysics. Terminology used (Made Ground, Fill Material, C&D) should be explained through glossary and be consistent across all the reports comprising the site investigations (e.g. consistency between descriptions of strata in borehole logs, cross sectional drawings and geophysics reports.)

2.5.1 Waste Delineation (Plan):
Action: Mulroy Environmental will include additional Geophysics runs north of Houses 29-34 and east of Houses 25 & 26 to clarify the nature of the strata in the vicinity of these residences. Mulroy Environmental to consult Geophysics surveyors re interpretation of strata in the vicinity of BH9. Mulroy Environmental will correct the waste delineation maps accordingly.
As with section 2.5. terminology used in describing waste body in cross section the same applies in representing waste body in plan; (e.g. Made Ground, Fill Material, Domestic Waste, C&D etc.) should be explained through glossary and be consistent across all the reports comprising the site investigations (e.g. consistency between descriptions of strata in borehole logs, cross sectional drawings and geophysics reports.)
Careful review of trial pit logs and borehole logs needed to inform delineation of waste boundary (plan and cross sections).

2.6 Groundwater quality results: Arsenic and Mercury
Dealt with during meeting 21/3/2018.
2.7 "Recovering" Groundwater
Dealt with during meeting 21/3/2018.
2.8 Groundwater Quality Migration Off-site:
Dealt with during meeting 21/3/2018.
2.9 Groundwater Flow:
Dealt with during meeting 21/3/2018.
2.11 Gas; Gas cut-off wall:
Dealt with during meeting 21/3/2018.
2.12 Methane:
Dealt with during meeting 21/3/2018.
2.13 H2S:
Dealt with during meeting 21/3/2018.
2.14 Risk Assessment – Surface Water:
Dealt with during meeting 21/3/2018.
2.15 Risk Assessment Table – Landfill Gas:
Dealt with during meeting 21/3/2018.

4.0 Close:

GP closed meeting suggesting that notes from meeting to be circulated by FCC. ME to compile a draft ERA / SI report as a single reference source for extensive work conducted to date. ME to proceed with action items in notes. Set a date for next meeting.

ADDENDUM:

RPS COMMENTS ON OMI REPORT. "OCCUPATIONAL MONITORING OF HEADSPACE WITHIN HOUSE No. 25, 26, 52 & 53 AND HEADSPACE MONITORING OF GAS WELL1, GASS WELL 2, GAS WELL 3 AND GAS WELL 4 LOCATED IN BARNAGEERAGH COVE, SKERRIES, COUNTY DUBLIN.

"….

- I note that is it queried previously why the OEL data (typically used to determine workplace exposure over an 8-hour shift) are employed in a residence where 24 hour occupancy is assumed. In this regard, a better comparator would be the WHO Air Quality Guidelines. These are based on continuous exposure and offer a more stringent benchmark for determining health impacts at a residential property. For example the 8-hour OEL employed in the report for Formaldehyde is 0.26 mg/m^3 whereas the WHO guideline is 0.1 mg/m^3.
- The WHO indicate that there is no safe level for carcinogens such as Benzene and Arsenic. Benzene is picked up in significant quantities throughout the survey but is dismissed as it is below the OEL. As noted above, this is not a relevant level for determining health impact in a property. In the absence of a safe WHO level, the EU has set a limit of $0.005mg/m^3$ for benzene in ambient air (Irish Legislation S.I. 180 of 2011) – the levels detected in House 26 at Location 2 on the 14th February 2018 are ten times that limit ($0.059mg/m^3$) – this should be investigated.
- The report suggests that fresh paint and varnishes as re the main sources of the trace gases (benzene, toluene, etc.) - MSDS for the paints/varnishes should be reviewed to corroborate the findings that this is the main source of these gases.

I would consider the levels of the trace gases detected in a residential property to be a concern – both the types of gases and the levels detected. "

23/5/2018; Follow up to Minutes of Barnageeragh Site Investigation Meeting (21/3/2018).

