Preesall Underground Gas Storage Facility, Lancashire

Re-determination of Application for Development Consent Order

Senergy (GB) Ltd Response to Issues raised related to their Independent Geological Assessment of the Proposed Preesall Gas Storage Site

29th October 2014

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Section A : Senergy (GB) Ltd Response to 'Halite Response to the "Independent Geological Assessment" by Senergy

(Document Reference H43 dated 10 September 2014)

Senergy (GB) Ltd (Senergy) has reviewed the subject document as presented by Berwin Leighton Paisner LLP on behalf of Halite Energy Group Limited (Halite) on 11 September 2014. Below are our comments and responses to the referenced document.

1 Overall

Having reviewed the subject report (H43) and comments contained therein, Senergy's view is that our overall technical approach and interpretation remains as presented in the Independent Geological Assessment report as issued on 25 July 2014. We have reviewed the major technical objections to our technical approach, assumptions, technical interpretations and results and consider them to be robust, technically defensible and according to standard, appropriate and best industry practices. We fully respect the opinions and comments presented by Halite in their responses to our independent geological Assessment of the proposed Preesall Underground Gas Storage Facility site in Lancashire and we note numerous areas where they agree with our Assessments and where Halite highlights some of these areas to support their application to develop the site.

We do not propose to issue a commentary or response to each individual point (or line item) noted by Halite since these are repeated in numerous places throughout their report (H43). Rather we present below our response on two broad fronts as follows:

1. Halite's use of our Assessment in support of their application.
2. High level comments on specific technical points raised by Halite regarding our approach to, and outcome of, our Assessment of the subsurface data presented to Senergy by Halite.

It is stressed that despite any comments or responses we provide herein, Senergy respects the right of Halite to use the Assessment to support their planning application or to disagree with our Assessment as they deem necessary and fit.

Senergy's opinion is that the key issues noted by Halite result from either an alternative reading and understanding of the words written by Senergy in our Assessment report, or differences of interpretation and technical approach to the available data. This is a common situation when dealing with the evaluation of subsurface data where by its nature the data can be:

- uncertain where available;
- cause extrapolation or interpolation issues where not available (which appears to be the case in a number of areas in respect of the Preesall data set) or;
- can be evaluated and interpreted using different technical approaches or techniques, all equally acceptable but which can result in differences of technical opinion and results. This is well illustrated in the Assessments of the Preesall geological and volumetric data by Halite and Senergy.

While there are numerous areas of common ground in the technical opinions expressed by Halite and Senergy, there are clearly differences of understanding and technical opinion which we address below.

2 Halite's use of Senergy's Assessment in Support of their Application

In section 1.2 on the subject report (H43), Halite note and consider that: "*The key findings from the Senergy Report provide confirmation of the following central matters in the redetermination of the DCO Application*". In addition, other comments in support of the application linked to these comments are contained in other parts of the report, principally in sections 1, 3 and 5. These are summarised as follows where considered germane to the discussion, with high level Senergy responses.

The Halite Views noted below are made with reference to the Senergy Report and these are commented on as appropriate.

2.1 Geology at Proposed Project Site

- **Halite** View: In section 1.2(a) Halite notes "*That the geology of the Project site is suitable for the type of gas storage proposed*".
- **Halite** View: in section 5.4.5 Halite notes "*on the basis of Senergy's Assessment, there can now be no serious question that the geology within the Planning Polygons is "suitable" (in the context of paragraph 2.8.9) for the type of storage facility proposed, i.e. storage in salt cavities*".
- **Senergy** Response: Senergy agrees that the geology at the proposed Project site is suitable for a gas storage project.

2.2 Scope of Proposed Project and Manner of Operation

- **Halite** View: in section 1.2 (b) Halite note "*That the geology can accommodate a very large underground gas storage facility, comprising 19 caverns, that can be operated on a fast cycle basis*"
- **Halite** View: in section 1.7, Halite notes "*Senergy agrees that fast cycling …. is entirely possible*"
- **Halite** View: in section 1.8, Halite notes "*The alternative working gas volumes proposed in the Senergy Report (base case static capacity of 203 Million sm^3 and effective annual capacity of 2434 Million sm^3)"*
- **Halite** View: in section 1.11, Halite notes "*it is of great significance that Senergy's Assessment of capacity is based on the Project being a* ***fast-cycle*** *facility*."
- **Halite** View: in section 1.15, Halite notes "*fast cycling facility, which Senergy has confirmed can be delivered*".
- **Halite** View: In section 5.4.5, Halite notes "o*n the basis of Senergy's Assessment, there can now be no serious question that the geology within the Planning Polygons is "suitable"…… all agree that the Preesall Halite could accommodate up to 19 caverns and could be operated as a fast cycle underground gas storage facility".*

- **Halite** View: In section 5.5.3, Halite notes "*Taking the Senergy Base Case of 203 Million sm^3, and on the basis of Senergy's conclusions on cycling, an effective annual capacity of 2434 Million sm^3, or 2.4 BCM, can be achieved*".
- **Halite** View: in section 5.5.31, Halite notes "*as a fast cycle facility, which Senergy accepts that it is*".
- **Halite** View: in section 5.5.34, Halite notes "*Senergy has perfectly properly assessed the Project as a fast cycle facility*".
- **Halite** View: in section 5.3.35, Halite notes "*it is of great significance that Senergy's Base Case Assessment of capacity is* ***based on the Project being a fast-cycle facility*****"**.

