From:	[redacted]
To:	One Earth Solar
Subject:	Re: Technical Critique of Environmental Statement Appendix 7.2: Flood Risk and Water Management Strategy (One Earth Solar Farm - EN010159
Date:	02 December 2025 22:07:03

For the avoidance of doubt the above submissions is made
Under the following terms Reservation of Rights (Litigant in Person)
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The Interested Party's continued participation is legally compelled by the statutory process (Planning Act 2008) to maintain standing, but this action does not constitute a waiver, acceptance, or validation of any alleged procedural impropriety, ExA bias, unlawful censorship, or fundamental flaws in the Administrative Record.
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To The Examining Authority
Regards

On Tue, 2 Dec 2025, 18:51 Stephen Fox, [redacted] wrote:

> **TO:** The Examining Authority **PROJECT:** One Earth Solar Farm (EN010159) **FROM:** Stephen Fox (Interested Party Ref: [redacted]) **DATE:** 02.12.25
>
> Dear Sirs
>
> Please accept this as a submission for deadline 6.
>
> # Technical Critique of Environmental Statement Appendix 7.2: Flood Risk and Water Management Strategy (One Earth Solar Farm - EN010159)
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> # Contents
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Technical Critique of Environmental Statement Appendix 7.2: Flood Risk and Water Management Strategy (One Earth Solar Farm - EN010159)

Executive Summary

This report presents an exhaustive technical critique of the water environment submissions supporting the Application for Development Consent for the One Earth Solar Farm (OESF), specifically addressing the "Tidal Trent Hydraulic Model" (Jacobs, 2023) and the associated strategies for flood risk management, water resources, and pollution control outlined in Appendix 7.2.[1] The critique is

necessitated by the representations made by the Environment Agency (EA) regarding the hydraulic independence of floodplains, the omission of critical construction water demands, and the viability of fire water management strategies for the Battery Energy Storage System (BESS).

The analysis challenges the Applicant's assertion that the eastern and western floodplains of the River Trent function as distinct hydraulic cells, a premise used to justify the non-summation of flood level increases (3.5mm and 2.2mm).[2] Through a detailed review of hydrodynamic principles, inundation timing, and floodplain topography, this report demonstrates that the "distinct cell" hypothesis is flawed under the extreme stress of a 1-in-100-year event plus 39% climate change. A critical weakness in the current submission is that model sensitivity has not been demonstrated; while the critique asserts affluxes should be summed, the Applicant has failed to present a sensitivity run or combined-afflux map showing the spatial extent of this incremental risk.

Furthermore, the Water Resources Assessment (WRA) is found to contain material omissions regarding Horizontal Directional Drilling (HDD) fluid requirements.[3] The current assessment lacks site-specific data; while conservative volumetric examples suggest high demand, these must be converted into a formal demand profile tied to the actual number of bores, diameters, and the construction schedule to accurately quantify peak abstraction rates for licensing.

Finally, the proposed strategy for managing contaminated fire water runoff from BESS infrastructure—relying on "tankering away" and "controlled burns"—is exposed as operationally fragile. The current documentation flags the need for dedicated freeboard but lacks a simple mass balance showing required containment volume under plausible multi-day cooling scenarios and concurrent floodwater occupancy.

1. Hydraulic Modelling and Flood Risk Assessment

1.1 The Theoretical Basis of the Jacobs 2023 Tidal Trent Model

The assessment of flood risk for the One Earth Solar Farm relies fundamentally on the "Tidal Trent hydraulic model" produced by Jacobs in 2023.[4] This numerical model serves as the primary evidence base for determining the fluvial and tidal impacts of the proposed development, which spans approximately 4,000 acres across the Trent Valley.[5] The River Trent in this locale represents a transitional hydraulic regime, shifting from a purely fluvial system to one heavily influenced by tidal propagation, necessitating a complex modelling approach that accounts for both upstream discharge and downstream tidal boundary conditions.

The integrity of the Environmental Statement depends entirely on the accuracy of this model's schematization—specifically, how it represents the interaction between the main river channel and the adjacent washlands (floodplains). The Applicant has utilized this model to demonstrate that the introduction of solar PV arrays, substations, and BESS infrastructure will result in negligible off-site detriment. However, the methodological choices made regarding the summation of water level increases challenge the robustness of these conclusions and warrant deep technical scrutiny.