By way of response to minutes of meeting of 21/3/2018 Peter Conroy,HUCT,(PC) emailed Paul Heaney (RPS) 10/5/2018 responding to actions items and comments raised therein. This communication focused on items relating to DQRA for Ground Water. Paul Heaney's (RPS) response to Peter Conroy is outlined below.

- Peter Conroy acknowledged that the comments we provided after the meeting (RPS email 28/03/18) accurately reflected the discussions held at the meeting.
- In the response provided by Peter (HUCT 10/05/18), he states that he agrees with all the comments that RPS provided and he has presented an approach to addressing each of the comments in turn. Peter also include an additional two comments relating to ammonia characterisation/modelling and additional borehole drilling/testing to which he also provides an approach to progressing.
- We suggest that further consideration be given to the following points:
    - **Remedial Strategy PH Item 2 & 8:** The response states that timelines will be established for the MNA strategy. It is also stated that chloride concentration peaks are expected to occur within 10 to 15 years. While the MNA monitoring timelines are not presented, as yet, it is worth noting that there may be a long term monitoring requirement associated with an MNA approach.
        - Who will be responsible for the implementation and costs of the on-going relatively long term water monitoring programme?
    - **Remedial Strategy PH Item 2 & 8:** The response suggests that "*Capping is not a desirable approach due to the potential to build up landfill gas pressure beneath the cap and result in undesirable sub-surface landfill gas migration*."
        - Have the hydrogeological implications (or advantages) of a capping layer been tested/modelled?
        - Is it required from a groundwater perspective?
        - Rather than dismissing it on a "gas" focussed basis it might be better to firstly address whether it is required or the benefit offered from a groundwater perspective.
    - **Remedial Strategy PH Item 2 & 8:** The response sets out a comprehensive approach to supporting an MNA remedial strategy and then to discussing other remedial strategy options. The EPA Code of Practice for Environmental Risk Assessment for Unregulated Waste Disposal Sites suggests an approach where, by default, the waste should be removed and that only where it can be demonstrated that an alternative solution provides "*greater protection to the environment and the health of the local population"* should the waste remain in place.
        - Is MNA the "best" remedial strategy?
        - Would it be acceptable to the EPA, given the CoP direction described above?
- The only other comment we would raise is that it appears that hydrogeological field investigations and data gathering is still on-going at site, on completion of the field programme there is still a significant amount of data analysis, modelling and result interpretation to complete. Can an estimate be provided of the likely completion of the DQRA, interpretation of the results and presentation of an appropriate remedial strategy (with adequate supporting information)?

Additionally, Mortimer Loftus (Fingal County Council), telephoned Mulroy Environmental , spoke to Patrick McCabe – 16/5/2018, seeking an update on other issues raised in the minutes of 21/3/2018. ML informed PMc that communications between PC and RPS should be circulated also to FCC. Please see comments below for action which are in addition to or in support of the actions itemised in the minutes of meeting of 21/3/2018.

Gas Venting Wells:
PMC explained that five gas venting wells have been installed WE11/5/2018 – 3 beside BH4 and 2 beside BH1. They have undertaken pre installation monitoring and are allowing a week for them to settle. They will begin post installation monitoring WE25/5/2018 and continue for a period through to site investigation completion - to determine effect.

Action: Proceed in timeframe indicated.
Question: Will there be monitoring of the venting wells?

Soil Sampling:
PMC advised that, in order to characterise source ammonia concentrations for revision of GW DQRA 10 samples were taken from the drill arisings (2 samples from different depths at each venting well). All five locations were within "Type 2" waste. PMC explained that ME intend to sample soil by trial pitting soil from the "Type 1" waste area also. Once samples taken all soil samples will be sent for laboratory analysis - WE25/5/2018.

Action: Proceed in timeframe indicated.