Senergy Responses

1. The geology at the proposed project site can accommodate a large underground gas storage facility. We cannot comment on its relative scale to other projects.
2. The proposed Project site can accommodate up to 19 caverns designed for gas storage.
3. Senergy did not assess the capability of the site to be operated on a fast cycle basis but only considered Total, Working and Cushion volumes of gas to be stored, with the working volume being assessed for one cycle only. Senergy did not evaluate cycling periods or annual Storage volumes. Any references to annual storage volumes attributed to Senergy in the Halite report (H43) have been calculated by Halite based on their assumption of annual cycles of injection and production. This will be further discussed in the next section of our response below.
4. Senergy did not explicitly state anywhere in their report that there is an annual working capacity of 2434 Million sm^3 - this is a number estimated by Halite based on our base case estimation of the working gas storage capacity of 203 Million sm^3 and using their Assessment of the number of annual cycles.
5. Senergy has not confirmed a fast cycling facility since we did not evaluate this - our Assessment was confined to Total, Working and Cushion gas volumes.
6. In our report, we noted the use of a 10-12 day withdrawal period (Executive Summary and Sections 4.1.1, 5.2 and 5.3) purely for illustrative purposes to compare daily extraction rates with those used by Halite (0.6-0.7 bscfd vs. 1 bscfd respectively). Note that in section 4.1.1, the daily withdrawal/injection rate of 1 bscfd for the 12 day period refers to the Halite proposed operational procedure and does not represent a Senergy view based on a detailed engineering Assessment of cycle periods.
7. With regard to fast cycle operations, Senergy (based on the report provided by independent geomechanics experts KBB) only commented (section 4.2 of the Independent Geological Assessment, July 2014) that fast cycling or a so called "*huff and puff*" operation is a "*relatively recent development*" for which there is little long term experience available.
8. Senergy did not assess fast cycling operations but confined their Assessment to static volumes.

2.3 Senergy Additional Comments on Volumes and Mode of Operation

This section is included here to provide an update on Senergy's position with respect to volumes and mode of operation of the project in light of additional information supplied (regarding volumes, please see section 3.2.1 of this report).

Static Working Volumes: In light of the additional information now available, Senergy has revised its Base Case volumetric calculation to reflect this additional information. In this revised analysis, caverns 1 and 4 are Type III with the rest being Type II. **This increases the working gas volume to 216.9 Million sm^3 (i.e. an increase of 7% compared to the earlier estimate of 202.8 Million sm^3)**.

Mode of Operation: The above comments regarding Fast Cycle Operations are presented to clarify the actual content of the original Senergy report. The following is our opinion in respect of the Mode of Operation of the proposed site - this was not included in our original report as it was not part of our remit but having reconsidered the issue feel able to provide a high level view on the topic.

In their review of the Geostock Geomechanical Study (H27: GKF0001 RevR/J/0001 RevA), KBB considers the ongoing work to be 'state of the art' (Section 5 in Appendix 1 of the Senergy report). However, they also note that although the calculated maximum pressure rate of 5 bar/d is relatively modest, the Geostock coupled thermo-mechanical analysis does show thermally induced fractures in a small zone up to 2m behind the cavern wall. They further say that if it cannot be proven that these fractures will not grow during operations and that the cavern contour stability and tightness is not impaired by this occurrence of thermally induced fractures, the permissible pressure rate (mainly the gas withdrawal rates) will have to be reduced, which will impair the maximum daily rate and not the overall working gas volume.

Notwithstanding this reservation, Senergy has retained the maximum pressure rate of 5 bar/d and the consequent 10 to 12 day period for injection or production of the full working volume assuming an average rate during this period in each cavern. Thus Senergy agrees with Halite that 12, approximately 30 day cycles are possible throughout the year giving a maximum 'effective' working gas storage over a year of 12 times the nominal working gas storage for a single cycle.

Note that Senergy does not endorse the statements ascribed to it in Sections 2.1.24 and 2.3.2 of the Geological Technical Appendix of the Halite response (Report H43) nor does it agree that it has made 'an incorrect deduction' (as stated in Sections 2.2.6 and 4.1.18) in reducing the daily deliverable rate to reflect its reduced estimate of working gas volume. Based on Senergy's volumetric Assessment, to stay below the 5 bar/d pressure change, the daily injection or withdrawal rate based on a 10-12 day injection or withdrawal period at a uniform rate would be 18.1 to 21.7 Million sm^3/d (assuming Senergy's revised working volume estimate of 216.9 Million sm^3). The 32.4 Million sm^3/d rate quoted in Sections 2.1.24 and 2.3.2 is based on Halite's working capacity estimate of 324 Million sm^3 and a 10 day injection period. Injecting at a uniform rate of 32.4 Million sm^3/d with the Senergy now revised working volume of 216.9 Million sm^3 would result in a pressure change of ~7.5 bar/d which significantly exceeds the maximum recommended rate of 5 bar/d - see Geostock Geomechanical Study (H27: GKF0001 RevR/J/0001 RevA).

