FORMAL SUBMISSION TO THE SECRETARY OF STATE

Interested Party Reference:[redacted] **Project:** One Earth Solar Farm (EN010159)
Submission Type: Written Representation in Response to the Secretary of State's Consultation Letter dated 21 May 2026 (Requesting Responses to the Post-Examination Submissions Regarding Draft Requirements 7 and 22)

INDEPENDENT HYDROLOGICAL & HYDRAULIC ASSESSMENT

One Earth Solar Farm and the Six Contingent Solar NSIPs in the Hydraulically Conjoined Trent and Witham Valleys

APPENDIX 2: HYDRAULIC CALCULATION REGISTER

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INDEPENDENT HYDROLOGICAL & HYDRAULIC ASSESSMENT: One Earth Solar Farm and the Six Contingent Solar NSIPs in the Hydraulically Conjoined Trent and Witham Valleys.

THE FATAL FLAWS OF STATIC NATIONAL MAPPING IN ASSESSING CUMULATIVE SOLAR IMPACTS

1PREAMBLE: *The Fallacy of the Environment Agency Mapping Framework*

This model unequivocally demonstrates that the current Nationally Significant Infrastructure Project (NSIP) methodology for evaluating flood risk is simply not fit for purpose. The proposed infrastructure represents a **systemic threat to over 206,000** residents across the conjoined catchments of the Trent and Witham valleys. Furthermore, it is entirely hydrologically structurally invalid to evaluate the One Earth Solar Farm in isolation. While assessing cumulative impact is a recognized requirement of established planning policy, it is a physical reality consistently ignored by developers, the Planning Inspectorate (PINS), and ultimate decision-makers.

To properly evaluate the extreme flood risks posed by the proposed clusters of utility-scale solar infrastructure (including One Earth, Cottam, Gate Burton, West Burton, Tillbridge, Springwell, and GNR), the Secretary of State must first recognize a fundamental, widely acknowledged limitation in current statutory planning: the fatal inability of the Environment Agency's (EA) national mapping framework to simulate dynamic compound flooding.

Despite the technical advancements introduced in the May 2026 spatial updates, the EA's Flood Map for Planning and the National Flood Risk Assessment (NaFRA2) models are built as discrete, single-source datasets. They map surface water (pluvial) and river (fluvial) risks as isolated hazards, ignoring the physical reality that in catchments like the River Trent Valley and the River Witham, these forces interact to cause catastrophic "compound flood events."

Relying solely on these generalized national screening maps—as the developers have done—is hydrologically defective for four critical reasons:

2. Surcharged Outfalls and the "Locked" Drainage System

In a real-world catchment during an extreme winter storm, fluvial and pluvial risks do not occur independently. If high river levels on the River Trent or River Witham coincide with heavy localized rainfall, the elevated river physically blocks (surcharges) local gravity drainage outfalls, flap valves, and dykes. Because the receiving river is too high, surface water run-off cannot discharge into its natural fluvial outlet. It backs up behind existing flood defences, flooding the dry side of the embankments. The EA's static surface water maps assume standard drainage performance, completely failing to model this critical physical blockage mechanism. This physical mechanism was vividly demonstrated during Storm Dennis (February 2020), Storm Babet (October 2023), and Storm Henk (January 2024), where elevated river levels along the Trent and Witham catchments physically locked local gravity outfalls and forced extensive surface water accumulation on the dry side of flood embankments. *(This independent assessment specifically rectifies this failure by mathematically modelling tailwater surcharge within Scenario 3c/d: Surge Saturated).*

3. The Fallacy of the "Distinct Cell" Hypothesis

During solar farm examinations (such as the One Earth Solar Farm), forensic hydrological audits challenged the EA and the applicants for utilizing a "salami-sliced" modelling approach. Applicants assess their sites by dividing the floodplain into distinct spatial cells (e.g., eastern and western) to artificially dilute the perceived impact and justify negligible tolerances (such as a 5mm tolerance). By failing to model the combined, synchronous catchment-level run-off alongside River Trent peak flows, traditional developer modelling hides the true risk of localized regional drainage systems being completely overwhelmed by cumulative volume. *(This independent assessment rectifies this by calculating the contiguous Combined 7-Project Regional Totals).*

4. Cumulative Timing, Peak Synchronization, and Topographical Fall

The national maps fundamentally fail to account for how massive land-use changes—such as converting 8,844 combined hectares of agricultural land into hard-framed solar panels—alter catchment-wide timing. Topographical surveys reveal severe relief drops across these sites (e.g., falling from 23.0m Above Ordnance Datum (AOD) at the boundaries down to 4.5m AOD at the river). Under intense rainfall, the gravity-accelerated run-off generated by tilted panels (the Baiamonte effect) drastically shortens the catchment's Time of Concentration. This acceleration forces local tributary flood peaks from these massive sites to violently synchronize directly with the main river peak. The EA's national maps cannot capture these dynamic, non-linear catchment interactions.

5. Technical Constraints of the National Mapping Service

Even the EA and local planning authorities acknowledge that national-scale surface water maps are generalized models. They are computationally constrained and designed primarily as static "screening tools" for high-level spatial planning, rather than detailed hydraulic simulators for megaprojects. Consequently, they do not calculate the dynamic hydraulic transfer of water between surcharged channels and overland pluvial flow paths.

Conclusion to Preamble:

Ultimately, relying solely on the EA's updated mapping system to assess flood risk for an infrastructure rollout of this unprecedented scale is a legal and technical failure. It treats the site's hydrology as static and isolated, failing to account for the dangerous compound interactions between rising fluvial levels and accelerated pluvial runoff that directly threaten the safety of surrounding 62 rural communities in the Trent and Witham Valleys.

To demonstrate the true threat to these communities, this Independent Hydrological Assessment abandons static mapping. Instead, it utilizes dynamic kinematic modelling, incorporating gravitational relief drops, wind-driven rain multipliers, and dynamic conveyance penalties to expose the true Lateral Overtopped Volumes these projects will force into the region.

PROCEDURAL SUBMISSION: **The Imperative for Independent, Non-Commercial Peer Review**

While this forensic assessment is strictly grounded in statutory UK methodologies (CIRIA, FEH) and contemporary peer-reviewed kinematic science (e.g., Baiamonte et al.), we transparently acknowledge that it is an independently commissioned community model that has not yet undergone formal institutional peer review.

However, the sheer scale of the compound flood risk identified herein—demonstrating 5.49 million cubic metres of unattenuated lateral overtopping—presents an acute and material threat to life, property, and regional infrastructure. The catastrophic disparity between the developers' traditional 2D static mapping and the kinetic, 3D reality of these sites is too severe to be dismissed as a mere difference of opinion or administrative inconvenience.

When presented with credible, physics-based evidence of a systemic threat of this magnitude, the Precautionary Principle dictates that the burden of investigation fundamentally shifts. We respectfully submit that the Secretary of State now holds a statutory duty of care to subject these mathematical findings to rigorous, independent peer review at the highest level before any Development Consent Orders (DCOs) can be safely granted.

Crucially, we must formally stipulate that this review cannot be delegated to standard commercial engineering or planning consultancies. The commercial environmental consultancy sector is structurally and financially reliant on utility-scale developers for their ongoing DCO planning contracts. This creates an inherent and insurmountable conflict of interest when asking them to evaluate a disruptive model that exposes the dangerous inadequacies of their own industry-standard methodologies. A commercial consultancy cannot be expected to objectively validate a community model that proves standard developer mathematics are fundamentally flawed.

Instead, to ensure the absolute integrity of the Examination process, we strongly urge the Secretary of State to commission a truly independent, uncompromised review of this model by top-tier academic or institutional hydrodynamic experts. We formally request that the Secretary of State submits this framework to a body completely insulated from developer funding, such as the UK Centre for Ecology & Hydrology (UKCEH) or a leading university department specialising in advanced catchment kinematics and compound flood dynamics.

The physical safety of the Trent and Witham valley communities—and the integrity of the national infrastructure planning process—must be judged by rigorous, independent science, and must not be left to the compromised assurances of an industry marking its own homework.

PART I: Introduction to the Hydrological & Hydraulic Model

The Reconciled Master Hydrological & Hydraulic Model is a quantitative framework commissioned to assess the true surface water runoff, peak discharge rates, and localized flood stage impacts of seven proposed co-located utility-scale solar installations.

By calculating the volumetric difference between the natural baseline ("Greenfield") and the industrialized state ("Post-Development"), the model identifies the **Lateral Overtopped Volume**. This represents the sheer mass of excess floodwater that cannot be realistically retained by the developers' proposed Sustainable Drainage Systems (SuDS). Consequently, this water will be forcibly discharged off-site, transferring severe flood risk directly to neighbouring third-party communities, local road networks, and residential properties.

To accurately model these catchments, the parameters must reflect both the highly restrictive, historically documented geology of the region and the modern scientific consensus on solar park hydrology—even where UK regulatory handbooks have failed to catch up.

- **The Severe Soil Profile (Trent Valley Context):** The geographic area hosting most of these projects features notoriously poor-draining, highly impermeable soils. The Trent Valley and Lincolnshire floodplains are dominated by deep alluvial deposits and pelostagnogleys (stagnant groundwater gley soils)—specifically the Fladbury, Foggathorpe, and Compton soil associations. [1] Under the Hydrology of Soil Types (HOST) classifications, these soils suffer from naturally high groundwater tables and lack deep macro-drainage. While they may fissure and permit moderate infiltration during dry summers, they rapidly reach absolute field capacity during the winter. Once saturated, these alluvial flats seal completely, becoming entirely impermeable and instantly converting subsequent precipitation into catastrophic surface runoff. (For Springwell see section 4.3)
- **The "Dripline" Effect (Baiamonte et al.):** The hydrological impact of industrial solar arrays is severe. The latest empirical kinematics research by Baiamonte et al.[2] proves that rainwater falling onto impermeable solar panels concentrates massive kinetic energy at the lower "dripline." This localized force scours the topsoil, strips vegetation, and etches preferential micro-channels. Crucially, Baiamonte's research demonstrates that solar arrays can increase peak discharge (Q) by up to 11.7 times and accelerate the speed to runoff by 5 times compared to a natural baseline.
- **A Restrained, "Conservative" Methodology:** To ensure the developers cannot dismiss this community-led assessment as "overstated," this model deliberately restricts its parameters to standard UK statutory methodologies (CIRIA, FEH). Because UK handbooks do not yet possess specific multipliers for solar panel driplines, this model is highly conservative—meaning it actively understates the true risk. We have not applied Baiamonte's 11.7x peak

discharge multiplier. Instead, we conservatively used standard handbook adjustments for compacted soils. Therefore, the devastating flood volumes proven in this model represent the *absolute* ***minimum threat*** to the region; the scientific reality is that the flooding will be much worse.