Additional Ground Water Wells:
PMC reported that Drilling of 3 no. additional groundwater monitoring boreholes along the eastern site boundary, commences 17/5/2018. These wells will have pump trial tests completed and sampling round completed by WE25/5/2018. Sample gone for laboratory analysis WE25/5/2018.

Action: Proceed in timeframe indicated.

Topographic Survey of site boundary stream:

PMC stated that this will be undertaken during WE25/5/2018 when additional surface water quality monitoring round is to be undertaken. This will include taking an upstream sampling point south of the railway line. Sample for laboratory Analysis before WE25/5/2018.

Action: Proceed in timeframe indicated.

DQRA and ERA Report Compilation
Once all of the data from the additional site investigations become available (WE8/6/2018) PC will progress the additional interpretative and DQRA work.

Action: Progress DQRA revision ASAP.
Action: It is noted that during meeting of 21/3/2018 it was indicated that the first draft of Site Investigation / ERA report would be issued by the end of June. Proceed to this deadline.

Trace Element Analysis.

PMC indicated that apart from some communication between ME and OMI (Brian Sheridan), he had no progress to report on Action Items, under this heading, cited in minutes of meeting of 21/3/2018. ML referred PMC to Action Items again and to RPS comments in Addendum to minutes – saying that there were issues raised which need to be considered. PMC asked if it would be ok for Brian Sheridan (OMI) to contact RPS directly to discuss.

Action: Refer to Action Items under this heading in Minutes of 21/3/2018 and make contact with RPS (through) Conrad Wilson if needing further clarification on their comments.

Soil / Waste Matrix - DQRA.
PMC indicated that the Risk Assessment of the waste body and its interaction vis a vis Human Contact (dermal contact / ingestion / inhalation) etc. had not yet been undertaken. PMC indicated that Padraic Mulroy has experience of this and that it is his intention to conduct the risk assessment.

Action: Refer to Action item under this heading in Minutes of 21/3/2018. This should proceed without delay.

Type	PH Item #	P. Heaney Comment (28/03/2018)	P. Conroy Comment (10/05/2018)
General	5	On numerous instances throughout the meeting it was articulated that the work which was completed was “worst case”, “conservative” or would “over-estimate concentration”. Where appropriate in the report it would be good to highlight this fact.	The conservative nature of the DQRA will be emphasised in the revised report.
Source Character-isation	4	Consider including commentary in the report regarding the nature of the substances of concern. At the meeting it was articulated that these “contaminants” where not that harmful (i.e. not heavy hydrocarbons, etc.). Providing some more context around the toxicity of the predicted SOC may be beneficial in support of an MNA approach.	Add text on SOC selection to say clearly that the selected SOCs are representative. • Include comments on relative levels of toxicity. Clarify that the other compounds (incl SO_4) do not need to be modelled because: • Their concentrations and attenuation properties (Kd) fall within the ranges of the SOCs modelled • As such, model predictions for additional compounds would fall within the ranges of peak concentrations, and minimum and maximum travel times already modelled. • As such, it is considered that the modelled SOCs represent a conservative, worst case scenario for the site. Carry out soil sampling to characterise soil ammonia concentrations in the waste body during the proposed gas venting drilling. • This will allow for an improved representation of ammonia in the DQRA compared to the current conservative representation based on a single high concentration of ammonia in a leachate sample, which may have had a significant component of ammonia from a recent, short-term septic tank discharging to the waste body that is now decommissioned. • Further characterisation of soil ammonia concentrations across the waste body may indicate that the ammonia source concentrations are lower than currently modelled, which would reduce the predicted impact of ammonia on groundwater. ○ The QRA will be re-run for ammonia once the waste-soil ammonia concentrations have been characterised in detail. ○ The modelled half-life for ammonia is 1 to 6 years based on UK guidance; however ammonia half lives as short as 13-days have been reported. As such, it is possible that the site specific half-life for ammonia could be significantly shorter than the range used in the QRA.
Modelling SO_4 in DQRA	11	There were discussions regarding whether it may be beneficial to also look at modelling sulphate, as it had previously been detected at elevated concentrations. Although it was discussed that it may have a very similar Kd to the chloride which was modelled.	
Ammonia Modelling in DQRA	n/a		