1.2 Critique of the "Distinct Cell" Hypothesis

A central point of technical contention, raised during Issue Specific Hearing 3 on November 6th, 2025, involves the calculation of afflux—the localized rise in water level resulting from the development's encroachment into the floodplain. The modelling predicts a level increase of **3.5mm** for the eastern floodplain and **2.2mm** for the western floodplain. The Applicant has declined to sum these values (which would yield a resultant increase of 5.7mm), arguing that the eastern and western floodplains operate as "two distinctive cells."[2]

1.2.1 Hydrodynamic Connectivity vs. Temporal Separation

The Applicant's justification for this separation rests heavily on the observation of differing peak inundation timings:

- **Eastern Floodplain:** Water levels reach their maximum between **82 and 116 hours** into the design event simulation.
- **Western Floodplain:** Water levels reach their maximum at approximately **127 hours**.

This temporal offset, ranging from 11 to 45 hours, is cited as definitive evidence of hydraulic separation. However, this interpretation conflates *peak timing* with *hydraulic isolation*. In an open channel system like the River Trent, the main channel acts as the common boundary condition—the hydraulic spine—connecting all adjacent floodplain storage areas. The "cells" are not isolated reservoirs; they are communicating vessels connected via the conveyance capacity of the river channel.

When volume is displaced in the eastern floodplain (causing a 3.5mm local rise), that displaced volume does not vanish from the system once the eastern peak passes. It is forced into the main channel, increasing the conveyance burden and raising the hydraulic grade line (HGL) of the river itself. Since the western floodplain fills later (peaking at 127 hours), it draws its volume from this same main channel. If the main channel level is elevated—even marginally—due to the displacement from the eastern floodplain, the western floodplain will fill to a higher absolute level than it would have otherwise.

Therefore, the refusal to combine the level increases assumes that the hydraulic influence of the eastern floodplain dissipates entirely before the western floodplain reaches its critical filling phase. Given the extremely low gradient of the Tidal Trent and the prolonged duration of the design flood event (lasting over 120 hours), the recession limb of the hydrograph is likely slow. The "mounding" effect of water in the eastern sector would contribute to the overall volume in the system, maintaining elevated river levels that subsequently drive the western inundation mechanisms.

1.2.2 The Physics of Floodplain Interaction

To understand why the "distinct cell" argument is physically unsound, one must consider the principles of conservation of mass and momentum in unsteady flow. The River Trent floodplains at North and South Clifton are not sealed compartments. They are part of a continuous hydraulic continuum.

1. **Mass Conservation:** The solar farm infrastructure (panels, mounting systems, BESS compounds) introduces solid volume into the floodplain. This reduces the available storage volume. According to the continuity equation, for a given inflow hydrograph, a reduction in storage must result in an increase in stage (water level) or discharge downstream.
2. **Momentum Transfer:** The displacement in the East (occurring at 82-116 hours) alters the energy gradient of the river. By occupying storage, the

development forces the river to carry more flow downstream rather than attenuating it laterally.
3. **The Superposition of Effects:** Even if the peaks are offset, the *tail* of the eastern event overlaps with the *rising limb* and peak of the western event. At hour 127 (Western Peak), the eastern floodplain is not dry; it is merely past its peak. It still holds millions of cubic meters of water. If the development has raised the level of that stored water by 3.5mm, that represents a massive volume of "rejected" water that is now occupying the river channel. This rejected volume raises the stage of the river at hour 127, directly contributing to the severity of the western peak.

The "distinct cell" argument treats the floodplains as if they are separate bathtubs filled by different taps. A more accurate physical analogy for the Trent Valley is a single large basin with a central trough. Displacement on one side inevitably propagates across the free surface to the other side. While wave propagation takes time (hence the lag), the hydrostatic equilibrium drives a unified level rise.

1.3 Analysis of Peak Inundation Timing Anomalies

The significant lag between the eastern and western peaks (up to 45 hours) is an anomaly that requires rigorous hydraulic explanation, which the Applicant's summary dismisses too easily. This delay suggests that the mechanisms of flooding differ fundamentally between the two banks, yet they remain coupled.

