



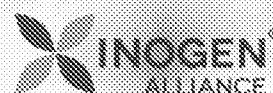
Foundation Works Risk Assessment

Oldlands Farm, Bognor Regis.

Presented to Lysander Associates

Issued: September 2021

Delta-Simons Project No. 20-1543.07



Report Details

Client	Lysander Associates
Report Title	Foundation Works Risk Assessment
Site Address	Oldlands Farm, Newlands Road, Bognor Regis, PO22 9NN
Project No.	20-1543.07
Report Date	September 2021
Delta-Simons Contact	David Josling (I [REDACTED])

Quality Assurance

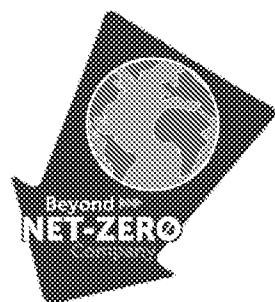
Issue No.	Status	Issue Date	Comments	Author	Technical Review	Authorised
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				Mark James Senior	David Josling Associate	David Josling Associate

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Appendix A Limitations

1.0 Introduction

1.1 Appointment

Delta-Simons Environmental Consultants Limited ("Delta-Simons") was instructed by Lysander Associates (the "Client") to prepare a Foundation Works Risk Assessment for Oldlands Farm, Newlands Road, Bognor Regis PO22 9NN (the "Site").

1.2 Context & Purpose

It is understood that the southern section of the Site is to be developed for the erection of a warehouse (Use Class B8) with ancillary office, associated vehicle parking, van storage, plant, ancillary structures, lighting, landscaping and infrastructure works including earthworks to facilitate flood compensation area. The northern section of the Site is to be used as a flood compensation area (FCA), with material excavated from the FCA used to raise Site levels within the main development area.

As part of the proposed development planning application to be submitted to the Local Authority, it is envisaged that a Foundation Works Risk Assessment will be required to support the development.

1.3 Existing Information

For full information on the Site setting, and full details of intrusive investigations completed at the Site, this Foundation Works Risk Assessment should be read in conjunction with Delta-Simons' previous reports as follows:

- ▲ Preliminary Geo-Environmental Risk Assessment, Bognor Regis, Oldlands Farm, Ref. 20-1543.04 dated March 2021

In addition to the above Delta Simons Reports, the following information has also been made available to Delta Simons for review:

- ▲ Hydrock – Phase 1a and 2 Oldlands Farm, Bognor Regis ref BOG-HYDGI-RP-GE1001-S2-P4, dated 31st August 2018)

1.4 Objectives

Given that the Site is located over a Secondary A Aquifer (Superficial, Raised Marine Deposits) and a Principal Aquifer (Undifferentiated Chalk Formation), it is anticipated that the Environment Agency will require the provision of a Foundation Works Risk Assessment to provide confidence and demonstrate that the proposed development scheme will not result in the degradation of groundwater quality at the Site. .

1.5 Limitations

The assessment is limited to the issues agreed within the proposal for the works. Notes on limitations associated with this assessment are provided in Appendix A. In addition, there are the following specific limitations that apply to this assessment:

- ▲ Foundation solutions have not yet been formalised by the structural engineer however based on the identified ground conditions, foundation solutions are considered to be limited and a range of options corresponding to each of the options considered has been included within the following document.

2.0 Site Details

2.1 Site Setting

A summary of the current Site status is presented below.