PART II: Scenario Definitions

The model subjects the catchments to three distinct series of hydrological conditions to reflect the lived reality of the local communities:

Series 1: Regulatory Baselines (Standard Soil Conditions)

This series represents the highly optimistic, unsaturated soil conditions typically used by developers in standard planning applications.

- **Scenario 1a [100-Yr (+39% CC) Greenfield]:** The regulatory baseline. The natural agricultural land experiencing a 1-in-100-year storm, adjusted for climate change.
- **Scenario 1b [100-Yr (+39% CC) Post-Development]:** The operational solar farm experiencing the same storm, utilizing standard, restrained handbook adjustments for soil compaction and channelling.
- **Scenario 1c & 1d [1000-Yr Greenfield & Post-Dev]:** Represents the absolute limits of the historical floodplain under an extreme (0.1% annual chance) storm event before and after industrialization.

Series 2: Saturated Ground Conditions (The Winter Reality)

Rather than theoretical assumptions, this series models the empirically documented realities of the Trent Valley winter storm season. These conditions accurately reflect recent, devastating historical events experienced by the community, such as the widespread prolonged flooding of 2000, 2020 storm Dennis and the compounding impacts of Storm Babet followed rapidly by Storm Henk in the winter of 2023/2024.

- **Scenarios 2a & 2b [100-Yr (+39% CC) Saturated Greenfield & Post-Dev]:** Simulates a major storm hitting a landscape that is already saturated by sequential winter rains. Scenario 2b drives *Stress Test 1*, proving that once the region's clay soils lock up, the sheer volume of displaced Post-Development water will immediately overwhelm realistic SuDS capacities, flooding the surrounding region.
- **Scenarios 2c & 2d [1000-Yr Sat Greenfield & Post-Dev]:** Applies an extreme storm to the fully waterlogged landscape.

Series 3: Pluvial & Compound Events (System Failure)

- **Scenarios 3a & 3b [Extreme Pluvial Greenfield & Post-Dev]:** Simulates a sudden, highly intense localized "cloudburst" to demonstrate how the shortened Time of Concentration created by the solar arrays will rapidly inundate the local area before developer SuDS can react.
- **Scenario 3c/d [Surge Saturated]:** A compound exceedance test (*Stress Test* 2). It assumes heavy rainfall hits saturated ground simultaneously with a downstream fluvial/tidal surge in the River Trent that hydraulically "locks" the

drainage network outfalls, forcing all site water to spill laterally into adjacent communities.

PART III: Justification of Restrained Discretionary Parameters

The mathematical equations within the model utilize parameters based strictly on established United Kingdom statutory and engineering frameworks. [3] By refusing to inflate these numbers beyond what the developer's own guidance manuals dictate, the community establishes an undeniable baseline of harm.

(Note: The Conveyance Coefficient [k] is applied across all localized Stage Rise calculations. Its dynamic application to the regional models is fully detailed in Section 4.4).

Scenario 1a: 100-Yr (+39% CC) Greenfield

- **Runoff Coefficient (C=0.25):** Derived directly from the CIRIA SuDS Manual for flat, rural arable land. Even on restrictive Trent Valley clay, active agricultural management (deep ploughing, crop cover) allows the topsoil to intercept roughly 75% of initial rainfall prior to winter saturation.
- **Precipitation Depth (P=103.416 mm):** The statutory depth derived from the Flood Estimation Handbook (FEH) for the specific site coordinates (74.4 mm), mathematically adjusted using the Environment Agency's mandated "Upper End" climate change allowance (+39%).
- **Rainfall Intensity (I=27.8 mm/hr):** Natural arable landscapes possess high surface roughness, slowing overland flow and yielding a lower peak intensity profile on the FEH Intensity-Duration-Frequency (IDF) curves.

Scenario 1b: 100-Yr (+39% CC) Post-Development

- **Runoff Coefficient (C=0.55) & Rainfall Intensity (I=80.0 mm/hr):**
    - *Crucial Restraint:* Baiamonte et al. demonstrate that solar arrays accelerate speed to runoff by 5x and increase peak discharge by up to 11.7x. If we applied the true science, the intensity and runoff factors would be materially higher. By conservatively limiting ourselves to C=0.55 (standard industrial compaction) and I=80, we deliberately understate the risk to ensure the developer cannot claim the model is exaggerated.
    - Because micro-channelled driplines and engineered tracks route water off-site faster, we selected a higher peak Rainfall Intensity (I=80.0 mm/hr) from standard IDF curves but kept it well below the 5x speed multiplier documented in current science.
- **Precipitation Depth (P=103.416 mm):** Mirrored exactly from 1a to provide an undeniable comparative volumetric baseline.

Scenario 1c & 1d: 1000-Yr Greenfield & Post-Development

- **Runoff Coefficients (C=0.25 & C=0.55):** Maintained from 1a and 1b respectively.
- **Precipitation Depth (P=93.0 mm):** Sourced strictly from the FEH statistical depth for a 1-in-1000-year storm. EA guidelines do not require a climate multiplier for the 0.1% return period.

- **Rainfall Intensities (I=26.7 & I=105.0 mm/hr):** The delta reflects the slow travel time of the natural terrain versus the accelerated routing of the formalized solar farm under extreme load.

Scenarios 2a, 2b, 2c, 2d: Saturated Ground Conditions

- **Runoff Coefficient (C=0.80):** Selected from the standard CIRIA C753 guidance for highly impermeable clay soils. This is not an extreme assumption; it is the physical reality of Trent Valley alluvial gleys. Once the ground reaches field capacity (as historically experienced during Storms Babet and Henk), infiltration drops to near-zero, forcing 80% of rainfall to instantly convert to overland flow. The model proves that at this 0.80 threshold, the sheer volume of water generated mathematically dwarfs any realistic attenuation basin the developer could install.

Precipitation & Intensity: Kept identical to Series 1 baselines. While the volume of runoff matches between Greenfield and Post-Dev when saturated, the much higher Post-Dev intensity (I) is retained to model the devastating speed at which the panel driplines force that water into the local community.

Scenarios 3a & 3b: Extreme Pluvial Greenfield & Post-Development

- **Precipitation Depth (P=125.0 mm):** A standard synthesized upper-bound depth used to simulate a Probable Maximum Precipitation (PMP) event that physically exceeds standard FEH statistical models.
- **Rainfall Intensity (I=140.0 mm/hr):** Reflects the violent, short-duration nature of a sudden summer cloudburst, where the extreme rate of rainfall generates immediate overland flash-flood peaks before the soil can absorb it.

Scenario 3c/d: Surge Saturated

- **Runoff Coefficient (C=0.90):** Models the systemic community threat of the Trent Valley: heavy rainfall hitting alluvium that is fully saturated and hydraulically locked by high water levels in the receiving river networks. The site effectively becomes a paved bowl, converting 90% of the rainfall directly into flood volume that will overtop boundaries and impact neighbouring properties.

PART IV: Core Model Adjustments & Community Defences

The Causal Chain of Flood Failure: Key Mathematical Framework To categorically prove the catastrophic flood risk posed by this infrastructure, this Independent Assessment utilizes a sequential mathematical chain. The causal chain of the core equations is laid out below to demonstrate how standard developer volume assumptions trigger total systemic failure in the real world:

- **STEP 1: THE TOTAL MASS (Equation 1: Volumetric Formulation)** Calculates the total cubic volume of water generated over the entire lifespan of the storm event. *(This total volume is held in the ledger until Step 4).*

$$V = AxCxPx10x1.18 \tag{1}$$

- **STEP 2: THE MAXIMUM SPEED (Equation 2: Peak Discharge, Q)** Uses the Rational Method to calculate the violent peak flow rate driven off the solar arrays at the storm’s most intense moment.

$$Q = \frac{C\ x\ I\ x\ A\ 1.18}{360} \tag{2}$$

STEP 3: THE SYSTEM RUPTURE (Equation 4: Exceedance Index, h = Q/k) This is the critical failure threshold. When the massive Peak Discharge (Q from Step 2) hits the choked, obstructed river network (Dynamic Conveyance Penalty *k* from Equation 3), forward flow stops and converts to vertical hydrostatic pressure (*h*). When *h* mathematically exceeds the physical height of the riverbanks, containment violently fails.

$$h = \frac{Q}{k} \tag{4}$$

- **STEP 4: THE CATASTROPHIC SPILL (Equation 5: Lateral Overtopped Volume)** Once Step 3 proves the riverbanks have ruptured, this equation utilizes the total mass calculated back in Step 1 to quantify the exact volume of unattenuated floodwater that spills laterally into neighbouring, third-party communities.

$$V\ lateral = V\ post\ dev - V\ greenfield + V\ stilt\ displacement$$

Section 4.1: Topographical Relief, Panel Driplines, and Kinetic Acceleration

Standard industry SuDS models frequently fail to adequately account for the kinetic acceleration of overland flow on sloping, industrialized terrain. The topographical surveys for these catchments reveal severe relief drops (e.g., falling from 23.0m **Above Ordnance Datum (AOD)** at the catchment boundaries down to 4.5m AOD at the receiving river levels). While this 18.5-meter gravitational fall(16.57- metre average) provides the baseline slope for a flash-flood response, the primary kinetic accelerator is the introduction of the solar arrays themselves.

Developers routinely rely on the fallacy of "hydrological neutrality," often citing the foundational field testing of Cook and McCuen (2013) to claim panels do not alter overall catchment volume. However, this selectively ignores the authors' critical physical finding: impermeable solar panels forcefully concentrate water. Rain coalesces on the glass and falls from the lower edge, striking the ground with up to **10 times the kinetic energy** of natural, dispersed rainfall. This extreme, 10-fold kinetic bombardment acts like a localized pressure washer, violently scouring the topsoil, destroying vegetative friction, and etching highly efficient micro-channels at the dripline.

This initial mechanical destruction sets the stage for the kinematic multipliers established by contemporary hydrodynamic research (Baiamonte et al., 2023, detailed in Part I). Baiamonte mathematically proves that this panel-driven structural concentration acts as a massive flow amplifier, increasing overall peak discharge (Q) by up to 11.7 times and accelerating the speed to runoff by 5 times compared to unaltered ground.

When this violent, 10-fold kinetic strike and 11.7x discharge spike is hurled down an 18.5-meter topographical gradient over artificially compacted tracks, natural surface friction is obliterated, and the catchment's Time of Concentration (T_c), is drastically shortened. This compound physical reality—topographical gravity combined with the immense Cook and Baiamonte dripline multipliers—provides the irrefutable geographic justification for the elevated Peak Rainfall Intensities (I = 80.0 to 105.0 mm/hr) utilized in the Post-Development modelling. Attempting to mitigate this gravity-accelerated, panel-concentrated shockwave using standard flat-catchment attenuation basins will mathematically guarantee violent, immediate overtopping at the 4.5m valley floor.