GW Pathway	9	Review the need for any additional monitoring boreholes – particularly along the southern and south-eastern site boundaries [between BH2 and BH1; and between BH1 and BH7(no data); and between BH7(no data) and BH12].
		If (as articulated at the meeting), that there is no access in this area and no space between the waste and the site boundary to install extra boreholes then comment on this in the report….as this may be something which would be identified as a gap in the future.
		If (as articulated at the meeting), that while there are a limited number of boreholes in these locations, it is believed that the groundwater migrating to the south and southeast of the waste body would be no different in water quality to that migrating northwards (as defined by the boreholes north of the waste body), then consider including this comment in the report and provide back-up support for this conclusion (e.g. trial pitting results, waste all very similar, waste not expected to be any different, etc.).
			Additional boreholes to monitor southerly and easterly groundwater flow paths:
			• A borehole has been proposed between BH7 & BH12 to be located as close to the stream and as far south as possible given the waste boundary and access restrictions.
			○ Update revised report to account for the new data.
			Additional clarifications (with relevant supporting material) to include in Report :
			• Physically there is no space to install MWs downgradient of the waste inside the site boundary to the south of the waste (i.e. between BH7 to BH1 to BH2). Waste is effectively up to site boundary in south and sewage main is an additional obstruction.
			• The Type 1 & Type 2 waste areas are considered to be largely homogeneous in themselves. This means that the waste encountered by infiltration feeding groundwater flowpaths heading east and south from the landfill area is considered to be the same as the waste encountered by infiltration feeding the flowpaths heading north past the existing groundwater monitoring wells. Hotspots of contaminated material different to the general waste types and that only occur in areas recharging eastern and/or southern flowpaths are not expected to occur.
			• Geological setting to east and south is considered to be similar to that investigated on site to the north of the landfill. GSI mapping shows the same subsoil body and bedrock underlying the whole area downgradient of the landfill to the stream discharge boundary to the north, east and south of the landfill area. As such, we expect the groundwater flow and contaminant transport conditions monitored in the existing boreholes on site to be representative of conditions along other flowpaths to the east and south where it is not possible to install monitoring wells.

GW Pathway	n/a		Two additional boreholes to be installed in the bedrock northeast of GW12 to further characterise the nature and extent of the potential sandstone bedrock preferential pathway. • Carry out pumping tests on the new MWs.

Type	PH Item #	P. Heaney Comment (28/03/2018)	P. Conroy Comment (10/05/2018)
Modelling Impact on GW in DQRA	10	The report evaluates water quality at a representative location (BH4) which is approx. 10m from the boundary of the waste. There does not appear to be any comment in the report regarding groundwater quality at further away locations. It was articulated in the meeting that groundwater quality would improve further from the waste body, due to natural attenuation, if this is the belief then inclusion of this comment in the report may be beneficial.	Additional discussion and modelling results to be presented on this issue in revised report.
GW Receptor	3	Consider inclusion within the report comments regarding the predicted impact on groundwater quality on a more regional aquifer basis (as articulated in the meeting) e.g. with regard to the status of the groundwater body etc.	Additional discussion to be included in the report on this issue. This will be in terms of assessment of the annual mean groundwater quality of the Groundwater Body in line with the GW Regs requirements, taking account of the observed groundwater contaminant concentrations at the site.