Co-ordinates	Centred approximately at National Grid Reference 494570, 101850	Elevation	0 – 5.96m AOD
		Area	18.9 Ha
Site Location	The Site is located in two parcels of land in the northern outskirts of Bognor Regis, approximately 3 km north-east from central Bognor Regis. The first parcel of land to be used for development is located to the south-east of the A259 road. The second parcel of land is indicated to be used as a flood compensation zone and it is proposed to excavate fill material from this area and transport it to the southern parcel of land to create a development platform. A Site Location Map is provided as Figure 1.		
Current Site Use	The main development Site and adjacent proposed flood compensation land currently comprises undeveloped agricultural land with field boundaries and drains present crossing horizontally in an east-west direction. The Site is accessible from the A259, turning south-east onto an access road which grants entry to the Site.		
Proposed Development	It is understood that the development will comprise the erection of a warehouse (Use Class B8) with ancillary office, associated vehicle parking, van storage, plant, ancillary structures, lighting, landscaping, and infrastructure works in the southern parcel of land. Activities in the northern parcel of land will comprise the excavation of a Flood Compensation Area with suitable engineered materials transferred to the main development area in order to raise Site levels by approximately 2m. To achieve this, it is proposed to import 85700m³ of material from the Flood Compensation Area. Due to the shallow groundwater table, it is likely that insufficient material will be available from the FCA to adequately raise levels and further excavation beyond the FCA will be required from a Fill Extraction Area (FEA) to provide a net mass balance for the development scheme. The resulting excavation within the FCA and FEA will then be backfilled with site won topsoil reinstating this area back to its original surfacing.		

3.0 Ground Conditions

3.1 Geology

The Site has undergone several phases of ground investigation, with ground conditions within the main Development Area generally found to comprise a sequence of Topsoil to depths of 0.70 m bgl followed by Raised Marine Deposits comprising gravelly, sandy clay to depths of 6.0 m bgl which in turn was found to be underlain by The Undifferentiated Chalk Formation, comprised of structureless chalk which was recovered as white silty gravel to depths of >35 m bgl

Ground conditions within the FCA/FEA were found to comprise a sequence of Topsoil to depths of 0.50 m bgl followed by River Terrace deposits comprising gravelly silty clay to depths of 3.0 m bgl. A limited area of Made Ground was identified where traces of red brick were identified within the topsoil. Deposits of the Undifferentiated Chalk Formation was found underlying the River Terrace Deposits and was comprised of structureless chalk that was recovered as white silty gravel.

3.2 Hydrology and Hydrogeology

The Environment Agency (EA) classifies the Raised Marine Deposits as a Secondary A Aquifer and the bedrock of the Undifferentiated Chalk Formation as a Principal Aquifer. Information contained within the Envirocheck report indicates that the Site is not located within a Source Protection Zone (SPZ).

There are numerous unnamed drains on Site, within the Site Development Area. These drains in turn discharge into the Ryebank Rife / Lidsey Rife approximately 250 m to the east. Due to the depth to groundwater that has been identified at the Site, the Ryebank Rife / Lidsey Rife may be in hydraulic continuity with groundwater within the Raised Marine Deposits.

There are two surface water abstraction licenses at Lindsey Rife located 165m to the east of the Site for construction related dust suppression.

During the most recent Delta-Simons investigation in March 2021, groundwater was encountered and monitored within the Raised Marine Deposits at depths between 0.51 and 1.66m bgl (-0.55 to 0.71m AOD) and between 0.51 and 1.89m bgl (-0.01 to 0.56m AOD) within the Undifferentiated Chalk Formation. Based on these recorded groundwater levels reaching similar levels of equilibrium there is anticipated to be a degree of hydraulic continuity between the aquifers.

A winter groundwater monitoring programme has also been undertaken at the Site by Hydrock between November and February 2021 where groundwater levels were recorded between 0.07 and 2.34 m bgl (-0.43 – 1.26 m AOD) within the Raised Marine Deposits.

It is noted that there is a degree of seasonality, and groundwater levels appear to reduce within summer months with a variance of approximately 0.40 mm recorded to date.

During reconnaissance visits to the Site during February 2021, standing water was noted to be widespread across the Site Development Area, indicating that groundwater during winter months is extremely shallow, resulting in the ground becoming saturated.