- **Eastern Mechanism (82-116h):** The earlier peak on the eastern bank suggests this floodplain is either lower-lying, has lower defence thresholds, or is filled by local tributaries reacting faster than the main Trent flood wave. If the eastern floodplain fills early, it essentially "pre-loads" the system.
- **Western Mechanism (127h):** The later peak on the western bank aligns more closely with the arrival of the main fluvial flood peak from the upper catchment or a tidal locking interaction downstream.

If the eastern floodplain is already full (and artificially raised by 3.5mm) when the main Trent peak arrives to inundate the west, the channel capacity is already compromised. The main channel cannot spill effectively to the east because the hydraulic gradient is reduced (the east is full). This forces the main channel to convey more flow or stage higher to push water into the west. Consequently, the 3.5mm rise in the east acts as a *boundary condition modifier* for the western event. The Applicant's approach of separating volumetric calculations effectively ignores the *loss of conveyance and storage efficiency* caused by the eastern development, which manifests as increased pressure on the western defences.

1.4 Topographical and Geological Constraints at North and South Clifton

The topography around North and South Clifton is critical to this interaction. The Strategic Flood Risk Assessment (SFRA) for Newark and Sherwood identifies this area as the "mid-Nottinghamshire farmlands," where the Trent Valley dominates the landscape.[6] The geology is characterized by "Older River Deposits" and blown sand overlying Mercia Mudstone.[7] This creates a highly permeable interface between the river and the floodplain, allowing for significant hyporheic exchange (sub-surface flow).

The "South Clifton Major Embankment" provides a nominal 1-in-100-year standard

of protection.[1] However, the area behind the defences relies on the river level being lower than gravity outfalls to drain. If the displacement from the solar farm raises the river level (even by millimeters), it reduces the window of opportunity for gravity drainage from the floodplains back into the river. This "tide-locking" effect is exacerbated by the development.
The Jacobs model likely uses a 1D-2D linkage (1D river, 2D floodplain). In such models, the transfer of water is governed by spill units (weirs) representing the embankments. The flow over a weir is a function of the head difference ($H^{1.5}$). If the river level is higher due to cumulative displacement, the flow into the western floodplain (once defences are overtopped or breached) will be more energetic, and conversely, the drainage out of the floodplain will be retarded.

1.5 Implications of Climate Change Assumptions (+39%)

The design event utilized in the model includes a **39% climate change** allowance.[2] This is a severe uplift in flow, pushing the hydraulic system into a regime of extreme stress where non-linear behaviors emerge.
In a standard flood, the separation of floodplains might be defensible if the river remains within bank or only spills locally. However, under a +39% scenario, the Trent Valley effectively becomes a fully activated floodway. The distinction between "channel" and "floodplain" blurs as the entire valley floor contributes to conveyance. In this "valley-wide" flow regime, the "distinct cell" hypothesis collapses entirely. The water surface becomes a continuous plane across the valley (superelevation effects aside).

Under these conditions, any reduction in storage volume (via solar panels, inverters, BESS compounds) anywhere in the cross-section contributes to a rise in the global water level. The failure to sum the 3.5mm and 2.2mm estimates likely underestimates the true impact on third-party assets, particularly agricultural land and isolated properties that sit on the margins of the flood outline.

1.6 Residual Risk and Breach Analysis Reliability

The Flood Risk Assessment (FRA) notes that the BESS compounds are protected by the South Clifton Major Embankment.[1] However, embankments are prone to failure, particularly during events exceeding their design standard.
If the eastern floodplain levels are elevated by 3.5mm, this places additional hydrostatic load on the eastern defences. While 3.5mm appears negligible structurally, in hydraulic modelling, it represents a change in the energy gradient. More critically, if the separation logic is flawed and the river level is actually higher than predicted, the overtopping frequency and duration for the defences protecting the BESS and the villages (North/South Clifton) may be underestimated.

The "Flood Cell" concept is often used in breach analysis,[9] where a breach in one location fills a specific low-lying area. However, the OESF site spans a massive area. The "cells" are not small, enclosed basins; they are vast tracts of open land. The connectivity between these areas via culverts, drains, and minor road undulations means that water can bypass theoretical cell boundaries during long-duration events.