Section 4.2: The Wind-Driven Rain & Panel Tilt Multiplier (1.18)

When standard industry models calculate the volume of rainfall hitting a catchment, they rely on 2D topographical maps, effectively treating the ground as a perfectly flat plane. While acceptable for natural Greenfield land, this “flat-earth mathematics” represents a catastrophic error when applied to industrial solar infrastructure.

Solar panels are pitched at steep angles (typically 15° to 35° in the UK). During severe winter storms and summer cloudbursts, rain does not fall vertically; it is driven at severe angles by high winds. Consequently, a tilted panel acts as a geometric sail, physically intercepting a significantly larger volume of angled rain than the horizontal ground beneath it would have naturally caught. Trigonometry dictates that the effective catchment area of a tilted plane intercepting angled rain increases by the inverse cosine of the tilt angle $(1/cos(32°) \approx 1.18)$ For an array tilted at roughly 32 degrees, this generates a geometric catchment multiplier of exactly 1.18. By failing to include this physical reality, standard developer models mathematically hide 18% of the water that will strike their arrays, guaranteeing their SuDS will critically overtop. This geometrical and physical reality is exceptionally critical when applied to the One Earth proposal and the six contingent proposals (Cottam, Gate Burton, West Burton, Tillbridge, Springwell, and Great North Road) sharing the hydrological systems of the Trent and Witham valleys. When this 1.18 geometric tilt multiplier is cumulatively applied across all seven interacting and contiguous sites, the suppressed volumetric data exposes the true regional hazard that developers are attempting to mitigate in isolation.

Section 4.3: Catchment Sensitivity Analysis – Springwell & The River Witham

While six of the proposed installations interact with the severe alluvial gleys of the Trent Valley, the Springwell site is located further east, interacting with the fen-edge loams of the River Witham catchment. To pre-empt any developer attempts to dismiss the model based on “better local soil,” the model evaluates Springwell using a bespoke Catchment Sensitivity Profile. Rather than mitigating the development’s impact, integrating these localized parameters proves that the volumetric shock to the community during winter storms will be mathematically worse.

- **The "Baseline Shock" (Lowered Runoff Coefficients):** The model conservatively concedes the developer's likely premise: that the natural fen-edge loam absorbs rainwater better than Trent clay. The Greenfield baseline Runoff Coefficient (C) is lowered from 0.25 to 0.15. By acknowledging the land's current superior ability to absorb water, the model proves a catastrophic "Baseline Shock." Paving over highly functioning natural soil creates a far more violent hydrological displacement than paving over clay. When the winter water table rises and the soil inevitably locks up (Stress Test 1), the loss of this vital natural sponge means the displaced water dumped into the local community increases.
- **The Witham Bottleneck (Lowered Conveyance Coefficient):** The Trent tributaries are wide and possess high volumetric capacity. Conversely, the River Witham and the local fen drains are notoriously narrow, heavily constrained, and prone to rapid, "flashy" backing up. To mathematically reflect this restricted capacity, the model cuts the conveyance coefficient (k) in half for Springwell, down to 180. When the artificially accelerated peak discharge hits this restricted river network, the model proves that the localized floodwaters will breach a catastrophic 1.19-meter vertical depth during a compound surge event.

Section 4.4: Floodplain Constriction & Surcharge (Dynamic Conveyance k)

To accurately model the regional aggregation of floodwaters, the model utilizes Dynamic Conveyance Penalties (k) to reflect the physical obstructions introduced by industrialization. In the Greenfield baselines, a high conveyance (k ≈ 326 to 367) is utilized to represent the unhindered movement of floodwater across open agricultural floodplains.

However, the proposed developments intersect over 4,361 hectares of active floodplain. The introduction of raised access tracks and kilometres of mesh security fencing physically obstructs overland flow routes. During a flood event, security fencing acts as a debris screen, catching vegetation and creating impermeable "debris dams." To mathematically account for this severe loss of floodplain conveyance, the Post-Development regional capacity is accurately penalized down to $k \approx 205.8$. Furthermore, under Scenario 3c/d (Surge Saturated), the model accounts for the "Tailwater Surcharge" (Hydraulic Locking) of the River Trent and River Witham. When downstream water levels surge, the hydraulic gradient flattens, dropping the effective evacuation capacity of the regional network to a modeled threshold $k = 84.0$. This proves that during a major winter surge, the artificially accelerated solar farm runoff physically cannot escape the catchment, forcing the system into catastrophic hydraulic failure**.**

Clarification on the Theoretical Exceedance Index (h = Q / k): To quantify this systemic failure, Equation 4 of this model introduces the fundamental hydraulic relationship between flow and capacity to calculate the Theoretical Hydrostatic Exceedance Index. Derived from the principles of open-channel specific conveyance (e.g., Manning's Equation), this formula evaluates what happens when a massive kinetic flow (*Q*, Peak Discharge) hits a severely restricted bottleneck (*k*, Dynamic Conveyance Penalty).

Normally, water flows down a gradient. However, during a “hydraulic lock” caused by downstream river surges, the forward hydraulic gradient flattens to zero and kinetic flow converts to vertical pressure. This linear formulation is deliberately deployed as a theoretical pressure gauge, not a literal prediction of localized standing flood depths. It mathematically calculates the violent vertical hydrostatic pressure spike (*h*) required to force the aggregate peak flow through a fully surcharged and debris-locked outfall.

Because open-channel fluid mechanics dictate that water cannot physically stack vertically to these extreme theoretical heights (e.g., reaching 23.37 metres under a combined locked scenario), the moment this mathematical index (*h*) breaches the physical bank level, the system suffers a catastrophic containment failure. The massive vertical potential energy immediately converts into horizontal kinetic energy, violently blasting the unattenuated volumes (quantified strictly in **Equation 5: Lateral Overtopped Volume**) sideways into adjacent, unprotected third-party land.

PART V: The Statutory & Policy Data Vacuum

The mathematical failures demonstrated in this Reconciled Master Model expose a severe structural vulnerability in how the developers and host authorities evaluate cumulative risk. By applying standard empirical greenfield formulas to a macro-canopy structure, the developers are exploiting a fundamental vacuum in statutory planning policy.

1. The Baseline Vacuum in Local Strategic Flood Risk Assessments (SFRAs)

The One Earth proposal, alongside the six contingent NSIPs, anchors its environmental baseline to the existing SFRAs and Water Cycle Studies maintained by the host authorities (e.g., Newark & Sherwood District Council, Central Lincolnshire). However, these strategic documents were drafted to assess traditional growth metrics (housing and commercial development). Their baseline models assume the Trent and Witham valleys remain uniform agricultural land. Because these host authorities possess no joint, cross-boundary macro-catchment model capable of calculating the aggregate impact of an 8,844-hectare impermeable solar canopy, developers are anchoring their localized "greenfield runoff" assertions to a completely fictional baseline.

2. Section 104, NPPF Paragraph 35, and Cumulative Lag

Developers routinely attempt to shield themselves from cumulative scrutiny by arguing that the National Planning Policy Framework (NPPF) does not strictly govern NSIPs. Under Section 104 of the Planning Act 2008, Local Development Plan frameworks—and the fundamental "Effectiveness" tests of NPPF Paragraph 35 requiring joint working on cross-boundary strategic priorities—remain explicitly "important and relevant" matters. By using artificially limited "Zones of Influence" to evaluate neighbouring schemes sequentially, developers ignore the physical reality of Cumulative Lag. While individual attenuation ponds might delay peak flow for a localized storm on paper, they do not prevent a massive increase in the total volume of water discharged into the hydraulically locked Trent catchment over a prolonged wet period. Without a joint, catchment-wide model to assess this conjoined cluster, it is legally impossible to conclude that site-specific SuDS are resilient.

3. The Environmental Target Retrogression and Core Baseline Failure

This Independent Hydrological and Hydraulic Assessment establishes the empirical certainty of massive, unattenuated lateral overtopping—quantified in the Master Hydraulic Matrix and Calculation Register (Appendices 1 and 2) as generating between 4.94 million and 5.49 million cubic metres of uncompensated floodwater under conjoined post-development conditions. Propelled at a non-linear kinetic velocity of 1,962.96 cubic metres per second, this unattenuated volume will act as a highly destructive kinematic shockwave across the low-lying Trent and Witham catchments.

This data proves that the proposed industrial rollout forces a severe, active retrogression of regional flood resilience. Although this application is procedurally evaluated under the transitional framework of the Infrastructure Planning (EIA) Regulations 2017 rather than active 2026 Environmental Outcomes Report (EOR) statutory metrics, this independent assessment provides the exact site-specific data that exposes the Applicant's environmental statement as a scientific fiction. In the absolute absence of a joint macro-catchment model funded and verified by the Applicant or the statutory authorities to mathematically disprove these first-principles findings, the baseline record remains terminally defective, and the scheme's claims of hydrological neutrality are entirely dismantled.

PART VI: EXECUTIVE CONCLUSION AND STATUTORY DEMAND TO THE SECRETARY OF STATE

1. Uncontradicted Evidence and the Collapse of the Safety Case

With the submission of this Independent Hydrological and Hydraulic Assessment, the Secretary of State is now in possession of formal, mathematically proven, and uncontradicted evidence. By integrating the empirical proofs of Cook and McCuen’s 10-fold kinetic dripline strikes, Baiamonte’s kinematic flow acceleration, and the strict volumetric realities of Surge Saturated hydraulic locking, this model proves that standard static drainage assumptions cannot safely accommodate the unprecedented industrialization of the Trent and Witham Valleys.

Consequently, it is an undeniable evidentiary fact that the fundamental safety cases for the pending **One Earth Solar Farm** and the **Great North Road** project have simply not been made during their respective Examinations. Furthermore, this systemic mathematical and forensic failure inherently invalidates the safety cases of the **five contiguous solar NSIPs that have already been granted Development Consent Orders** (Cottam, Gate Burton, West Burton, Tillbridge, and Springwell).

2. Dereliction of Statutory Duty under the EIA Regulations 2017

The reliance on isolated, static 2D screening maps to evaluate 8,844 hectares of hydraulically conjoined, kinetic infrastructure is not merely a technical oversight; it is a profound regulatory failure. The host authorities, the Environment Agency, and the Examining Authorities have allowed developers to systematically "salami-slice" their impact boundaries, evading the physical reality of cumulative mass displacement.

This represents a clear and indefensible dereliction of responsibility under the **Infrastructure Planning (Environmental Impact Assessment) Regulations 2017**. Specifically, Schedule 4, Paragraph 5 of the EIA Regulations legally mandates the rigorous assessment of the *"cumulation of effects with other existing and/or approved projects,"* alongside the vulnerability of the project to *"major accidents or disasters"* (including extreme compound flooding). By failing to demand a joint, macro-catchment hydrodynamic model capable of calculating synchronized peak discharge and dynamic tailwater surcharge across the Trent and Witham valleys, the statutory authorities have failed to protect the public. They have authorized an unprecedented industrialization of the floodplain without understanding the physics of the water they are displacing.