3.3 Contaminant Data Review

3.3.1 Soils

Hydrock have previously undertaken a ground investigation across the Site with soil samples sent for laboratory testing for a number of contaminants, including inorganics, total phenols, speciated PAHs, total PAHs, metals (arsenic, boron, chromium (III, hexavalent), beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc), BTEX (benzene, toluene, ethylbenzene and xylene), TPHs and pesticide and herbicide. The majority of contaminants were found to have concentrations below their adopted screening criteria with slight exceedances of boron recorded in the topsoil when compared to adopted screening criteria for plant life.

As part of the more recent ground investigation works by Delta Simons soil laboratory analysis was undertaken on samples recovered from the main development area and FCA/FEA and subject to a similar suite of analysis with none of the contaminants assessed found to have concentrations above their respective human health screening criteria.

3.3.2 Groundwater

The results of previous Hydrock ground investigation identified two out of six samples to exceed generic assessment criteria for Sulphate and one out of six samples exceeding generic assessment criteria for chloride when compared to Water Framework Directive and Drinking Water Standards. Additionally, manganese was found to exceed generic assessment criteria in 5 out of 6 samples tested and copper in all samples tested for The Water Framework Directive. No other exceedances were identified of the adopted screening criteria within the soil leachate and groundwater samples assessed.

Subsequent investigation by Delta Simons of groundwater samples from the chalk aquifer generally confirmed the findings of the previous ground investigation with marginally elevated chloride concentrations recorded in one out of three samples when compared to Water Framework Directive and Drinking Water Standards. A further five out eleven samples were found to marginally exceed the more stringent Water Framework Directive screening criteria for sulphate concentrations, 11 samples for Copper concentrations and one Nickel concentrations.

On the basis that no specific sources of sulphate, manganese chloride, copper or Nickel have been identified at the Site, the recorded concentrations were considered to be reflective of wider background levels.

3.3.3 Ground Gas:

The results of preliminary ground gas monitoring have indicated that the Site can be provisionally classified as Characteristic Situation (CS1) as such no ground gas protection measures are deemed necessary for the Site.

4.0 Proposed Development

It is understood that the development will comprise the erection of a warehouse (Use Class B8) with ancillary office, associated vehicle parking, van storage, plant, ancillary structures, lighting, landscaping, and infrastructure works in the southern parcel of land.

Due to the expected high design loads it is anticipated that the development scheme will comprise the use of piled foundations for all buildings and structures including a suspended floor slab. For external areas ground conditions are likely to be prone to excessive and differential settlements and it is likely that a range of ground improvement techniques comprising the following will need to be adopted:

- Surcharging
- Ground Improvement Techniques
- Reinforced raft of stiffened material
- Piled foundation Solution.

As the Site Development Area is located within a Flood Zone, it has been deemed necessary to raise Site levels by approximately 2m. An earthworks scheme is proposed to be undertaken in the northern parcel of land which will comprise the excavation of a Flood Compensation Area resulting in the requirement to import 85700m³ of material. It will also be necessary to provide a Flood Compensation Zone (FCS) to allow for excess water to drain away from the existing development into adjacent fields during flood events. Based on initial calculations, the FCS will need to be constructed to a minimum depth of 0.9m AOD resulting in the generation of ~122,169m³ of material from the River Terrace Deposits of which a proportion (sands and clay) have been designated for reuse as engineered fill.

5.0 Proposed Piling and Ground Improvement Works

At this stage, pile design layout and type have not been confirmed; however, piling solutions may comprise bored, Continuous Flight Auger (CFA) or driven piles taken into the Undifferentiated Chalk Formation depending on the required design loads.

Where ground improvement techniques are utilised, these are likely to comprise the use of vibro concrete columns or controlled modulus columns with other options comprising a stiffened raft of engineered fill or the use of surcharging techniques.