1.7 Table 1: Comparative Hydraulic Parameters (East vs. West Floodplain)

Parameter	Eastern Floodplain	Western Floodplain	Implication of Difference
Peak Timing (Design Event)	82 – 116 hours	~127 hours	Western peak occurs while East is inundated.
Peak Level (mAOD)	6.2 – 6.9 m	> 7.0 m	Gradient drives flow West-to-East or implies river superelevation.
Predicted Level Increase	+3.5 mm	+2.2 mm	Cumulative displacement ignored.
Defence Standard	Variable (Rural)	1 in 100yr (South Clifton)	Differential protection standards complicate breach modelling.
Topography	Lower lying (older river deposits)	Higher ridge interactions	East acts as initial storage; West acts as peak storage.

2. Water Resources Assessment and Construction Demands

The Water Resources Assessment (WRA) submitted by the Applicant has been challenged regarding the omission of water demands for **Horizontal Directional Drilling (HDD).**[3] This section provides a technical critique of this omission, quantifying the potential water demand and analyzing the implications for abstraction licensing.

2.1 The Material Omission of HDD Water Demands

The project involves a significant cable crossing under the River Trent to connect the eastern solar arrays to the High Marnham substation on the west bank.[10] The chosen method is HDD to avoid disturbing the riverbed and flood defences. The cable route length is cited as approximately **4.38 km** in the context of trenchless options.[11]
The Applicant's WRA currently lists construction demands but explicitly excludes "Volumes of water required for horizontal directional drilling fluids (bentonite clay mixing)."[3] This is a fundamental oversight. HDD is a hydro-mechanical process that relies entirely on drilling fluid (mud) to:

1. **Stabilize the Borehole:** The hydrostatic pressure of the fluid prevents the borehole from collapsing, particularly in the soft "Older River Deposits" (sands and gravels) found at the site.[7]
   Suspend Cuttings: The fluid viscosity transports drilled spoil out of the hole.

2.
3. **Cool and Lubricate:** It prevents the drill bit and electronics from overheating.

2.2 Quantification of HDD Water Usage

To demonstrate the materiality of this omission, we must calculate the potential water demand. While the exact bore length for the river crossing itself may be shorter than the full 4.38km route, the cumulative drilling required for the river and associated approaches is significant. The volumetric example below is conservative and useful, but it highlights the need for the Applicant to convert this into a **formal demand profile** tied to the actual number of bores, bore diameters, and construction schedule in the DCO application to quantify peak abstraction rates for licensing.

2.2.1 Drilling Fluid Volumetrics

Drilling fluid is typically composed of 95-98% water and 2-5% bentonite clay.[12] The volume of fluid required is a function of the borehole volume and a "washout factor" or circulation factor (typically 1.5 to 3 times the hole volume to ensure hole cleaning).

- **Assumptions for Calculation:**
  - **Bore Length:** Conservatively assume the river crossing and immediate approaches constitute **1,000 meters** (1 km) of HDD work.
  - **Bore Diameter:** For high-voltage export cables, a bundle is often pulled, or multiple ducts are installed. A typical bore diameter for this scale might be **24 inches (0.6 meters)**.
  - **Annular Volume:** $V = \pi \times r^2 \times L$
  - $V = 3.14159 \times (0.3)^2 \times 1000 = 282.7$ cubic meters per bore.
- **Fluid Circulation Requirement:**
  - HDD operations typically consume fluid at a rate of 2-3 times the hole volume due to losses into the formation, surface spillage, and recycling inefficiencies.
  - **Total Fluid Volume:** $282.7 \times 3 \approx 848$ cubic meters (848,000 liters) per bore.

If the project requires multiple ducts (e.g., separate bores for different circuits), this number multiplies. For a project of 740MW, multiple circuits are a certainty. A conservative estimate for the total HDD water demand could easily exceed **2,000 - 3,000 cubic meters (2-3 megaliters)**. This is not a trivial volume that can be absorbed into a "petty cash" water budget.

2.2.2 Bentonite Mixing and Water Quality

The quality of water used for mixing bentonite is critical. Bentonite (sodium montmorillonite) hydrates and swells to form a gel structure (thixotropy) that provides viscosity.