Senergy thus recommends the determination be based on Senergy's revised base case estimate of nominal working gas volume for a single cycle of 216.9 Million sm^3 and annual working gas capacity of 12 times this value, i.e. 2602.8 Million sm^3. Senergy recognizes that there is uncertainty around this value with potential upside and downside but considers this a reasonable base case estimate given the current start-of-the-art in solution mining and the implementation of gas storage facilities of this nature.

2.4 Data Coverage

- **Halite** View: In section 1.2(C) Halite notes: "*that Halite has obtained a reasonable set of geological data, including seismic-reflection data".*
- **Halite** View*:* In section 3.5 Halite notes "A *significant volume of subsurface data has been acquired by Halite. The database of seismic lines provides reasonable data coverage within the Planning Polygons. The interpretation by Halite is valid and the conclusions are broadly acceptable (Sections 2.2.3, 2.3, 3.7 of the Senergy Report)".*
- **Halite** View: In section 5.4.4, Halite notes "*In the light of Senergy's conclusions on data coverage, which accord with the position taken by Halite, there can now be no serious question that the totality of the geological data before the Secretary of State amounts to a "detailed geological assessment" for the purposes of paragraph 2.8.9 of National Policy Statement EN-4".*

Senergy Response

While Senergy agrees that there is a "reasonable" body of subsurface data available covering the proposed gas storage site (Sections 2.3 and 3.7 of the Senergy report), and that the interpretations by Halite are broadly acceptable (section 3.7 of the Senergy report), there are a number of areas of concern raised by Senergy related to data coverage and the geological model. These would tend to question the validity of the phrase "*totality of the geological data*". These issues are as follows:

1. **Seismic Coverage**:

   a) Strike Line: Senergy noted in section 2.3 of their report that it would have been preferable to have a second strike line to supplement the single strike line (HEG-13-08).This would have allowed a better assessment of the Base Salt seismic pick.

   b) Southern Polygon: Senergy noted in section 2.3 of their report that a gap of 550 m exists between seismic lines HEG-13-01 and HEG-13-02 due to access issues. However, this increases the uncertainty related to caverns 17 and 18 in terms of the current Assessment and future data acquisition.

2. **Well data**:

   In section 2.2.3 of the Senergy report, we note that of the two recent wells, only two penetrate the Base Salt and an additional data point would have been useful to reduce the uncertainty associated with this pick across the area. However, it is recognised that additional well penetrations may result in reduced site integrity or elimination of areas for storage caverns.

3 Senergy Response to Halite Technical Comments

Halite has noted that there are two particular areas of our geological Assessment with which they disagree. As noted in section 1 and repeated here for clarity, Senergy's opinion is that the key issues noted by Halite result from either an alternative reading and understanding of the words written by Senergy in our Assessment report, or differences of interpretation and technical approach to the available data. This is a common situation when dealing with the evaluation of subsurface data where by its nature the data can be:

- uncertain where available;
- cause extrapolation or interpolation issues where not available (which appears to be the case in a number of areas in respect of the Preesall dataset) or;
- can be evaluated and interpreted using different technical approaches or techniques, all equally acceptable but which can result in differences of technical opinion and results. This is well illustrated in the Assessments of the Preesall geological and volumetric data by Halite and Senergy.

The two key technical areas which Halite notes in section 4.3 of the subject report (H43) as having significant differences between their Assessment of the site and that of Senergy's are as follows:

1. **Senergy's Interpretation of the Base Salt seismic pick and depth**
2. **Senergy's Treatment of Uncertainty**

Senergy has reviewed these issues in light of the comments made by Halite in sections 4.5 - 4.17 and Section 3 of their Geological Technical Appendix and provide our responses below. It is not our intention to enter into a lengthy refutation or discussion on each and every point raised by Halite. Rather we refer to our comment above about how different, equally skilled, teams assessing the same subsurface data can arrive at different interpretations and conclusions, all of which can be equally valid within reason.

Where there are clear indications that we have made a mistake in our Assessment, we will correct this but our Assessment and interpretation of the data provided by Halite was based on our best technical understanding and geological judgment. However, our primary methodology was to assess the uncertainties associated with the data presented and interpret it accordingly. Our understanding is that Halite used a largely deterministic approach in their Assessment while Senergy used a stochastic methodology to assess ranges of volumes and probabilities of occurrence. This difference we consider lies at the root of the major technical differences between Halite and Senergy.

3.1 Senergy's Interpretation of Base Salt

3.1.1 Halite View

In the subject response report (H43), Halite provides a number of responses related to the issues they have with the Senergy approach to the Base Salt seismic pick. A summary of their key comments contained in sections 4.6 to 4.11 (and also in section 3.2 of the Geological Technical Appendix) is as follows:

Senergy Alternative Base Salt Seismic Pick: While noting that Senergy accepts the BGS Base Salt pick as being "not incorrect", Halite considers that another alternative higher pick used by Senergy as an alternative is in effect incorrect and only a "*partial pick*" and does not extend across the area (section 4.6).

BGS review of Senergy Base Salt Seismic pick: Halite note that the BGS has tried to pick this alternative event across the area (section 4.7) but they have concluded the Senergy pick is actually an interval of "muddier salt and thicker interbedded mudstones" and suggesting salt is present below this picked horizon. Further they note it is a partial pick which we assume means it cannot be mapped around the area.