3. The Statutory Demand for a Catchment-Wide Halt

The Precautionary Principle and the fundamental tenets of UK planning law dictate that national infrastructure cannot proceed on a foundation of compromised, incomplete, or missing mathematics. The uncontradicted evidence proves that millions of cubic metres of unattenuated lateral overtopping represent an acute and material threat to the lives, properties, and infrastructure of the rural communities in the Trent and Witham Valleys.

It is therefore legally and morally incumbent upon the Secretary of State to acknowledge this systemic regulatory failure and immediately call a halt to this regional rollout. We formally demand that the Secretary of State:

1. **Halts all progression and refuses to grant** Development Consent Orders for the active One Earth and Great North Road applications.
2. **Issues an immediate statutory suspension** on the commencement and implementation of the five already-approved solar NSIPs in this catchment cluster.

This statutory halt must remain in absolute effect until a fully independent, multi-project, kinematic hydrodynamic model is commissioned to accurately assess the cumulative flood hazard as strictly required by the EIA 2017 regulations. Until this cumulative safety case is indisputably proven, permitting this localized industrialization to proceed represents an unacceptable and unlawful threat to human life.

Stephen Fox *BA MSc*

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Footnotes & Data Provenance

1. **Soil Classification Context:** Soil profile descriptions are derived from the Cranfield University National Soil Resources Institute (NSRI) Soilscapes index and the Hydrology of Soil Types (HOST) classifications specific to the Trent Valley and Lincolnshire floodplains. *Full Citations: Cranfield University (2001). Soilscapes England & Wales. Cranfield National Soil Resources Institute (NSRI). LandIS. Available at: https://www.landis.org.uk/data/nmsoilscapes.cfm; Boorman, D. B., Hollis, J. M., & Lilly, A. (1995). Hydrology of soil types: a hydrologically-based classification of the soils of the United Kingdom. Institute of Hydrology, Report No. 126.*
2. **Solar Hydrology Dynamics & Scientific Restraint:** References the contemporary academic proofs established by Baiamonte, G. (2023). "Impact of solar panels on runoff generation process." *Hydrological Processes*, 37(12), e15053. https://doi.org/10.1002/hyp.15053. This peer-reviewed literature demonstrates that panel “driplines” significantly concentrate flow, scour topsoil, and can increase peak discharge (Q) by up to 11.7 times, while increasing the speed to runoff by up to 5 times compared to unaltered ground. This model has explicitly not applied these catastrophic multipliers, opting instead to use standard UK regulatory proxies to categorically avoid developer allegations of exaggeration.
3. **Restrained Standard Derivations:** To ensure findings are unassailable, baseline coefficients and methodologies are restrained within the boundaries of the CIRIA C753 framework (*The SuDS Manual*, Woods Ballard, B. et al., 2015, CIRIA, London, Chapter 24); Precipitation Depths are generated via the UK Centre for Ecology & Hydrology (UKCEH) *Flood Estimation Handbook (FEH) Web Service* (2026, available at: https://fehweb.ceh.ac.uk/); Climate Change uplifts adhere strictly to the Environment Agency (EA) statutory guidance (*Flood risk assessments: climate change allowances*, updated 2022/2026, Humber River Basin District, “Upper End” 39% allowance).

Appendix 1 MASTER HYDRAULIC MATRIX sheet 1

Variables & Scenarios	**West Burton**	**One Earth**	**Springwell (Bespoke)**	**Combined 7-Project Total**
Site Boundary Area (Order Limits) (ha)	886	1409	1280	8844
Active PV Array Footprint (ha)	734	735	623	4753
Floodplain Intersect Area (100-Yr) (ha)	734	463	504	4362
Floodplain Intersect Area (1000-Yr) (ha)	734	504	550	4449
Topographic Relief Drop (m)	15	22.5	16.5	16.57 (avg)
Uncompensated Stilt Storage Loss (m^3)	33250	39900	31150	230965
Scenario 1a: 100-Yr Greenfield Volume (m3)	189768	190027	96642	1164400
Scenario 1a: 100-Yr Greenfield Peak Flow Q (m3/s)	14.1703	14.1896	7.2164	86.9474
Scenario 1a: 100-Yr Greenfield Theoretical Exceedance Index (m)	0.0394	0.0394	0.0401	0.2667
Scenario 1b: 100-Yr Post-Dev Volume (m3)	492639	493310	342114	3114011
Scenario 1b: 100-Yr Post-Dev Peak Flow Q (m3/s)	105.8591	106.0033	73.514	669.1446
Scenario 1b: 100-Yr Post-Dev Theoretical Exceedance Index (m)	0.2941	0.2945	0.4084	3.2514
Scenario 1c: 1000-Yr Greenfield Volume (m3)	170655	170888	86909	1047122
Scenario 1c: 1000-Yr Greenfield Peak Flow Q (m3/s)	13.6096	13.6281	6.9309	83.507
Scenario 1c: 1000-Yr Greenfield Theoretical Exceedance Index (m)	0.0378	0.0379	0.0385	0.2562
Scenario 1d: 1000-Yr Post-Dev Volume (m3)	443020	443624	307656	2800370
Scenario 1d: 1000-Yr Post-Dev Peak Flow Q (m3/s)	138.9401	139.1294	96.4871	878.2522
Scenario 1d: 1000-Yr Post-Dev Theoretical Exceedance Index (m)	0.3859	0.3865	0.536	4.2675
Scenario 2a: 100-Yr Sat Greenfield Volume (m3)	607259	608086	483211	3900035
Scenario 2a: 100-Yr Sat Greenfield Peak Flow Q (m3/s)	45.3449	45.4067	36.0821	291.2212
Scenario 2a: 100-Yr Sat Greenfield Theoretical Exceedance Index (m)	0.126	0.1261	0.2005	0.8933
Scenario 2b: 100-Yr Sat Post-Dev Volume (m3)	716565	717542	570189	4602041
Scenario 2b: 100-Yr Sat Post-Dev Peak Flow Q (m3/s)	153.9769	154.1867	122.5233	988.8951
Scenario 2b: 100-Yr Sat Post-Dev Theoretical Exceedance Index (m)	0.4277	0.4283	0.6807	4.8051
Scenario 2c: 1000-Yr Sat Greenfield Volume (m3)	546096	546840	434543	3507225
Scenario 2c: 1000-Yr Sat Greenfield Peak Flow Q (m3/s)	43.5507	43.61	34.6544	279.6981
Scenario 2c: 1000-Yr Sat Greenfield Theoretical Exceedance Index (m)	0.121	0.1211	0.1925	0.858
Scenario 2d: 1000-Yr Sat Post-Dev Volume (m3)	644393	645271	512760	4138526
Scenario 2d: 1000-Yr Sat Post-Dev Peak Flow Q (m3/s)	202.0947	202.37	160.8119	1297.9248
Scenario 2d: 1000-Yr Sat Post-Dev Theoretical Exceedance Index (m)	0.5614	0.5621	0.8934	6.3067
Scenario 3a: Extreme Pluvial Greenfield Volume (m3)	229375	229688	116813	1407422
Scenario 3a: Extreme Pluvial Greenfield Peak Flow Q (m3/s)	71.3611	71.4583	36.3417	437.8646
Scenario 3a: Extreme Pluvial Greenfield Theoretical Exceedance Index (m)	0.1982	0.1985	0.2019	1.3431
Scenario 3b: Extreme Pluvial Post-Dev Volume (m3)	595458	596269	413516	3763938
Scenario 3b: Extreme Pluvial Post-Dev Peak Flow Q (m3/s)	185.2534	185.5058	128.6495	1171.003
Scenario 3b: Extreme Pluvial Post-Dev Theoretical Exceedance Index (m)	0.5146	0.5153	0.7147	5.69
Scenario 3c/d: Surge Saturated Volume (m3)	974385	975713	827033	6309541
Scenario 3c/d: Surge Saturated Peak Flow Q (m3/s)	303.142	303.555	257.299	1962.9683
Scenario 3c/d: Surge Saturated Theoretical Exceedance Index (m)	0.8421	0.8432	1.4294	23.3687
100-Yr (+39% CC) Lateral Overtopped (m3)	336120	343183	276621	2180577
1000-Yr Lateral Overtopped Volume (m3)	305615	312636	251898	1984213
Stress Test 1: Lateral Overtopped Volume (m3)	560047	567415	504697	3668606
Stress Test 2: Lateral Overtopped Volume (m3)	836980	844725	771274	5493384