- **Hardness/Salinity:** Hard water or saline water inhibits the swelling of bentonite, requiring chemical additives (soda ash) or significantly more bentonite to achieve the required yield point and viscosity.[13]
- **Source Implications:** The Applicant cannot simply pump raw water from the

River Trent (which is tidal and potentially brackish/turbid) without treatment or testing. If the river water is incompatible with the drilling mud chemistry, they will require potable water tankered in or a high-quality abstraction source.

2.3 Abstraction Licensing and "Low Flow" Conditions

The Environment Agency has flagged that the use of existing abstraction licenses is "unclear."[3] The critique here is threefold:

1. **License Identification:** The Applicant mentions "existing licenses" but fails to specify if these are agricultural licenses (for irrigation) being repurposed. Agricultural licenses often have "Hands Off Flow" (HOF) conditions.
2. **Seasonality Conflicts:** HDD operations are continuous once started (to prevent hole collapse). If construction coincides with a "prolonged dry weather" period,[3] HOF conditions may trigger, legally preventing abstraction from the River Trent.
3. **Dust Suppression vs. HDD:** The query notes the conflict during dry weather when demand for dust suppression is highest. The simultaneous demand for HDD water (which is non-negotiable for the drilling rig's operation) and dust suppression (required for environmental compliance) creates a peak water stress scenario that has not been modelled.

The WRA must effectively prove that the **20m³/day** non-domestic limit[3] is either not breached or that Anglian Water Services (AWS) has guaranteed bulk supply. However, 20m³/day is insufficient for an active HDD rig, which can circulate hundreds of liters per minute.[14] If AWS cannot supply the peak demand, and river abstraction is restricted by low flows, the project faces a critical stoppage risk or a requirement for hundreds of tanker movements, which affects the Transport Assessment.

2.4 Table 2: Water Demand Scenario for HDD Operations

Activity	**Water Demand Rate**	**Duration**	**Total Volume Estimate**	**Supply Constraint**
Bentonite Mixing	~500 - 1,000 L/min	Continuous during drilling	800 - 3,000 m³	Quality (Salinity/Hardness)
Dust Suppression	Variable (High in Summer)	Daily (Dry Weather)	50 - 200 m³/day	Hands Off Flow (River Trent)
Potable Supply	< 5 m³/day	Continuous	Low	AWS Connection Limits
Combined Peak	**> 200 m³/day**	**Overlap Period**	**Critical Stress**	**License Trading Required**

3. Battery Energy Storage System (BESS) Fire Safety and Pollution Control

The proposed Battery Energy Storage System (BESS) introduces a significant chemical hazard into a flood-sensitive environment. The Applicant's strategy relies on a combination of "controlled burn," "boundary cooling," and "tankering away" fire water.[5] This section critiques the viability of these strategies, specifically calculating the disparity between fire water volumes and tanker logistics under flood conditions.

3.1 The "Controlled Burn" Policy vs. Environmental Protection

The National Fire Chiefs Council (NFCC) guidance and the Environment Agency often advocate for a "controlled burn" strategy for Lithium-ion battery fires to minimize contaminated runoff.[15] The logic is that water cannot effectively extinguish a thermal runaway deep inside a battery module, so applying water only generates vast quantities of toxic runoff.

However, the Applicant's reliance on this policy presents a contradiction in the Environmental Statement:

- **Safety Argument:** "We will use water for boundary cooling only to prevent spread."
- **Environmental Argument:** "We will contain all runoff and tanker it away."

3.1.1 The Definition of Boundary Cooling

"Boundary cooling" is not a dry process. It involves spraying high volumes of water onto adjacent battery containers to keep them below the thermal runaway threshold temperature (approx. 60-100°C).[16]

- **Volume Calculation:** The NFCC guidance suggests a supply of **1,900 liters/minute** for at least **120 minutes**.[17]
- **Total Water Volume:** 1,900Lmin times 120 = 228,000Liters.

This is a *minimum*. Grid-scale BESS fires can burn for days (e.g., the Liverpool fire lasted 3 days). If boundary cooling is required for 24 hours, the volume escalates to **2.7 million liters**.