Concrete columns are typically constructed by the introduction of a vibrating probe. The probe is raised and lowered while concrete is simultaneously pumped to form a bulb at the base, transferring loads into a dense end bearing strata. Concrete then fills the resulting void as the probe is removed from the void. Controlled Modulus Columns are typically constructed using a reverse flight auger which is used to drill down to competent strata while laterally displacing soils creating minimal surface spoil whilst simultaneously densifying the surrounding soils. Concrete or Grout is then pumped through the hollow stem auger whilst the auger is slowly removed. The concrete then provides an unreinforced pile which allows the transfer of surface loads to the competent strata below.

Additionally, due to the requirement to import material and raise Site levels by approximately 2 m. Surcharging of materials is likely to be utilised, comprising placement of a load of equivalence on to the surface of the area of development prior to construction. Once sufficient consolidation has been achieved the temporary load can be removed allowing for the commencement of construction.

6.0 Piling and Ground Improvement Methods

At this stage, the exact foundation solution has not been confirmed and discussions regarding each of the techniques in *section 5.0* is presented below

6.1 Pre-Cast Driven Piles

Precast concrete piles are typically driven into the ground using hydraulic drop hammers mounted on a tracked rig to the required founding depth, utilising typical segment lengths including 1.5 m, 3 m, 4 m, 6 m, or 8 m.

Precast driven piles are quick to install and very cost effective in most ground conditions. In addition, the use of driven piles (a displacement pile) results in no spoil or arisings being generated resulting in a corresponding reduction in lorry movements in the area of the works.

The risk of drag down of contaminated material, into the underlying strata is considered negligible in the absence of any sources of contamination at the Site.

6.2 Continuous Flight Auger (CFA) Piles/ Bored Piles

The CFA method will involve constructing the piles with a CFA piling rig which has a full-length hollow stem auger. The pile will be bored in a continuous downward movement to the founding depth of the pile. As the auger rotates spoil will travel upwards, keeping the flights of the auger full of spoil, at all times. Once the auger has reached the founding depth, sand-cement or concrete is pumped down the hollow stem at a controlled rate as the auger is steadily withdrawn. A steel reinforcement cage is inserted into the liquid concrete immediately after.

A similar process is applicable for a bored pile with the only variation being that piles are excavated using a short auger with arisings transported to the surface at the end of each drill movement. Where pile holes are subject to instability casing can be used to stabilise the strata. This technique allows for the construction of deeper foundations that readily available for CFA piles and also allows for large diameter piles to be constructed allowing higher working loads to be achieved.

6.3 Ground Improvement Methods – External areas.

Vibro Concrete Columns

Constructed using a vibrating probe that simultaneously pumps concrete in to the resulting void forming a bulb at the base and a concrete column to the surface. Once soils have been sufficiently densified it is then possible to raise site levels using engineered fill.

Controlled-Modulus-Columns

A reverse flight auger is used to drill down to competent strata while laterally displacing soils creating minimal surface spoil whilst simultaneously densifying the surrounding soils. Concrete or Grout is then pumped through the hollow stem auger whilst the auger is slowly removed. Once soils have been sufficiently densified it is then possible to raise site levels using engineered fill.

Pre-Loading and Surcharging

The placement of a load of equivalence on to the surface of the area of development prior to construction. By imposing a load that is representative of final as built conditions, consolidation can be achieved over a period of several months. Where surcharging techniques are adopted it is likely that wicking drains will be constructed to enhance vertical and lateral migration of porewater which will be discharged to existing receiving surface water streams via a treatment plans (if required). Once sufficient consolidation has been achieved the temporary load can be removed allowing for the commencement of construction.

6.4 Earthworks

The development will require cut and fill earthworks to raise Site levels and achieve the proposed development platforms in the Site Development Area of the wider Site. It is understood that site levels will be raised by approximately 2 m utilising natural material from the FCA/FEA to the north.

Materials used as fill will need to be placed to a suitable engineering specification with the degree of compaction required will be dependent on end usage and serviceability criteria. Depending on the final performance requirements of the development it may be necessary to modify the soil performance and include the use of geotextiles.