Appendix 1 MASTER HYDRAULIC MATRIX sheet 2

Variables & Scenarios	**GNR**	**Tillbridge**	**Gate Burton**	**Cottam**
Site Boundary Area (Order Limits) (ha)	1765	1400	834	1270
Active PV Array Footprint (ha)	550	739.56	474	897.39
Uncompensated Stilt Storage Loss (m3)	23750	35625	19790	47500
Scenario 1a: 100-Yr Greenfield Volume (m3)	142197	191205.84	122547.96	232011.21
Scenario 1a: 100-Yr Greenfield Peak Flow Q (m3/s)	10.6181	14.2776	9.1508	17.3246
Scenario 1a: 100-Yr Greenfield Theoretical Exceedance Index (m)	0.0295	0.0397	0.0254	0.0481
Scenario 1b: 100-Yr Post-Dev Volume (m3)	369143.41	496370.37	318134.5	602301.1
Scenario 1b: 100-Yr Post-Dev Peak Flow Q (m3/s)	79.3222	106.661	68.3613	129.4236
Scenario 1b: 100-Yr Post-Dev Theoretical Exceedance Index (m)	0.2203	0.2963	0.1899	0.3595
Scenario 1c: 1000-Yr Greenfield Volume (m3)	127875	171947.7	110205	208643.18
Scenario 1c: 1000-Yr Greenfield Peak Flow Q (m3/s)	10.1979	13.7127	8.7888	16.6391
Scenario 1c: 1000-Yr Greenfield Theoretical Exceedance Index (m)	0.0283	0.0381	0.0244	0.0462
Scenario 1d: 1000-Yr Post-Dev Volume (m3)	331963.5	446376.23	286092.18	541637.68
Scenario 1d: 1000-Yr Post-Dev Peak Flow Q (m3/s)	104.1104	139.9925	89.7243	169.8684
Scenario 1d: 1000-Yr Post-Dev Theoretical Exceedance Index (m)	0.2892	0.3889	0.2492	0.4719
Scenario 2a: 100-Yr Sat Greenfield Volume (m3)	455030.4	611858.7	392153.47	742435.87
Scenario 2a: 100-Yr Sat Greenfield Peak Flow Q (m3/s)	33.9778	45.6884	29.2827	55.4388
Scenario 2a: 100-Yr Sat Greenfield Theoretical Exceedance Index (m)	0.0944	0.1269	0.0813	0.154
Scenario 2b: 100-Yr Sat Post-Dev Volume (m3)	536935.87	721993.26	462741.1	876074.33
Scenario 2b: 100-Yr Sat Post-Dev Peak Flow Q (m3/s)	115.3778	155.1433	99.4347	188.2525
Scenario 2b: 100-Yr Sat Post-Dev Theoretical Exceedance Index (m)	0.3205	0.431	0.2762	0.5229
Scenario 2c: 1000-Yr Sat Greenfield Volume (m3)	409200	550232.64	352656	667658.16
Scenario 2c: 1000-Yr Sat Greenfield Peak Flow Q (m3/s)	32.6333	43.8806	28.124	53.2451
Scenario 2c: 1000-Yr Sat Greenfield Theoretical Exceedance Index (m)	0.0906	0.1219	0.0781	0.1479
Scenario 2d: 1000-Yr Sat Post-Dev Volume (m3)	482856	649274.52	416134.08	787836.63
Scenario 2d: 1000-Yr Sat Post-Dev Peak Flow Q (m3/s)	151.4333	203.6255	130.508	247.0814
Scenario 2d: 1000-Yr Sat Post-Dev Theoretical Exceedance Index (m)	0.4206	0.5656	0.3625	0.6863
Scenario 3a: Extreme Pluvial Greenfield Volume (m3)	171875	231112.5	148125	280434.38
Scenario 3a: Extreme Pluvial Greenfield Peak Flow Q (m3/s)	53.4722	71.9017	46.0833	87.2462
Scenario 3a: Extreme Pluvial Greenfield Theoretical Exceedance Index (m)	0.1485	0.1997	0.128	0.2424
Scenario 3b: Extreme Pluvial Post-Dev Volume (m3)	446187.5	599968.05	384532.5	728007.64
Scenario 3b: Extreme Pluvial Post-Dev Peak Flow Q (m3/s)	138.8139	186.6567	119.6323	226.4913
Scenario 3b: Extreme Pluvial Post-Dev Theoretical Exceedance Index (m)	0.3856	0.5185	0.3323	0.6291
Scenario 3c/d: Surge Saturated Volume (m3)	730125	981765.9	629235	1191285.22
Scenario 3c/d: Surge Saturated Peak Flow Q (m3/s)	227.15	305.4383	195.762	370.6221
Scenario 3c/d: Surge Saturated Theoretical Exceedance Index (m)	0.631	0.8484	0.5438	1.0295
100-Yr (+39% CC) Lateral Overtopped (m3)	250696.41	340789.52	215376.54	417789.89
1000-Yr Lateral Overtopped Volume (m3)	227838.5	310053.53	195677.18	380494.51
Stress Test 1: Lateral Overtopped Volume (m3)	418488.87	566412.42	359983.14	691563.12
Stress Test 2: Lateral Overtopped Volume (m3)	626000	845443.2	538820	1030142.05

Appendix 2 HYDRAULIC CALCULATION LEDGER

METHODOLOGICAL CLARIFICATION: The Relationship Between Volume and Peak Discharge To accurately interpret this ledger, it is critical to understand that Equations 1 and 2 calculate two entirely separate physical metrics of the exact same storm event. They act as parallel engines within the model: Equation 2 proves the riverbanks will rupture; Equation 1 dictates exactly how much water spills out when they do.

EQUATION 1: VOLUMETRIC RUNOFF FORMULATION

Formula (Greenfield): Volume V (m^3) = Area A (ha) × Runoff Coefficient C × Precipitation Depth P (mm) × 10

Formula (Post-Dev): Volume V (m^3) = Area A (ha) × Runoff Coefficient C × Precipitation Depth P (mm) × 10 × 1.18 (Panel Tilt Multiplier)

*Routeing Note: Equation 1 calculates the **total mass** of water generated over the lifespan of the storm event. The output of this calculation bypasses the middle equations and is fed directly into **Equation 5** to determine the final Lateral Overtopped Volume*

Note: To strictly pre-empt standard commercial rebuttals regarding macro-atmospheric limits and Conservation of Mass, this Master Model subjects the 1.18 volumetric multiplier to a rigorous Bounding Mass Constraint Concession in Appendix 5. As proven therein, even when atmospheric mass limits are strictly capped, the system still generates a catastrophic 4.94 million cubic metres of lateral overtopping

Project Name	Scenario	Specific Calculation Step	Computed Runoff Volume (m3)
West Burton	1a: 100-Yr Greenfield	734 ha x 0.25 x 103.416 mm x 10	189768.36
West Burton	1b: 100-Yr Post-Dev	734 ha x 0.55 x 103.416 mm x 10 x 1.18	492638.66
West Burton	1c: 1000-Yr Greenfield	734 ha x 0.25 x 93.0 mm x 10	170655
West Burton	1d: 1000-Yr Post-Dev	734 ha x 0.55 x 93.0 mm x 10 x 1.18	443020.38
West Burton	2a: 100-Yr Sat Greenfield	734 ha x 0.8 x 103.416 mm x 10	607258.75
West Burton	2b: 100-Yr Sat Post-Dev	734 ha x 0.8 x 103.416 mm x 10 x 1.18	716565.33
West Burton	2c: 1000-Yr Sat Greenfield	734 ha x 0.8 x 93.0 mm x 10	546096
West Burton	2d: 1000-Yr Sat Post-Dev	734 ha x 0.8 x 93.0 mm x 10 x 1.18	644393.28
West Burton	3a: Extreme Pluvial Greenfield	734 ha x 0.25 x 125.0 mm x 10	229375
West Burton	3b: Extreme Pluvial Post-Dev	734 ha x 0.55 x 125.0 mm x 10 x 1.18	595457.5
West Burton	3c/d: Surge Saturated	734 ha x 0.9 x 125.0 mm x 10 x 1.18	974385
One Earth	1a: 100-Yr Greenfield	735 ha x 0.25 x 103.416 mm x 10	190026.9
One Earth	1b: 100-Yr Post-Dev	735 ha x 0.55 x 103.416 mm x 10 x 1.18	493309.83
One Earth	1c: 1000-Yr Greenfield	735 ha x 0.25 x 93.0 mm x 10	170887.5
One Earth	1d: 1000-Yr Post-Dev	735 ha x 0.55 x 93.0 mm x 10 x 1.18	443623.95
One Earth	2a: 100-Yr Sat Greenfield	735 ha x 0.8 x 103.416 mm x 10	608086.08

Project Name	Scenario	Specific Calculation Step	Computed Runoff Volume (m3)
One Earth	2b: 100-Yr Sat Post-Dev	735 ha x 0.8 x 103.416 mm x 10 x 1.18	717541.57
One Earth	2c: 1000-Yr Sat Greenfield	735 ha x 0.8 x 93.0 mm x 10	546840
One Earth	2d: 1000-Yr Sat Post-Dev	735 ha x 0.8 x 93.0 mm x 10 x 1.18	645271.2
One Earth	3a: Extreme Pluvial Greenfield	735 ha x 0.25 x 125.0 mm x 10	229687.5
One Earth	3b: Extreme Pluvial Post-Dev	735 ha x 0.55 x 125.0 mm x 10 x 1.18	596268.75
One Earth	3c/d: Surge Saturated	735 ha x 0.9 x 125.0 mm x 10 x 1.18	975712.5
Springwell (Bespoke)	1a: 100-Yr Greenfield	623 ha x 0.15 x 103.416 mm x 10	96642.25
Springwell (Bespoke)	1b: 100-Yr Post-Dev	623 ha x 0.45 x 103.416 mm x 10 x 1.18	342113.57
Springwell (Bespoke)	1c: 1000-Yr Greenfield	623 ha x 0.15 x 93.0 mm x 10	86908.5
Springwell (Bespoke)	1d: 1000-Yr Post-Dev	623 ha x 0.45 x 93.0 mm x 10 x 1.18	307656.09
Springwell (Bespoke)	2a: 100-Yr Sat Greenfield	623 ha x 0.75 x 103.416 mm x 10	483211.26
Springwell (Bespoke)	2b: 100-Yr Sat Post-Dev	623 ha x 0.75 x 103.416 mm x 10 x 1.18	570189.29
Springwell (Bespoke)	2c: 1000-Yr Sat Greenfield	623 ha x 0.75 x 93.0 mm x 10	434542.5
Springwell (Bespoke)	2d: 1000-Yr Sat Post-Dev	623 ha x 0.75 x 93.0 mm x 10 x 1.18	512760.15
Springwell (Bespoke)	3a: Extreme Pluvial Greenfield	623 ha x 0.15 x 125.0 mm x 10	116812.5
Springwell (Bespoke)	3b: Extreme Pluvial Post-Dev	623 ha x 0.45 x 125.0 mm x 10 x 1.18	413516.25
Springwell (Bespoke)	3c/d: Surge Saturated	623 ha x 0.9 x 125.0 mm x 10 x 1.18	827032.5
GNR	1a:100-Greenfield	550ha x .25 x 103.416mm x10	142197
GNR	1b: 100-Yr Post-Dev	550 ha x 0.55 x 103.416 mm x 10 x 1.18	369143.41
GNR	1c: 1000-Yr Greenfield	550 ha x 0.25 x 93.0 mm x 10	127875
GNR	1d: 1000-Yr Post-Dev	550 ha x 0.55 x 93.0 mm x 10 x 1.18	331963.5
GNR	2a: 100-Yr Sat Greenfield	550 ha x 0.8 x 103.416 mm x 10	455030.4
GNR	2b: 100-Yr Sat Post-Dev	550 ha x 0.8 x 103.416 mm x 10 x 1.18	536935.87
GNR	2c: 1000-Yr Sat Greenfield	550 ha x 0.8 x 93.0 mm x 10	409200
GNR	2d: 1000-Yr Sat Post-Dev	550 ha x 0.8 x 93.0 mm x 10 x 1.18	482856
GNR	3a: Extreme Pluvial Greenfield	550 ha x 0.25 x 125.0 mm x 10	171875
GNR	3b: Extreme Pluvial Post-Dev	550 ha x 0.55 x 125.0 mm x 10 x 1.18	446187.5
GNR	3c/d: Surge Saturated	550 ha x 0.9 x 125.0 mm x 10 x 1.18	730125
Tillbridge	1a: 100-Yr Greenfield	739.56 ha x 0.25 x 103.416 mm x 10	191205.84
Tillbridge	1b: 100-Yr Post-Dev	739.56 ha x 0.55 x 103.416 mm x 10 x 1.18	496370.37
Tillbridge	1c: 1000-Yr Greenfield	739.56 ha x 0.25 x 93.0 mm x 10	171947.7
Tillbridge	1d: 1000-Yr Post-Dev	739.56 ha x 0.55 x 93.0 mm x 10 x 1.18	446376.23
Tillbridge	2a: 100-Yr Sat Greenfield	739.56 ha x 0.8 x 103.416 mm x 10	611858.7
Tillbridge	2b: 100-Yr Sat Post-Dev	739.56 ha x 0.8 x 103.416 mm x 10 x 1.18	721993.26
Tillbridge	2c: 1000-Yr Sat Greenfield	739.56 ha x 0.8 x 93.0 mm x 10	550232.64
Tillbridge	2d: 1000-Yr Sat Post-Dev	739.56 ha x 0.8 x 93.0 mm x 10 x 1.18	649274.52
Tillbridge	3a: Extreme Pluvial Greenfield	739.56 ha x 0.25 x 125.0 mm x 10	231112.5
Tillbridge	3b: Extreme Pluvial Post-Dev	739.56 ha x 0.55 x 125.0 mm x 10 x 1.18	599968.05
Tillbridge	3c/d: Surge Saturated	739.56 ha x 0.9 x 125.0 mm x 10 x 1.18	981765.9
Gate Burton	1a: 100-Yr Greenfield	474 ha x 0.25 x 103.416 mm x 10	122547.96
Gate Burton	1b: 100-Yr Post-Dev	474 ha x 0.55 x 103.416 mm x 10 x 1.18	318134.5
Gate Burton	1c: 1000-Yr Greenfield	474 ha x 0.25 x 93.0 mm x 10	110205
Gate Burton	1d: 1000-Yr Post-Dev	474 ha x 0.55 x 93.0 mm x 10 x 1.18	286092.18
Gate Burton	2a: 100-Yr Sat Greenfield	474 ha x 0.8 x 103.416 mm x 10	392153.47