Halite conclude Senergy has "incorrectly" picked this horizon as Base Salt that the Senergy pick is "not plausible" (section 4.8) and that this "misidentification of the Base Salt" (section 4.9) is the key reason Senergy's volumetric calculations are unduly pessimistic.

Senergy's Depth Conversion: Halite notes that Senergy has used a "theoretical, unexplained and inconsistent" approach to the depth conversion (section 4.11).

Senergy Error Range for Base Salt pick: Halite note (Geological Technical Appendix, section 2.1.8) that Senergy applied an error margin of 0% (at well ties) -12% (at the deepest part of the basin) to the Base Salt depth conversion but it is unclear how this was applied in the geological Assessment.

3.1.2 Senergy Response

Alternative Base Salt Seismic Pick*:* Senergy attempted to look at a range of possible interpretations of the Base Salt seismic pick due to the lack of well ties at Base Salt and also the poor seismic imaging of the section below the Top Salt, especially in the deeper parts of the basin. Senergy agrees that the BGS interpretation is valid but given the uncertain nature of the data, lack of well ties (only two for the Base Salt) and the poor seismic imaging, Senergy considers the BGS pick to be only one of a number of alternative interpretations, especially in areas away from the well ties in the centre of the basin. This alternative is thus considered to be a valid input to the uncertainty estimations, along with potentially deeper picks such as the BGS pick for Base Salt.

Well Ties: Senergy also consider that there is some uncertainty in tying the wells at the Base Salt the due to the nature of the seismic imaging below the Top Salt. Senergy consider the last good well ties are at the Top Salt, below which they become more uncertain.

BGS Review of Senergy Base Salt pick: Senergy has reviewed their Base Salt pick and interpretation in light of the comment in section 4.7 of the Halite report (H43) that the BGS Assessment of the higher Senergy pick is that it equates to a muddier salt and thicker interbedded mudstone and that salt is present below this horizon. Senergy is still of the opinion that their reported Base Salt pick represents a valid alternative to that selected by the BGS and that it represents a feasible alternative interpretation of the available data, particularly in the centre of the basin away from the well ties.

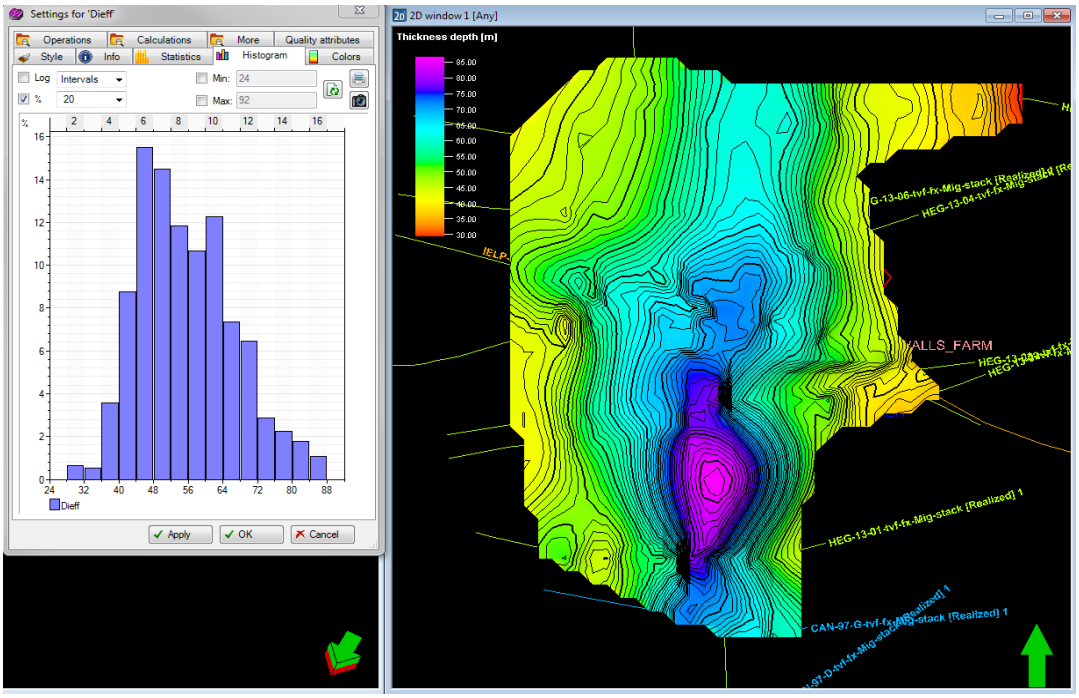
Senergy accepts that there are likely to be basin wide 'intra-salt mudstones' but they are not well visualized in the seismic in the basin centre and there is some uncertainty in exact picks. This uncertainty is not used in the volume calculation and has no impact on Senergy's range