SW Receptor	1	The stream surrounding the site has been identified as the primary receptor for the DQRA.
		It would be beneficial to include a cross section in the conceptual model section of the report to illustrate this and if possible to include some actual elevations (both groundwater and surface water) to demonstrate a hydraulic gradient from the groundwater to the surface water
		(i.e. demonstrate that they are in hydraulic continuity in both summer and winter; and that the stream is not perched above groundwater).
			Clarify HCM with respect to the boundary stream as the groundwater discharge boundary for the site.
			• Add figure showing natural stream course (from 25" historical map) and current culverted stream course, overlaid on subsoil map and with GW elevations contours and stream invert & water elevations; and annotated to explain that groundwater discharges to the stream.
			• Add row to HCM table stating data on:
			  ○ Groundwater levels (winter & summer) adjacent to the boundary stream (BH14 levels, GW Contour elevations).
			  ○ Surface water elevation and stream invert elevation at SW2 & SW3 (& SW1 if available).
			  ▪ Additional topographic survey of stream invert and water level if necessary.
			  ○ Highlight that GW elevation > Surface water elevation and that hydraulic gradient is from the GW into the stream, such that the stream acts as a discharge boundary for the site.
			• **Add HCM Cross-Section in line with PH comment #1.**
			Follow-on that as a result groundwater contamination does not migrate offsite by the groundwater pathway because it discharges to the stream at the site boundary.
			• Note that along the southern boundary the groundwater will flow a short distance offsite, under the railway as far as the stream.

SW Receptor	6	Consider taking this study to the next level. Now that the model has provided predictive concentrations in groundwater discharging to the identified surface water receptors, consider assessing:
		a. the loadings discharging to the receptors and
		b. the assimilative capacity of these receptors.
		c. Then based on these results comment on the implications…
		  ○ again, does this support an MNA approach or mean that an alternative remedial measure is required.
			Quantify contaminant concentrations in the stream via the following steps:
			• Estimation of the magnitude of groundwater baseflow to the stream and the contaminant load discharged to the stream.
			  ○ Take account of data from new boreholes in assessing contribution from potential preferential sandstone pathway.
			• Modelling of the surface water body to determine the range of flow expected in the stream
			• Estimation of the final contaminant concentration in the stream following mixing and dilution.
			  ○ Potentially take account of ongoing nitrification of ammonia in the stream.
			• Compare estimated stream concentrations to relevant surface water quality EQSs.
			• Comment on how representative the estimated surface water contaminant concentrations are with respect to the observed concentrations from Surface Water Quality monitoring.
			• Follow on to estimate contaminant concentrations in stream at marine discharge – further dilution and nitrification (consider nitrates)
			  ○ Compare estimated concentrations to relevant marine EQSs.
			  ○ If necessary (i.e. if concs at outfall exceed any marine EQSs), proceed to estimation of final marine contaminant concentrations following mixing and dilution etc.
			Carry out the following additional investigations in support of the surface water assessment:
			• Establish an upstream surface water monitoring location if possible.
			• An additional round of surface water quality monitoring

SW Receptor	7	The surface water receptors ultimately discharge to the sea not far from the site, consider assessing the risk to the marine environment from the discharge of these streams to the sea. In order to demonstrate that this has been considered and (if appropriate) then dismissed as "no impact"…again supporting the MNA case.	