Project Name	Scenario	Specific Calculation Step	Computed Runoff Volume (m3
Gate Burton	2b: 100-Yr Sat Post-Dev	474 ha x 0.8 x 103.416 mm x 10 x 1.18	462741.1
Gate Burton	2c: 1000-Yr Sat Greenfield	474 ha x 0.8 x 93.0 mm x 10	352656
Gate Burton	2d: 1000-Yr Sat Post-Dev	474 ha x 0.8 x 93.0 mm x 10 x 1.18	416134.08
Gate Burton	3a: Extreme Pluvial Greenfield	474 ha x 0.25 x 125.0 mm x 10	148125
Gate Burton	3b: Extreme Pluvial Post-Dev	474 ha x 0.55 x 125.0 mm x 10 x 1.18	384532.5
Gate Burton	3c/d: Surge Saturated	474 ha x 0.9 x 125.0 mm x 10 x 1.18	629235
Cottam	1a: 100-Yr Greenfield	897.39 ha x 0.25 x 103.416 mm x 10	232011.21
Cottam	1b: 100-Yr Post-Dev	897.39 ha x 0.55 x 103.416 mm x 10 x 1.18	602301.1
Cottam	1c: 1000-Yr Greenfield	897.39 ha x 0.25 x 93.0 mm x 10	208643.18
Cottam	1d: 1000-Yr Post-Dev	897.39 ha x 0.55 x 93.0 mm x 10 x 1.18	541637.68
Cottam	2a: 100-Yr Sat Greenfield	897.39 ha x 0.8 x 103.416 mm x 10	742435.87
Cottam	2b: 100-Yr Sat Post-Dev	897.39 ha x 0.8 x 103.416 mm x 10 x 1.18	876074.33
Cottam	2c: 1000-Yr Sat Greenfield	897.39 ha x 0.8 x 93.0 mm x 10	667658.16
Cottam	2d: 1000-Yr Sat Post-Dev	897.39 ha x 0.8 x 93.0 mm x 10 x 1.18	787836.63
Cottam	3a: Extreme Pluvial Greenfield	897.39 ha x 0.25 x 125.0 mm x 10	280434.38
Cottam	3b: Extreme Pluvial Post-Dev	897.39 ha x 0.55 x 125.0 mm x 10 x 1.18	728007.64
Cottam	3c/d: Surge Saturated	897.39 ha x 0.9 x 125.0 mm x 10 x 1.18	1191285.22
Combined 7-Project	Total 1a Volume	Sum of all 7 individual project volumes	1164399.52
Combined 7-Project	Total 1b Volume	Sum of all 7 individual project volumes	3114011.44
Combined 7-Project	Total 1c Volume	Sum of all 7 individual project volumes	1047121.88
Combined 7-Project	Total 1d Volume	Sum of all 7 individual project volumes	2800370.01
Combined 7-Project	Total 2a Volume	Sum of all 7 individual project volumes	3900034.53
Combined 7-Project	Total 2b Volume	Sum of all 7 individual project volumes	4602040.75
Combined 7-Project	Total 2c Volume	Sum of all 7 individual project volumes	3507225.3
Combined 7-Project	Total 2d Volume	Sum of all 7 individual project volumes	4138525.86
Combined 7-Project	Total 3a Volume	Sum of all 7 individual project volumes	1407421.88
Combined 7-Project	Total 3b Volume	Sum of all 7 individual project volumes	3763938.19
Combined 7-Project	Total 3cd Volume	Sum of all 7 individual project volumes	6309541.12

EQUATION 2: PEAK DISCHARGE FORMULATION (THE RATIONAL METHOD)

Formula (Greenfield): Peak Discharge Q (m^3/s) = (Runoff Coefficient C × Rainfall Intensity I (mm/hr) × Area A (ha)) / 360

Formula (Post-Dev): Peak Discharge Q (m^3/s) = (Runoff Coefficient C × Rainfall Intensity I (mm/hr) × Area A (ha) × 1.18) / 360

*(Routeing Note: While Equation 1 calculates total volume, Equation 2 calculates the maximum **kinetic rate** at which that water hits the river system. The output of this calculation [Q] is fed directly into **Equation 4** to calculate the hydrostatic pressure spike that bursts the system).*

We are not predicting a routed river gauge level at a single point. We are calculating the instantaneous kinetic shock applied to the macro-catchment because the solar arrays strip the land of its natural fractal attenuation

Project Name	Scenario	Specific Calculation Step	Computed Peak Flow Q (m3/s)
West Burton	1a: 100-Yr Greenfield	(734 ha x 0.25 x 27.8 mm/hr) / 360	14.1703
West Burton	1b: 100-Yr Post-Dev	(734 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	105.8591
West Burton	1c: 1000-Yr Greenfield	(734 ha x 0.25 x 26.7 mm/hr) / 360	13.6096
West Burton	1d: 1000-Yr Post-Dev	(734 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	138.9401
West Burton	2a: 100-Yr Sat Greenfield	(734 ha x 0.8 x 27.8 mm/hr) / 360	45.3449
West Burton	2b: 100-Yr Sat Post-Dev	(734 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	153.9769
West Burton	2c: 1000-Yr Sat Greenfield	(734 ha x 0.8 x 26.7 mm/hr) / 360	43.5507
West Burton	2d: 1000-Yr Sat Post-Dev	(734 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	202.0947
West Burton	3a: Extreme Pluvial Greenfield	(734 ha x 0.25 x 140.0 mm/hr) / 360	71.3611
West Burton	3b: Extreme Pluvial Post-Dev	(734 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	185.2534
West Burton	3c/d: Surge Saturated	(734 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	303.142
One Earth	1a: 100-Yr Greenfield	(735 ha x 0.25 x 27.8 mm/hr) / 360	14.1896
One Earth	1b: 100-Yr Post-Dev	(735 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	106.0033
One Earth	1c: 1000-Yr Greenfield	(735 ha x 0.25 x 26.7 mm/hr) / 360	13.6281
One Earth	1d: 1000-Yr Post-Dev	(735 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	139.1294
One Earth	2a: 100-Yr Sat Greenfield	(735 ha x 0.8 x 27.8 mm/hr) / 360	45.4067
One Earth	2b: 100-Yr Sat Post-Dev	(735 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	154.1867
One Earth	2c: 1000-Yr Sat Greenfield	(735 ha x 0.8 x 26.7 mm/hr) / 360	43.61
One Earth	2d: 1000-Yr Sat Post-Dev	(735 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	202.37
One Earth	3a: Extreme Pluvial Greenfield	(735 ha x 0.25 x 140.0 mm/hr) / 360	71.4583
One Earth	3b: Extreme Pluvial Post-Dev	(735 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	185.5058
One Earth	3c/d: Surge Saturated	(735 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	303.555
Springwell (Bespoke)	1a: 100-Yr Greenfield	(623 ha x 0.15 x 27.8 mm/hr) / 360	7.2164
Springwell (Bespoke)	1b: 100-Yr Post-Dev	(623 ha x 0.45 x 80.0 mm/hr x 1.18) / 360	73.514
Springwell (Bespoke)	1c: 1000-Yr Greenfield	(623 ha x 0.15 x 26.7 mm/hr) / 360	6.9309
Springwell (Bespoke)	1d: 1000-Yr Post-Dev	(623 ha x 0.45 x 105.0 mm/hr x 1.18) / 360	96.4871
Springwell (Bespoke)	2a: 100-Yr Sat Greenfield	(623 ha x 0.75 x 27.8 mm/hr) / 360	36.0821
Springwell (Bespoke)	2b: 100-Yr Sat Post-Dev	(623 ha x 0.75 x 80.0 mm/hr x 1.18) / 360	122.5233
Springwell (Bespoke)	2c: 1000-Yr Sat Greenfield	(623 ha x 0.75 x 26.7 mm/hr) / 360	34.6544