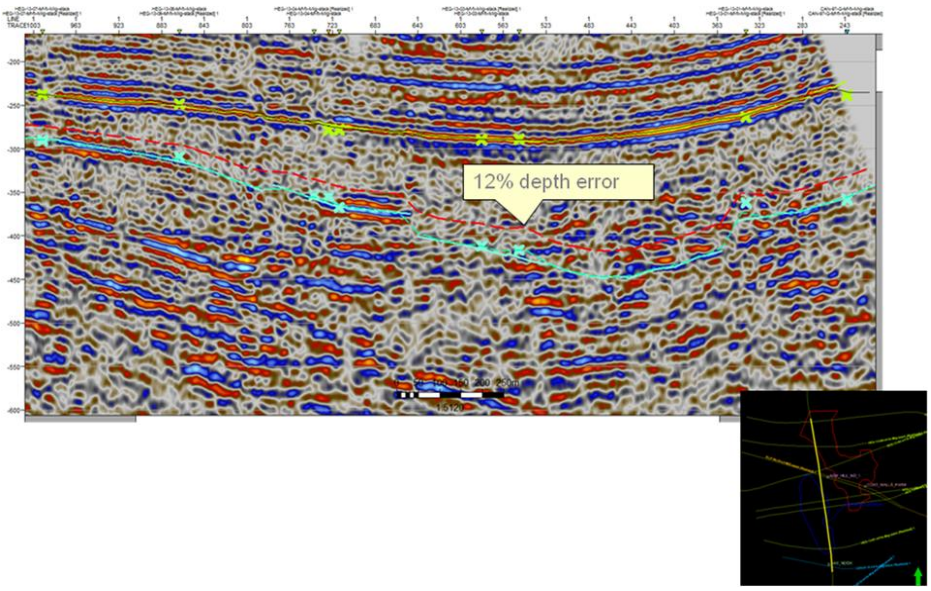
of capacity estimates; Senergy makes a clear differentiation between data uncertainty and interpretation uncertainty. Only the former was incorporated into the volume calculations.

Depth Conversion: Halite provided details regarding the depth conversion but despite Senergy requests, no information was provided on the error estimation for both the Top Salt and Base Salt depth calculations. This lack of data was noted in section 3.2.4 (Depth Conversion and Depth Uncertainty) and section 2.2.5.1 (Missing Data) of our report. Senergy agrees with the depth conversion for the Top Salt. However, while the Base Salt depths may be reasonably accurate at the well ties, Senergy note that these will become increasingly more uncertain with increasing distance from the well ties and this is reflected in the inputs to the Monte Carlo analysis. Senergy note that Halite has now provided the information on the depth conversion process in sections 3.2.9-3.2.17 of report H43. Upon review of these data, Senergy is still of the opinion that the methodology used by Senergy represents an acceptable interpretation of the available data.

Error Range on Base Salt pick: Senergy estimated the error in the depth conversion at the Base Salt pick as between 0% for areas close to well ties up to 12% plus or minus for areas away from well ties. Generally this equated to a 0% error at the margins of the basin to 12% at the deepest part of the basin which is mostly in the Western part of the area.

An image showing how this error range was estimated is shown on **Figures 1a and 1b** below.





Figures 1a and 1b: Selection of Error Range in Base Salt depth conversion

Based on this analysis Senergy considered how this uncertainty should be included in the Monte Carlo analysis and decided that a reasonable approach would be to use a ±12% uncertainty at the deepest BGS Base Salt pick and a zero uncertainty at the shallowest BGS Base Salt pick. The uncertainty at depths in between would be interpreted linearly. Based on the 19 cavern locations the shallowest Base Salt pick is 418 m below ground (cavern 1) and the deepest is 715 m (cavern 18).

3.2 Senergy's Treatment of Uncertainty

3.2.1 Halite View

Halite considers that Senergy has used an "*unduly pessimistic and arbitrary approach*" (section 4.12) in a number of key areas related to their geological evaluation of the uncertainties associated with the calculation of Total, Working and Cushion gas volumes associated with the Preesall gas storage project. In particular:

Cavern Size: Halite considers that Senergy has arbitrarily increased the separation between caverns and the heights of the caverns thus reducing the "*diameters of 13 caverns and the heights of all of them*"' (section 4.12.2) thereby reducing geometrical cavern volume by 21%.

In section 3.2.17 of the Halite Geological Technical Appendix (report H43), Halite note there are a number of "*inconsistencies and flaws/errors*" in the Senergy approach to how the uncertainty in the Base Salt pick has been included in the analysis.

Cavern Shape and other Miscellaneous Factors: Halite considers that Senergy used "*arbitrary factors and assumptions*" when assessing cavern shape factors such as insoluble content and rock mass density (section 4.12.3). In addition, Halite considers Senergy has used "*other miscellaneous factors on cavern volumes which are negative*" but that no details are presented (section 4.13).

Senergy's Monte Carlo Simulation: Halite considers that Senergy's Monte Carlo simulations use a "*range of parameters based on unjustified and pessimistic KBB recommendations*" (section 4.14). Halite further considers that the Base Salt location

parameters used are unduly pessimistic (section 4.15) and which are considered by Halite to be implausible as noted in section 4.16 of report H43 and discussed in section 3.1 of this report. Halite thus consider Senergy's Monte Carlo simulation results are "*unduly pessimistic*" and try to establish a minimum working capacity "*beyond reasonable doubt*" (Sections 4.16 and 4.17).

3.2.2 Senergy Response:

Cavern Size: Senergy used only the data uncertainty to calculate cavern sizes. The interpretations shown in our report merely served to illustrate the fact that Base Salt in the basin centre could have a range of seismic picks/depths.

The Base Salt pick uncertainty was utilised in the calculation of cavern volumes, and the table below (**Table 1**) shows how this was done for each cavern and confirms the range of zero to ±25% for salt thickness. The average of the numbers in the final column of the table works out at ±13%. This is further explanation of the statements in the Senergy report in Section 3.2.4 and Table 5.2, where the average salt thickness uncertainty is rounded to ±15% (*Note: in the Senergy report, the first row below the headings, final column: sand body thickness should read **salt** body thickness)*.