7.0 Conceptual Site Model

In accordance with current UK best practice and in line with the Environment Agency guidance on piling on land affected by contamination, the potential environmental hazards (with respect to groundwater) created by piling on the Site have been considered in the context of the following CSM risk assessment, based on the source-pathway-receptor principle.

It is noted that post development, the use of significant hardstanding will reduce infiltration through the fill materials.

7.1 Sources

Delta-Simons has reviewed available information and based on the findings of several phases of investigation have not identified any sources of significant contamination to be present at the Site. Where marginally elevated concentrations of Sulphate, Chloride Manganese, Copper and Nickel have been identified within the Raised Marine Deposits and undifferentiated Chalk Formation, These were considered to be representative of background water groundwater quality.

Additionally, no sources of contamination or contaminants were identified within proposed Flood Compensation Area, where materials will be utilised to rise Site levels within the development area.

7.2 Pathways

The Raised Marine Deposits and Undifferentiated Chalk Formation are considered to be in hydraulic continuity, albeit this may vary laterally due to the cohesive nature of the Raised Marine Deposits. None of the proposed techniques are considered to result in the creation of a pathway when considered in the context of the contamination assessment at the Site.

7.3 Receptors

The Site is not located within a groundwater Source Protection Zone (SPZ) and there are no recorded groundwater abstractions within 1 km of the Site. The Raised Marine Deposits are considered to be a Secondary A Aquifer whilst the Undifferentiated Chalk Formation is considered to be a Principal Aquifer.

The Ryebank Rife / Lidsey Rife is located approximately 250 m to the east and connected by a series of land drains located on the Site. The adjacent stream is potentially in hydraulic continuity with the Raised Marine Deposits representing a potential receptor. However, based on the lack of contamination identified at the Site the risk of contamination effecting these receptors is deemed low.

8.0 Plausible Pollutant Linkages

Based on the findings of the previous ground investigation, no potential sources of contamination have been identified. In the absence of any sources of significant contamination it is not possible to establish a plausible source pathway receptor linkage and the risks posed to controlled waters by the foundation construction is considered to be negligible.

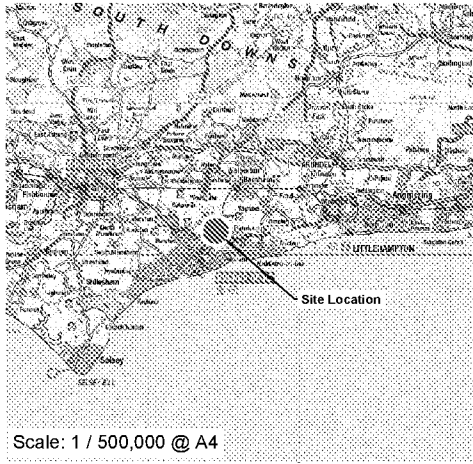
9.0 Piling Risk Assessment

Based on findings of the Conceptual Site Model, the use of piled or ground improvement techniques are considered to pose a negligible risk to controlled waters and no further risk assessment or mitigation measures are considered necessary.