Project Name	Scenario	Specific Calculation Step	Computed Peak Flow Q (m3/s)
Springwell (Bespoke)	2d: 1000-Yr Sat Post-Dev	(623 ha x 0.75 x 105.0 mm/hr x 1.18) / 360	160.8119
Springwell (Bespoke)	3a: Extreme Pluvial Greenfield	(623 ha x 0.15 x 140.0 mm/hr) / 360	36.3417
Springwell (Bespoke)	3b: Extreme Pluvial Post-Dev	(623 ha x 0.45 x 140.0 mm/hr x 1.18) / 360	128.6495
Springwell (Bespoke)	3c/d: Surge Saturated	(623 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	257.299
GNR	1a: 100-Yr Greenfield	(550 ha x 0.25 x 27.8 mm/hr) / 360	10.6181
GNR	1b: 100-Yr Post-Dev	(550 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	79.3222
GNR	1c: 1000-Yr Greenfield	(550 ha x 0.25 x 26.7 mm/hr) / 360	10.1979
GNR	1d: 1000-Yr Post-Dev	(550 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	104.1104
GNR	2a: 100-Yr Sat Greenfield	(550 ha x 0.8 x 27.8 mm/hr) / 360	33.9778
GNR	2b: 100-Yr Sat Post-Dev	(550 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	115.3778
GNR	2c: 1000-Yr Sat Greenfield	(550 ha x 0.8 x 26.7 mm/hr) / 360	32.6333
GNR	2d: 1000-Yr Sat Post-Dev	(550 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	151.4333
GNR	3a: Extreme Pluvial Greenfield	(550 ha x 0.25 x 140.0 mm/hr) / 360	53.4722
GNR	3b: Extreme Pluvial Post-Dev	(550 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	138.8139
GNR	3c/d: Surge Saturated	(550 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	227.15
Tillbridge	1a: 100-Yr Greenfield	(739.56 ha x 0.25 x 27.8 mm/hr) / 360	14.2776
Tillbridge	1b: 100-Yr Post-Dev	(739.56 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	106.661
Tillbridge	1c: 1000-Yr Greenfield	(739.56 ha x 0.25 x 26.7 mm/hr) / 360	13.7127
Tillbridge	1d: 1000-Yr Post-Dev	(739.56 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	139.9925
Tillbridge	2a: 100-Yr Sat Greenfield	(739.56 ha x 0.8 x 27.8 mm/hr) / 360	45.6884
Tillbridge	2b: 100-Yr Sat Post-Dev	(739.56 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	155.1433
Tillbridge	2c: 1000-Yr Sat Greenfield	(739.56 ha x 0.8 x 26.7 mm/hr) / 360	43.8806
Tillbridge	2d: 1000-Yr Sat Post-Dev	(739.56 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	203.6255
Tillbridge	3a: Extreme Pluvial Greenfield	(739.56 ha x 0.25 x 140.0 mm/hr) / 360	71.9017
Tillbridge	3b: Extreme Pluvial Post-Dev	(739.56 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	186.6567
Tillbridge	3c/d: Surge Saturated	(739.56 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	305.4383
Gate Burton	1a: 100-Yr Greenfield	(474 ha x 0.25 x 27.8 mm/hr) / 360	9.1508
Gate Burton	1b: 100-Yr Post-Dev	(474 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	68.3613
Gate Burton	1c: 1000-Yr Greenfield	(474 ha x 0.25 x 26.7 mm/hr) / 360	8.7888
Gate Burton	1d: 1000-Yr Post-Dev	(474 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	89.7243
Gate Burton	2a: 100-Yr Sat Greenfield	(474 ha x 0.8 x 27.8 mm/hr) / 360	29.2827
Gate Burton	2b: 100-Yr Sat Post-Dev	(474 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	99.4347
Gate Burton	2c: 1000-Yr Sat Greenfield	(474 ha x 0.8 x 26.7 mm/hr) / 360	28.124
Gate Burton	2d: 1000-Yr Sat Post-Dev	(474 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	130.508
Gate Burton	3a: Extreme Pluvial Greenfield	(474 ha x 0.25 x 140.0 mm/hr) / 360	46.0833
Gate Burton	3b: Extreme Pluvial Post-Dev	(474 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	119.6323
Gate Burton	3c/d: Surge Saturated	(474 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	195.762
Cottam	1a: 100-Yr Greenfield	(897.39 ha x 0.25 x 27.8 mm/hr) / 360	17.3246
Cottam	1b: 100-Yr Post-Dev	(897.39 ha x 0.55 x 80.0 mm/hr x 1.18) / 360	129.4236
Cottam	1c: 1000-Yr Greenfield	(897.39 ha x 0.25 x 26.7 mm/hr) / 360	16.6391
Cottam	1d: 1000-Yr Post-Dev	(897.39 ha x 0.55 x 105.0 mm/hr x 1.18) / 360	169.8684
Cottam	2a: 100-Yr Sat Greenfield	(897.39 ha x 0.8 x 27.8 mm/hr) / 360	55.4388
Cottam	2b: 100-Yr Sat Post-Dev	(897.39 ha x 0.8 x 80.0 mm/hr x 1.18) / 360	188.2525
Cottam	2c: 1000-Yr Sat Greenfield	(897.39 ha x 0.8 x 26.7 mm/hr) / 360	53.2451

Project Name	Scenario	Specific Calculation Step	Computed Peak Flow Q (m3/s)
Cottam	2d: 1000-Yr Sat Post-Dev	(897.39 ha x 0.8 x 105.0 mm/hr x 1.18) / 360	247.0814
Cottam	3a: Extreme Pluvial Greenfield	(897.39 ha x 0.25 x 140.0 mm/hr) / 360	87.2462
Cottam	3b: Extreme Pluvial Post-Dev	(897.39 ha x 0.55 x 140.0 mm/hr x 1.18) / 360	226.4913
Cottam	3c/d: Surge Saturated	(897.39 ha x 0.9 x 140.0 mm/hr x 1.18) / 360	370.6221
Combined 7-Project	Total 1a Peak Flow	Sum of all 7 individual project peak discharges	86.9474
Combined 7-Project	Total 1b Peak Flow	Sum of all 7 individual project peak discharges	669.1445
Combined 7-Project	Total 1c Peak Flow	Sum of all 7 individual project peak discharges	83.5071
Combined 7-Project	Total 1d Peak Flow	Sum of all 7 individual project peak discharges	878.2523
Combined 7-Project	Total 2a Peak Flow	Sum of all 7 individual project peak discharges	291.2214
Combined 7-Project	Total 2b Peak Flow	Sum of all 7 individual project peak discharges	988.8952
Combined 7-Project	Total 2c Peak Flow	Sum of all 7 individual project peak discharges	279.6981
Combined 7-Project	Total 2d Peak Flow	Sum of all 7 individual project peak discharges	1297.9248
Combined 7-Project	Total 3a Peak Flow	Sum of all 7 individual project peak discharges	437.8645
Combined 7-Project	Total 3b Peak Flow	Sum of all 7 individual project peak discharges	1171.0027
Combined 7-Project	Total 3c/d Peak Flow	Sum of all 7 individual project peak discharges	1962.9684

EQUATION 3: DYNAMIC CONVEYANCE PENALTY (k)

Category	Condition	Conveyance (k)
Standard Single Sites	All Scenarios	360
Springwell (Bespoke)	All Scenarios	180
Combined 7-Project Total	Greenfield Baselines	326
Combined 7-Project Total	Post-Development Scenarios	205.8
Combined 7-Project Total	Surge Saturated (Hydraulic Locking)	84

EQUATION 4: Theoretical Hydrostatic Pressure Head Equivalent INDEX (Formula: $h = \frac{q}{k}$*Where* h *is the Exceedance Index [m],* Q *is Peak Discharge [m*^{3}*/s], and* k *is the Dynamic Conveyance Penalty [*$\frac{m2}{s}$*].*

(Routeing Note: Derived from the principles of open-channel specific conveyance, this formula calculates the vertical pressure spike created when the Peak Discharge [Q from Eq. 2] is forced through a penalized, constricted river capacity [k from Eq. 3]).

Project Name	Scenario	Specific Calculation Step (Q / k)	Computed Stage Index h (m)
West Burton	1a: 100-Yr Greenfield	14.1703 m3/s / 360	0.0394
West Burton	1b: 100-Yr Post-Dev	105.8591 m3/s / 360	0.2941
West Burton	1c: 1000-Yr Greenfield	13.6096 m3/s / 360	0.0378
West Burton	1d: 1000-Yr Post-Dev	138.9401 m3/s / 360	0.3859
West Burton	2a: 100-Yr Sat Greenfield	45.3449 m3/s / 360	0.126
West Burton	2b: 100-Yr Sat Post-Dev	153.9769 m3/s / 360	0.4277
West Burton	2c: 1000-Yr Sat Greenfield	43.5507 m3/s / 360	0.121
West Burton	2d: 1000-Yr Sat Post-Dev	202.0947 m3/s / 360	0.5614
West Burton	3a: Extreme Pluvial Greenfield	71.3611 m3/s / 360	0.1982
West Burton	3b: Extreme Pluvial Post-Dev	185.2534 m3/s / 360	0.5146
West Burton	3c/d: Surge Saturated	303.1420 m3/s / 360	0.8421
One Earth	1a: 100-Yr Greenfield	14.1896 m3/s / 360	0.0394
One Earth	1b: 100-Yr Post-Dev	106.0033 m3/s / 360	0.2945
One Earth	1c: 1000-Yr Greenfield	13.6281 m3/s / 360	0.0379
One Earth	1d: 1000-Yr Post-Dev	139.1294 m3/s / 360	0.3865
One Earth	2a: 100-Yr Sat Greenfield	45.4067 m3/s / 360	0.1261
One Earth	2b: 100-Yr Sat Post-Dev	154.1867 m3/s / 360	0.4283
One Earth	2c: 1000-Yr Sat Greenfield	43.6100 m3/s / 360	0.1211
One Earth	2d: 1000-Yr Sat Post-Dev	202.3700 m3/s / 360	0.5621
One Earth	3a: Extreme Pluvial Greenfield	71.4583 m3/s / 360	0.1985
One Earth	3b: Extreme Pluvial Post-Dev	185.5058 m3/s / 360	0.5153
One Earth	3c/d: Surge Saturated	303.5550 m3/s / 360	0.8432
Springwell (Bespoke)	1a: 100-Yr Greenfield	7.2164 m3/s / 180	0.0401
Springwell (Bespoke)	1b: 100-Yr Post-Dev	73.5140 m3/s / 180	0.4084
Springwell (Bespoke)	1c: 1000-Yr Greenfield	6.9309 m3/s / 180	0.0385
Springwell (Bespoke)	1d: 1000-Yr Post-Dev	96.4871 m3/s / 180	0.536
Springwell (Bespoke)	2a: 100-Yr Sat Greenfield	36.0821 m3/s / 180	0.2005
Springwell (Bespoke)	2b: 100-Yr Sat Post-Dev	122.5233 m3/s / 180	0.6807
Springwell (Bespoke)	2c: 1000-Yr Sat Greenfield	34.6544 m3/s / 180	0.1925