In their response to the Senergy report, Halite (Geological Technical Appendix Section 3.3.37, Report H43) appears to have misunderstood how the depth uncertainty has been applied in their cavern 9 example (Figure 3.6). As explained above and in the original Senergy report (Sections 3.2.4 and 5.2), the full ±12% uncertainty only applies at the deepest seismic pick/depth (715 m bg). The BGS Base Salt pick at cavern 9 is 557m bg so the uncertainty (by linear interpolation from zero at 418 m to ±12% at 715 m) is ±5.6%. Thus, the minimum seismic pick/depth used by Senergy at cavern 9 is 526 m and not 490 m as shown in Figure 3.6 of Halite's Geological Technical Appendix.

The various inputs to the volumetric calculation proposed by Geostock (H29: GKF/0/J/0003) were reviewed by KBB (Appendix 1 of Senergy report) and discussed at a meeting between Senergy and KBB on 26th June 2014. The outcome of the review and the decisions made regarding the values to be used for the various parameters in the Senergy base case volumetric calculation and the ranges to be used in the Monte Carlo analysis are summarised in Table 5.2 of the Senergy report.

As noted in Section 5.1 of the Senergy report, Senergy was able to reproduce the Geostock volumetric calculation. There were minor differences, but as explained in Section 5.1 these are relatively insignificant. All the parameters that went into the Geostock calculation have been retained by Senergy (Rows 1 to 17 below the headings in Table 5.2 of the Senergy report). Only one additional parameter has been introduced by Senergy. This is a multiplier on effective volume to reflect the possibility that some caverns may never be commissioned because of possible gas tightness issues or failure to achieve a seal at the final casing string. KBB estimate that statistically 1 or 2 caverns would fall into this category, so using a round number of 1 or 2 out of 19 we put the probability of failure at 5 to 10% (i.e. probability of success at 90 to 95%). For the Base Case, the estimate of effective volume for each cavern is multiplied by 0.925 to account for this, with a range of 0.9 to 0.95 used in the Monte Carlo analysis.

Cavern	Top salt	Base salt	Uncertainty	Minimum base	Maximum base	Salt thickness (m)	Minimum salt	Maximum salt	Variation in salt
1	328	418	0.0	418	418	91	91	91	0
2	348	522	4.2	500	544	174	152	196	13
3	320	429	0.4	427	431	108	106	110	2
4	334	456	1.5	449	463	122	115	129	6
5	347	510	3.7	491	529	163	144	182	12
6	350	541	5.0	514	568	191	164	218	14
7	375	593	7.1	551	635	218	176	260	19
8	339	569	6.1	535	604	230	195	265	15
9	346	557	5.6	526	588	211	180	242	15
10	302	419	0.0	418	419	117	116	117	0
11	331	442	1.0	437	446	111	107	115	4
12	355	542	5.0	515	569	187	160	214	15
13	352	533	4.7	508	558	181	157	206	14
14	380	581	6.6	543	619	200	162	239	19
15	354	535	4.7	510	561	182	156	207	14
16	395	673	10.3	604	742	278	209	348	25
17	372	633	8.7	578	689	261	206	316	21
18	377	715	12.0	629	800	338	252	423	25
19	347	666	10.0	599	733	319	253	386	21

Table 1: Evaluation of Effect of Uncertainty on Base Salt Pick at Individual Caverns

Cavern Shape, Miscellaneous Factors and Monte Carlo Simulation: It would appear from the Halite response that there is a genuine difference in view regarding the appropriate values to use for a number the parameters that go into the volumetric calculation. However, Senergy and KBB do not believe they have made any mistakes or errors, nor have they been arbitrary, in selecting the base values and uncertainty ranges for these parameters as indicated in columns 4 and 5 in Table 5.2 in the Senergy report.

(*Note that there is a typographical error in Appendix I, Section 3.3 of the Senergy report. The second sentence of the second paragraph should read "Due to the Assessment of Geostock in geomechanical study the minimum cavern pressure should be raised to 0.08 and 0.07 bars/m (type I and III caverns respectively)" rather than the other way around as originally issued).*

This error also occurs in the main Senergy report in Section 5.1 and Table 5.2, row 14 below headings. However, all the volumetric calculations are correct in this respect, i.e. the minimum pressure gradient is 0.08 bar/m for Type I caverns (although there aren't in fact any of these) and 0.07 bar/m for Type III caverns, with a value 0.06 bar/m for Type II caverns.

As explained in Section 5.1 and in Table 5.2 row 14 below headings of the Senergy report, the Senergy analysis of Type I caverns had a usable volume >750,000 m^3 and Type III caverns a usable volume <380,000m^3 with Type II all values in between. This was based on the first table in Section 1 (Executive Summary) of the Geostock Geomechanical Study (H27: GKF0001 RevR/J/0001 RevA). The minimum gradients noted above were taken from the table in Section 6 (Conclusions) of the same report.