3.2 Inadequacy of "Tankering Away" in Flood Zones

The Applicant proposes that "Captured firewater runoff is to be tested and removed by tanker for offsite disposal."[3] This strategy is operationally flawed given the site's location in/adjacent to Flood Zones 2 and 3.[18]

3.2.1 Logistical Calculation of Tanker Requirements

- **Standard Vacuum Tanker Capacity:** 13,000 to 18,000 liters (approx. 13-18 tonnes).[19]
- **Fire Water Volume (2 hour minimum):** 228,000 liters.
- **Tanker Trips Required:** 228,000 / 15,000 =15.2 tanker loads

This assumes a short, 2-hour event. If the fire lasts 24 hours (requiring intermittent cooling), the requirement could exceed **100 tanker loads**. This logistical burden is immense, even in ideal conditions.

3.2.2 The Flood Coincidence Factor: The "Perfect Storm"

The BESS compounds are located "protected by an area of high ground and the South Clifton Major Embankment".[1] However, access roads to these compounds traverse the floodplain.

- **Scenario:** A flood event (1 in 100yr + CC) occurs. The roads are inundated. The high humidity or water ingress triggers an electrical fault in the BESS, leading to thermal runaway.
- **Failure Mode:** Fire crews may struggle to reach the site. More critically, **tankers cannot reach the site to remove the contaminated water.**

- **Result:** The containment lagoons fill up. The automatic penstock valves close to contain the toxins. The lagoons overtop due to the combined volume of *fire water* plus *heavy rainfall* (from the storm causing the flood). The toxic cocktail of HF (Hydrofluoric acid), heavy metals (Cobalt, Nickel), and PFAS (from firefighting foam if used) spills directly into the floodwaters of the River Trent.

The reliance on road-based tankering for a facility located in a flood-prone area is a single point of failure. The strategy relies on "fair weather" logistics to manage a hazard that is statistically more likely to occur during "foul weather" (flood-induced short circuits).

3.3 Drainage Design and Penstock Valve Reliability

The Applicant mentions "automatic penstock valve with manual override".[3]

- **Critique:** Penstock valves are mechanical devices prone to jamming, especially if debris is present (common in flood scenarios).
- **Containment Sizing and Mass Balance:** The drainage design must size the attenuation ponds not just for the 1 in 100-year storm, but for the **1 in 100-year storm PLUS the full volume of firefighting water**. The document correctly flags the need for a dedicated freeboard for firefighting water, but the argument would be stronger with a **simple mass balance** showing the required containment volume under plausible multi-day cooling scenarios and concurrent floodwater occupancy.
- **Dead Volume:** The "impermeable lined storage capacity"[3] must be empty and available at all times. If the lagoon is already full of rainwater when the fire starts, there is zero capacity for fire water. The design must demonstrate "freeboard" specifically reserved for fire water, distinct from the attenuation

volume.

3.4 Chemical Composition of Runoff

Lithium-ion battery fires produce run-off containing:

- **Hydrofluoric Acid (HF):** Extremely toxic to aquatic life, derived from the breakdown of the LiPF_6 electrolyte salt.
- **Heavy Metals:** Cobalt, Manganese, Nickel leached from the cathodes.
- **Organic Solvents:** Carbonates from the electrolyte.

The environmental sensitivity of the River Trent (a major migratory corridor for eels and salmonids) means that even a dilute release of this runoff could constitute a catastrophic pollution incident. **The dilution factor of the floodwater is not an acceptable mitigation strategy under the Water Framework Directive (WFD), which prohibits the deterioration of water body status.**

4. Cumulative Impacts and Regulatory Compliance

4.1 Interaction with Other NSIPs

The One Earth Solar Farm is not operating in isolation. The region is subject to multiple solar NSIP proposals, including **Cottam**, **West Burton**, and **Gate Burton**.

- **Cumulative Hydraulic Impact:** While OESF argues its 5.7 mm -3.5mm/2.2mm impact is negligible, the cumulative loss of floodplain storage across all four projects must be modelled. If each project raises levels by 5mm, the cumulative effect is 20mm, which significantly alters flood outlines and third-party risks. **Cumulative afflux and storage-loss modelling across nearby NSIPs is essential** and is a standard expectation in large valley floodplain assessments.

- **Cumulative Traffic/Water Demand**