Type	PH Item #	P. Heaney Comment (28/03/2018)	P. Conroy Comment (10/05/2018)
Remedial Strategy	2	Consider inclusion within the report of a specific section which provides a compelling case (as articulated during meeting) to support the proposed MNA proposal (if you believe appropriate). a) In particular, address the issues which may conflict with an MNA approach (e.g. existence of waste below the groundwater table, direct discharge to groundwater, hazardous substances, above EQS/DW standards, effect on receptors, long timescales, long duration period of monitoring, etc.). b) Discuss why other remedial options are not justified or required.	Report Section on Monitored Natural Attenuation Remedial Strategy including: • Summarise contaminant source setting, i.e. existence of waste below the groundwater table, direct discharge to groundwater, hazardous substances, contaminant concentrations in groundwater above EQS/DW standards, effect on receptors. • Summarise natural attenuation processes which act on an ongoing basis to mitigate the groundwater contamination by o diminishing the source concentrations through leaching and biodegradation, o attenuating the contaminants as they migrate through the unsaturated zone (where present beneath waste) and saturated zone by retardation, dispersion, dilution and biodegradation o attenuating the contaminants following groundwater baseflow discharge to surface water by dilution and biodegradation • Set out timescales for measuring degree of natural attenuation of the contaminants: o Predicted trends in the QRA CONSIM model suggest that chloride and ammonia contaminant concentrations in groundwater will peak and then decline to background levels over an extended time period. o For chloride the peak is expected to occur approximately 10 years from now, based on current source contaminant concentrations and only taking account of contamination from the present day onwards. o **It is feasible therefore to monitor chloride trends over a moderate timescale to confirm the predicted occurrence of a peak and subsequent decline.** o **Criteria for evaluating success of the MNA regime would be that chloride concentrations peak within a 10 to 15 year period and decline steadily thereafter.** o Assuming that the observed chloride trends confirm the model predictions for chloride, the longer-term trends for ammonia attenuation would attain a greater degree of confidence. • Set out the proposed monitoring regime. o Contaminant migration is via the groundwater pathway to the site boundary stream, such that monitoring of groundwater quality in onsite boreholes downgradient of the waste and of surface water in the site boundary stream will provide representative data against which to measure the progress of natural attenuation. Discount other potential Remedial Strategies: • The observed contaminant source concentrations and the observed contaminant concentrations in groundwater and surface water are lower than those observed at numerous other unlined historical landfills across the country. o Many of these sites are in public ownership and form parts of EPA licensed landfill site (examples can be stated if required). o In all cases it is the experience of the authors that the unlined waste bodies have been left in situ and Monitored Natural Attenuation has been adopted as the remedial strategy. • Capping is not a desirable approach due to the potential to build up landfill gas pressure beneath the cap and result in undesirable sub-surface landfill gas migration.
Remedial Strategy	8	Consider deriving target values and/or target observations for the proposed MNA approach, so that it can be “objectives based” and “measurable” (i.e. to demonstrate/confirm that in the future we are seeing results which are consistent with predicted concentrations, water quality is improving, there is no unexpected increase in substances of concern, there are no new substances of concern, etc.).	

Notes from Meeting on Environmental Risk Assessment – Site Investigations in Barnageeragh

Location: Room 1.2, County Hall, Blanchardstown, Dublin 15.

Date and Time: 08/11/2018; 10:00-13.15.

In Attendance:

Fingal County Council (FCC): Gilbert Power, John Daly, James Walls and Yvonne Cannon.

RPS: Conrad Wilson and Paul Heaney

Mulroy Environmental (ME): Padraic Mulroy and Andrena Meegan

HUCT: Peter Conroy

Winsac Ltd: (WL): Bernie Carroll and Malachy Clarke

Notes taken by Yvonne Cannon

1. Introduction

Refer to Agenda and attachments circulated on 6th November 2018. The purpose of the meeting was to progress the following reports-

- Residential Development, Barnageeragh Cove, Skerries, Phase II Site Investigation/DQRA & Landfill Gas Survey, Final Report, August 2018; and
- Detailed Quantitative Risk Assessment of Barnageeragh Cove Landfill Response to Queries, August 2018, prepared by Peter Conroy.