In Section 3.3.18 of the Geological Technical Appendix of the Halite response (H43) the following statement is made: "*The minimum pressure gradient was set at 0.06bar/m for all caverns based on the geotechnical study performed by Geostock. This study concluded that the minimum pressure ranges from 0.06 to 0.08bar/m as follows:*

- *for the cavern geometry Type I (large cavern with a volume >750,000m^3 and an aspect ratio H/D >3) a minimum pressure gradient of 0.08bar/m can be applied.*
- *for the cavern geometry Type III (small cavern with a volume <380,000m^3 and an aspect ratio H/D of <0.8) a minimum pressure gradient of 0.7bar/m can be applied.*
- *for medium sized caverns, Type II (between Type I and Type III) a minimum pressure gradient of 0.06bar/m can be applied."*

This statement does not appear anywhere in the Geostock Geomechanical Study (H27: GKF0001 RevR/J/0001 RevA) and we are unaware of what report is being referred to as 'the geotechnical study performed by Geostock'. As noted above, the conditions regarding cavern volumes have been applied when assigning the minimum pressure gradient in the Senergy volumetric analysis (in the Base Case, caverns 9, 16 and 17 are Type II with the rest being Type III). However, we were unaware of the additional H/D qualification.

Senergy Revised Static Working Volume: In light of the additional information now available**,** Senergy has revised its base volumetric calculation to reflect this additional information. In this revised analysis caverns 1 and 4 are Type III with the rest being Type II. **This increases the working gas volume to 216.9 Million sm^3 (i.e. an increase of 7% compared to the earlier estimate of 202.8 Million sm^3).** The Monte Carlo analysis has now been revised to reflect this change and gives a 50% probability of achieving a static working

gas volume of 203.7 Million sm^3, a 90% probability of 134.6 Million sm^3 and a 10% probability of 285.5 Million sm^3. The cumulative probability distribution indicates that there is a 50.4% probability of achieving a static working gas volume of 200 Million sm^3 and a 5.8% probability of achieving a static working gas volume of 300 Million sm^3.

Section B : Senergy (GB) Ltd Response to Halite's Comments on First Round Representations prepared by Berwin Leighton Paisner LLP

(Document Reference H42 dated 10 September 2014)

Senergy (GB) Ltd (Senergy) have no comments to make on this report other than to note that all necessary responses to issues raised by the subject report (H42) have been addressed in our responses to the issues raised by Halite Energy Group Limited (Halite) in Section A above.

It is however noted that Halite make significant reference throughout the report to the "Statement of Common Ground" agreed with the Lancashire County council dated 1 June 2012. These references APPEAR to be used to support the current subsurface interpretation despite this agreement having been reached before the acquisition of further data which provided the basis for the updated subsurface evaluation reports H27A, H27B, H28, H29, H30 and The Senergy Independent Geological Assessment reports as noted in sections 1.6 and 1.8 of the subject report (H42).

Section C : Senergy (GB) Ltd Response to The Protect Wyre Group's Response to the "Independent Geological Assessment" by Senergy

(Letter dated 9 September 2014 signed by Mr. Ian Mulroy, Geological Report by Mr. Howard Phillips)

Senergy (GB) Ltd. has no comment to make on the subject report by Protect Wyre Group (PWG) other than to acknowledge the error on our maps where the Barnaby Sands area has been misnamed as the Burrows Marsh. However, this does not change our Assessment of the geological and volumetric data from the proposed Project site.

Section D : Senergy (GB) Ltd Response to Letter from Lancashire County Council's regarding the "Independent Geological Assessment" by Senergy

(Letter dated 11 September 2014 signed by Mr Stuart Perigo)

Senergy (GB) Ltd has no specific comments to make on the subject letter by Lancashire County Council (LCC). Senergy would agree with their observations from our report as follows:

1. The data coverage has been improved by the acquisition of additional seismic data
2. The geological model can be validated down to the Top of the Salt
3. There are concerns about the level of the Base of the Salt horizon and thus the thickness of the salt deposit in the deeper parts of the basin (to the west)
4. There is a lack of borehole data defining the Base of the Salt
5. The Base of the Salt is not adequately imaged on the new seismic
6. That if the Base of the Salt is shallower than currently mapped [by Halite], the capacity of the proposed facility may be affected because the volumetric calculations demonstrate a significant difference between what is proposed by Halite and what could be stored in the absence of a clearer understanding of the Base of the Salt and the salt thickness.

For clarification, Senergy would add the following:

a) **LCC** notes that they assess Senergy's report to state that "*The interpretation within the development polygons is speculative and unconstrained in the deeper parts of the salt basin*".

b) **Senergy** would like to clarify that these were NOT the views expressed or words (*speculative, unconstrained*) used in our report. To clarify, the following is an extract from the Executive Summary of the Senergy Independent Geological Assessment report which summarises our opinion: "*The key risk to the current development plan is that if Base Salt is any shallower than currently mapped, the cavern placement, size, and therefore capacity will be affected; up to 9 caverns lie within 10 m of the current Base Salt interpretation – variation of 10s to 100s metres depth along this horizon may be possible. The alternative scenarios presented by both this review and the Applicant need to form the foundation of a range of working models that better capture the uncertainty remaining in the subsurface description. This uncertainty in the geological data has been carried forward to the methodology applied within the Volumetric Capacity review. To reduce uncertainty around the Base Salt depth within the cavern development areas, it is necessary to have more Base Salt penetrations or seismic which better images the relevant horizons*".