10.0 Conclusions

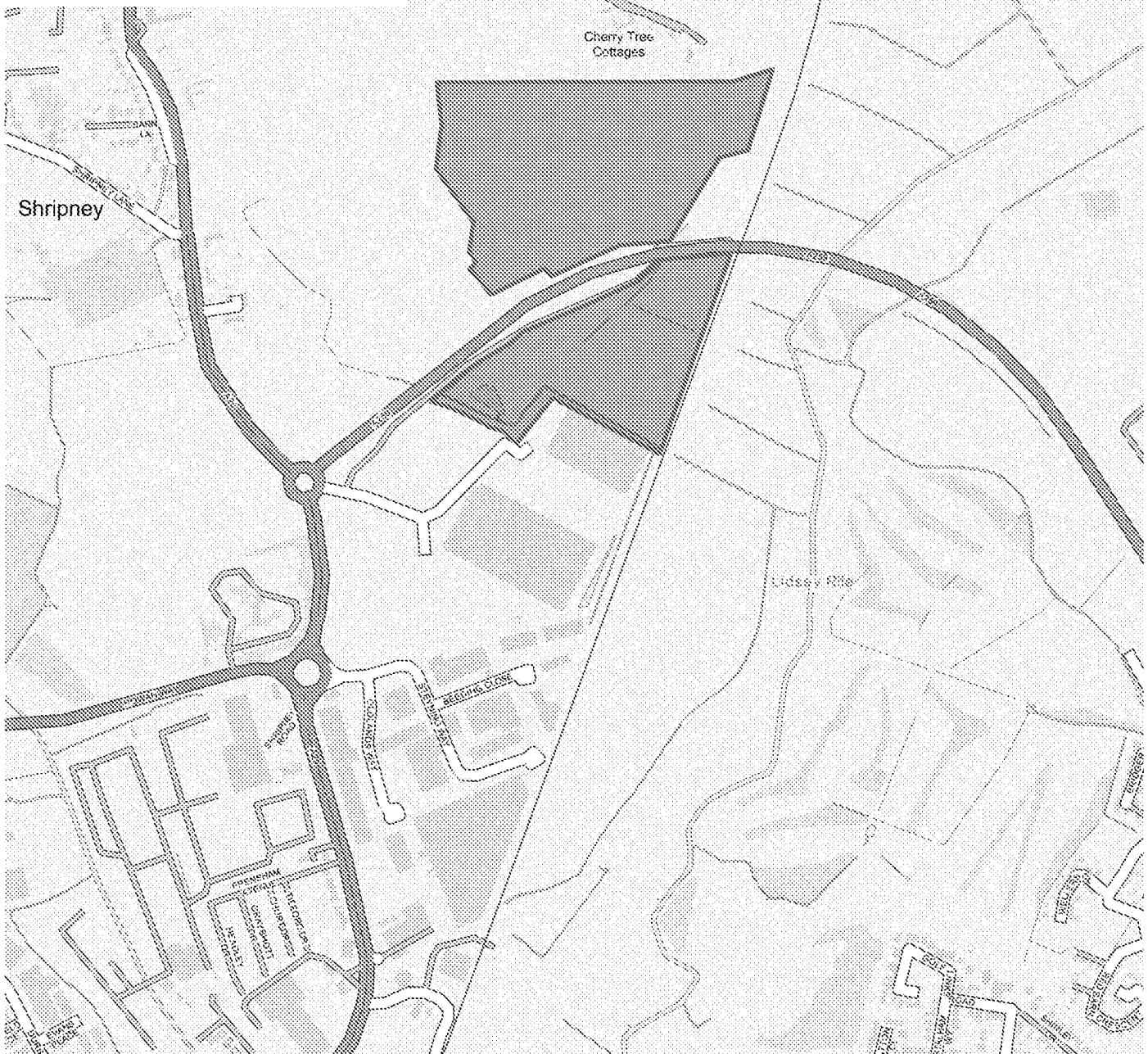
The piling risk assessment has considered a range of foundation options that may be considered as part of the development along with the potential risk associated with the mobilisation and creation of contaminant pathways by the construction of foundations at the Site. Broadly, the foundation options assessed are considered to have a low impact upon the identified receptors given the absence of any significant sources at the Site and no specific mitigation measures or further assessments are considered necessary in the context of the proposed foundation options.

Figure 1 – Site Location Map



LEGEND

 Site Boundary



Scale: 1 / 10,000 @ A4

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Appendix A – Limitations

Limitations

The recommendations contained in this Report represent Delta-Simons professional opinions, based upon the information listed in the Report, exercising the duty of care required of an experienced Environmental Consultant. Delta-Simons does not warrant or guarantee that the Site is free of hazardous or potentially hazardous materials or conditions.

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