2. Actions on Hydrogeological Risk Assessment Report with reference to notes from RPS dated 31/10/2018 (Agenda Item 2)

Number	Action	Person Responsible
1.	Include discussion of other options available for remediation of site	Mulroy Environmental
2.	Include discussion of impact of cap on groundwater level and any associated change in flow direction in and around the site	HUCT
3.	Confirm that any reduction in recharge to the site as a result of the cap is reflected in model output	HUCT
4.	Provide description of cap that is consistent throughout report	Mulroy Environmental
5.	Update groundwater section of Argentum Fox report	Argentum Fox

3. Actions on Landfill Gas with reference to notes from RPS email dated 8th August 2018 (Agenda Item 3)

Number	Action	Person Responsible

1.	Provide impact of cap on gas migration on the site and potential receptors	Mulroy Environmental
2.	Include septic tank and recent leak on rising main as possible sources of potential contamination on the site	Mulroy Environmental
3.	Table 11 checked by Mulroy Environmental, no errors found. RPS to revert with detail	RPS
4.	Provide explanation for increase in CH4 levels in BH11, BH12, BH15 & BH17	Mulroy Environmental Argentum Fox
5.	Review 30th July results, Houses 52-63	Mulroy Environmental Argentum Fox
6.	Update Argentum Fox Report having regard to further monitoring results & recent relevant gas and VOC issues raised	Mulroy Environmental/Argentum Fox

4. Actions on VOC monitoring with reference to notes from RPS email dated 24th October 2018 (Agenda Item 4)

Number	Action	Person Responsible
1.	Undertake a VOC survey in accordance with procedures outlined in the EPA Air Emissions Guidance Note #4 as recommended by RPS. Agree approach of survey in advance with RPS. Mulroy Environmental noted that possibility of VOC's from landfill migrating to residential properties was not supported by LFG and VOC monitoring and modelling (incl. soil and groundwater tests).	Mulroy Environmental

5. Actions on Dermal Impacts –Open Space (Agenda Item 5)

Number	Action	Person Responsible
1.	Undertake a topsoil sampling programme to establish any risk of dermal contact within the common areas of the site. Winsac confirmed that 400-500mm of topsoil was used on open space. This material was sourced from stockpile of top soil from entire Barnageeragh Cove development.	Mulroy Environmental

6. Actions arising from Draft DQRA Report (Agenda Item 6)

Number	Action	Person Responsible
1.	Revise Executive Summary to reflect time-line of awareness of landfill adjacent to development. Correct inaccurate reference to historic landfill material being discovered in basement groundworks.	Mulroy Environmental

	Refer to Structural Engineer Report and Home Bond documentation.	
2	Photos taken of foundations of 25/26 in May 2017 to be sent to Mulroy Environmental.	FCC
2.	Undertake probe survey at WWTP	FCC Mulroy Environmental
3.	Review linkage tables in Section 13 of report	Mulroy Environmental
4.	Assess whether or not the sand and gravel layer is acting as a pathway for contaminant transport	Mulroy Environmental
5.	Include Mercury results in Summary of Results p. 59	Mulroy Environmental

Notes:

A. The RPS comment of 8th August 2018 states –

"Human health is not addressed. The peer review does make note that given the flow rates and the volumes of gases present there is a very low risk to receptors."

It was noted in the meeting that human health was addressed comprehensively in the Argentum Fox Report and the Odour Ireland Monitoring Report (Appendix 14).

B. The RPS comment of 8th August 2018 states –

"*The radon barrier should have been signed off by an architect or engineer under BC(A)R. FCC should request this documentation for information purposes*".

A sample Ancillary Certificate of Compliance for the '*provision of house sub-structure, drainage and ground works, site development works and general site services'* was tabled by Winsac. Note: this certification was undertaken on behalf of the builder and not by the Assigned Certifier for the purposes of compliance with Building Control Regulations (1997-2015).

Certificates of Compliance on Completion have been submitted to Fingal County Council in accordance with Building Control Regulations (1997-2015). The Certificate is a statutory document signed by the builder and the Assigned Certifier stating that the works have been carried out in compliance with the Building Regulations.

C. The e-mail from James Walls dated 2nd November 2018 regarding sample results from monitoring on the 30th October states –

"I note the significant increase in CH4 (and consequent reduction in N) at BH4. Any comments on this?"

Mulroy Environmental explained that this was seasonal and tabled a graph to demonstrate this.