7. Any remaining points raised in the LCC letter relating to the sufficiency of geological data, its interpretation or the capacity estimates for the proposed development have been addressed in our report or in Section A above being Senergy's response to the Halite Response designated Report H43.

Section E : Senergy (GB) Ltd Response to e-mail from Mr. B Bayley with comments on the "Independent Geological Assessment" by Senergy

(e-mail dated 31 July 2014)

Senergy (GB) Ltd has the following comments on the points raised in Mr. Bayley's e-mail as follows:

1. Disclaimer and Confidence in Senergy Report

Mr. Bayley's View: Mr. Bayley states that "*The introductory "sweep up" rider to the report which seeks to exclude liability for inaccuracy, omission etc renders the report worthless and undermines the whole purpose of such a report".* He further comments about the authors' lack of confidence in the report and asks if any of the report can be "*factually guaranteed*".

Senergy's Response: Disclaimer clauses such as that contained at the start of our report are almost universally common in engineering reports prepared for a third party. The onus of accountability for issues arising from use of such reports lies with the Duty Holder or Owners of the project. Senergy cannot be held accountable for the consequences of the execution and operation of the project since Senergy will have no involvement in same.

To the extent possible, and based on the data with which we were supplied, we have conducted the work according to best industry practices and taken reasonable care in addressing the issues associated with the data. As highlighted in our report there are a number of uncertainties with the subsurface interpretations but we are reasonably confident that our Assessment is as accurate and true to our understanding of the data we were presented as is possible at this time.

2. Unstable nature of caverns

Mr. Bayley's View: Mr. Bayley states: *"The report confirms the unstable nature of the caverns which should be sufficient evidence in itself to prevent the storage of explosive gases."*

Senergy's Response: It is not clear to Senergy where we state that the proposed gas storage caverns are unstable in nature. Reference is made to possible partial instability in older brine extraction caverns. However, as noted in section 4.4.1.1 of our report, the design and location of the new caverns will have a minimum distance between them and older caverns.

3. Comments 3, 4, 5 and 6: Senergy has no comment on these points since they did not form part of our remit in undertaking the Independent Geological Assessment.

Section F : Senergy (GB) Ltd Response to e-mail from Mr. E Greenwood with comments on the "Independent Geological Assessment" by Senergy

(e-mail dated 10 September 2014)

Mr. Greenwood notes that Senergy's volumetric assessments may be proven to be incorrect once "g*reater seismic detail is obtained*".

Senergy agrees with this comment.

Senergy has no other comment to make on any of the other issues noted by Mr. Greenwood as these appear to be for Halite to address.

Section G : Senergy (GB) Ltd Comments to Halite's Response to DECC Request for Information dated 15 October 2014

(Document Reference H44 dated 22 October 2014)

The Department of Energy and Climate Change (DECC) issued a letter to Halite Energy Group on 15th October 2014 requesting further information from them in respect of the following items in relation to Halite's application for a development consent for an underground gas storage facility at Preesall, Lancashire:

- the planned daily injection rate and withdrawal rate;
- the planned number of annual cycles;
- the anticipated static working volume and the anticipated annual volumes; and
- if different from that applied for, the size of the above ground infrastructure that would be required for a range of working volumes under the planned operating conditions (e.g. 600, 300, 200, 150, 100Mcm).

This request was in response to the letter from Lancashire Council referred to above in section D of this report (letter dated 11 September 2014 signed by Mr Stuart Perigo). Lancashire County Council asked if the project static working volumes were less than those proposed by Halite Energy Group (as per the "Independent Geological Assessment" by Senergy issued on 25 July 2014), would this result in lower daily injection and withdrawal rates leading to smaller surface facilities requirements, thereby reducing the "Visual Impact" of the surface facilities.

The Halite response was issued on 22 October by Mott Macdonald on behalf of Halite Energy Group Limited (document reference H44).

Senergy Comments on Document H44:

Planned daily injection rate and withdrawal rate:

a) Sections 1.1.1 and 1.1.5 of Document H44: Proposed Daily Injection Rate

- KBB did not suggest that Geostock's proposed injection rate of 32.4Mcm/day was "*moderate*" (or even "*modest*" as noted in section 5.6.10b in report H43). They only suggested the calculated pressure rates of "*about 5 bars/d in maximum are relatively moderate*".

- KBB further noted "*Required minimum cavern pressures maybe slightly higher than proposed by Geostock (as already indicated in the Geomechanical Study) in order to sustain long-term stability of the cavern contour*".
- **Senergy Comment:** Senergy cannot confirm nor deny that the proposed injection rate of 32.4 Mcm/day is reasonable, moderate or modest without further dynamic simulation work.

Planned number of annual cycles:

- Senergy has no comment on this

Anticipated static working volume and the anticipated annual volumes:

- Senergy has no comment on this

Size of the above ground infrastructure:

- *Section 4.1.1 of the Halite response (H44)* specifically states that Halite do not propose to reduce the daily injection and withdrawal rates volumes and pressures for the proposed site (though they may increase the number of annual cycles based on their geomechanical and dynamic analyses if static working volumes are lower than currently estimated) and concomitantly do not propose to reduce or amend the proposed size of the surface facilities
- Thus it is considered that the "Visual Impact" of the surface facilities will remain unchanged from the application for development consent submitted by Halite.