Project Name	Scenario	Specific Calculation Step (Q / k)	Computed Stage Index h (m
Springwell (Bespoke)	2d: 1000-Yr Sat Post-Dev	160.8119 m3/s / 180	0.8934
Springwell (Bespoke)	3a: Extreme Pluvial Greenfield	36.3417 m3/s / 180	0.2019
Springwell (Bespoke)	3b: Extreme Pluvial Post-Dev	128.6495 m3/s / 180	0.7147
Springwell (Bespoke)	3c/d: Surge Saturated	257.2990 m3/s / 180	1.4294
GNR	1a: 100-Yr Greenfield	10.6181 m3/s / 360	0.0295
GNR	1b: 100-Yr Post-Dev	79.3222 m3/s / 360	0.2203
GNR	1c: 1000-Yr Greenfield	10.1979 m3/s / 360	0.0283
GNR	1d: 1000-Yr Post-Dev	104.1104 m3/s / 360	0.2892
GNR	2a: 100-Yr Sat Greenfield	33.9778 m3/s / 360	0.0944
GNR	2b: 100-Yr Sat Post-Dev	115.3778 m3/s / 360	0.3205
GNR	2c: 1000-Yr Sat Greenfield	32.6333 m3/s / 360	0.0906
GNR	2d: 1000-Yr Sat Post-Dev	151.4333 m3/s / 360	0.4206
GNR	3a: Extreme Pluvial Greenfield	53.4722 m3/s / 360	0.1485
GNR	3b: Extreme Pluvial Post-Dev	138.8139 m3/s / 360	0.3856
GNR	3c/d: Surge Saturated	227.1500 m3/s / 360	0.631
Tillbridge	1a: 100-Yr Greenfield	14.2776 m3/s / 360	0.0397
Tillbridge	1b: 100-Yr Post-Dev	106.6610 m3/s / 360	0.2963
Tillbridge	1c: 1000-Yr Greenfield	13.7127 m3/s / 360	0.0381
Tillbridge	1d: 1000-Yr Post-Dev	139.9925 m3/s / 360	0.3889
Tillbridge	2a: 100-Yr Sat Greenfield	45.6884 m3/s / 360	0.1269
Tillbridge	2b: 100-Yr Sat Post-Dev	155.1433 m3/s / 360	0.431
Tillbridge	2c: 1000-Yr Sat Greenfield	43.8806 m3/s / 360	0.1219
Tillbridge	2d: 1000-Yr Sat Post-Dev	203.6255 m3/s / 360	0.5656
Tillbridge	3a: Extreme Pluvial Greenfield	71.9017 m3/s / 360	0.1997
Tillbridge	3b: Extreme Pluvial Post-Dev	186.6567 m3/s / 360	0.5185
Tillbridge	3c/d: Surge Saturated	305.4383 m3/s / 360	0.8484
Gate Burton	1a: 100-Yr Greenfield	9.1508 m3/s / 360	0.0254
Gate Burton	1b: 100-Yr Post-Dev	68.3613 m3/s / 360	0.1899
Gate Burton	1c: 1000-Yr Greenfield	8.7888 m3/s / 360	0.0244
Gate Burton	1d: 1000-Yr Post-Dev	89.7243 m3/s / 360	0.2492
Gate Burton	2a: 100-Yr Sat Greenfield	29.2827 m3/s / 360	0.0813
Gate Burton	2b: 100-Yr Sat Post-Dev	99.4347 m3/s / 360	0.2762
Gate Burton	2c: 1000-Yr Sat Greenfield	28.1240 m3/s / 360	0.0781
Gate Burton	2d: 1000-Yr Sat Post-Dev	130.5080 m3/s / 360	0.3625
Gate Burton	3a: Extreme Pluvial Greenfield	46.0833 m3/s / 360	0.128
Gate Burton	3b: Extreme Pluvial Post-Dev	119.6323 m3/s / 360	0.3323
Gate Burton	3c/d: Surge Saturated	195.7620 m3/s / 360	0.5438
Cottam	1a: 100-Yr Greenfield	17.3246 m3/s / 360	0.0481
Cottam	1b: 100-Yr Post-Dev	129.4236 m3/s / 360	0.3595
Cottam	1c: 1000-Yr Greenfield	16.6391 m3/s / 360	0.0462
Cottam	1d: 1000-Yr Post-Dev	169.8684 m3/s / 360	0.4719
Cottam	2a: 100-Yr Sat Greenfield	55.4388 m3/s / 360	0.154
Cottam	2b: 100-Yr Sat Post-Dev	188.2525 m3/s / 360	0.5229
Cottam	2c: 1000-Yr Sat Greenfield	53.2451 m3/s / 360	0.1479
Cottam	2d: 1000-Yr Sat Post-Dev	247.0814 m3/s / 360	0.6863

Project Name	Scenario	Specific Calculation Step (Q / k	Computed Stage Index h (m)
Cottam	3a: Extreme Pluvial Greenfield	87.2462 m3/s / 360	0.2424
Cottam	3b: Extreme Pluvial Post-Dev	226.4913 m3/s / 360	0.6291
Cottam	3c/d: Surge Saturated	370.6221 m3/s / 360	1.0295
Combined 7-Project Total	1a: 100-Yr Greenfield	86.9474 m3/s / 326.0	0.2667
Combined 7-Project Total	1b: 100-Yr Post-Dev	669.1446 m3/s / 205.8	3.2514
Combined 7-Project Total	1c: 1000-Yr Greenfield	83.5070 m3/s / 326.0	0.2562
Combined 7-Project Total	1d: 1000-Yr Post-Dev	878.2522 m3/s / 205.8	4.2675
Combined 7-Project Total	2a: 100-Yr Sat Greenfield	291.2212 m3/s / 326.0	0.8933
Combined 7-Project Total	2b: 100-Yr Sat Post-Dev	988.8951 m3/s / 205.8	4.8051
Combined 7-Project Total	2c: 1000-Yr Sat Greenfield	279.6981 m3/s / 326.0	0.858
Combined 7-Project Total	2d: 1000-Yr Sat Post-Dev	1297.9248 m3/s / 205.8	6.3067
Combined 7-Project Total	3a: Extreme Pluvial Greenfield	437.8646 m3/s / 326.0	1.3431
Combined 7-Project Total	3b: Extreme Pluvial Post-Dev	1171.0030 m3/s / 205.8	5.69
Combined 7-Project Total	3c/d: Surge Saturated	1962.9683 m3/s / 84.0	23.3687

EQUATION 5: LATERAL OVERTOPPED VOLUME FORMULATION

Formula: $V_{lateral}\ (m^3) = V_{post\_dev} - V_{greenfield} + V_{stilt\_displacement}$

*(Routeing Note: This final equation utilizes the Total Volumes calculated back in **Equation 1**. It deducts the natural Greenfield volume from the industrialized Post-Development volume, and adds the physical space lost to steel stilt displacement, revealing the exact cubic mass of floodwater forcibly displaced off-site).*

Project Name	Analysis Metric	Specific Calc Step	Lateral Overtopped Volume (m3)
West Burton	100-Yr (+39% CC) Lateral	492638.66 - 189768.36 + 33250.00	336120.3
West Burton	1000-Yr Lateral Overtopped	443020.38 - 170655.00 + 33250.00	305615.38
West Burton	Stress Test 1 Lateral	716565.33 - 189768.36 + 33250.00	560046.97
West Burton	Stress Test 2 Lateral	974385.00 - 170655.00 + 33250.00	836980
One Earth	100-Yr (+39% CC) Lateral	493309.83 - 190026.90 + 39900.00	343182.93
One Earth	1000-Yr Lateral Overtopped	443623.95 - 170887.50 + 39900.00	312636.45
One Earth	Stress Test 1 Lateral	717541.57 - 190026.90 + 39900.00	567414.67
One Earth	Stress Test 2 Lateral	975712.50 - 170887.50 + 39900.00	844725
Springwell (Bespoke)	100-Yr (+39% CC) Lateral	342113.57 - 96642.25 + 31150.00	276621.32
Springwell (Bespoke)	1000-Yr Lateral Overtopped	307656.09 - 86908.50 + 31150.00	251897.59
Springwell (Bespoke)	Stress Test 1 Lateral	570189.29 - 96642.25 + 31150.00	504697.03
Springwell (Bespoke)	Stress Test 2 Lateral	827032.50 - 86908.50 + 31150.00	771274
GNR	100-Yr (+39% CC) Lateral	369143.41 - 142197.00 + 23750.00	250696.41
GNR	1000-Yr Lateral Overtopped	331963.50 - 127875.00 + 23750.00	227838.5
GNR	Stress Test 1 Lateral	536935.87 - 142197.00 + 23750.00	418488.87
GNR	Stress Test 2 Lateral	730125.00 - 127875.00 + 23750.00	626000
Tillbridge	100-Yr (+39% CC) Lateral	496370.37 - 191205.84 + 35625.00	340789.53
Tillbridge	1000-Yr Lateral Overtopped	446376.23 - 171947.70 + 35625.00	310053.53
Tillbridge	Stress Test 1 Lateral	721993.26 - 191205.84 + 35625.00	566412.42
Tillbridge	Stress Test 2 Lateral	981765.90 - 171947.70 + 35625.00	845443.2
Gate Burton	100-Yr (+39% CC) Lateral	318134.50 - 122547.96 + 19790.00	215376.54
Gate Burton	1000-Yr Lateral Overtopped	286092.18 - 110205.00 + 19790.00	195677.18
Gate Burton	Stress Test 1 Lateral	462741.10 - 122547.96 + 19790.00	359983.14
Gate Burton	Stress Test 2 Lateral	629235.00 - 110205.00 + 19790.00	538820
Cottam	100-Yr (+39% CC) Lateral	602301.10 - 232011.21 + 47500.00	417789.89
Cottam	1000-Yr Lateral Overtopped	541637.68 - 208643.18 + 47500.00	380494.51
Cottam	Stress Test 1 Lateral	876074.33 - 232011.21 + 47500.00	691563.12

Project Name	Analysis Metric	Specific Calc Step	Lateral Overtopped Volume (m3)
Cottam	Stress Test 2 Lateral	1191285.22 - 208643.18 + 47500.00	1030142.05
Combined 7-Project Total	100-Yr (+39% CC) Lateral	3114011.45 - 1164399.52 + 230965.00	2180576.93
Combined 7-Project Total	1000-Yr Lateral Overtopped	2800370.01 - 1047121.88 + 230965.00	1984213.14
Combined 7-Project Total	Stress Test 1 Lateral	4602040.75 - 1164399.52 + 230965.00	3668606.22
Combined 7-Project Total	Stress Test 2 Lateral	6309541.12 - 1047121.88 + 230965.00	5493384.25

Appendix 3 The Hydrological and Hydraulic Mechanics of Mega-Scale Solar Catchments: A First-Principles Justification of the Reconciled Master Model

ABSTRACT The unprecedented deployment of 8,844 hectares of Nationally Significant Infrastructure Projects (NSIPs) across the restrictive soils of the Trent and Witham valleys fundamentally alters the physical parameters governing terrestrial hydrology. Utilising the empirical calculation ledger for a contiguous seven-project UK solar aggregate, this paper derives the underlying mechanics of solar-induced catchment modification strictly from mathematical, hydrological, and hydraulic first principles. By incorporating the kinematic wave frameworks of Baiamonte et al., wind-driven geometric catchment multipliers, and dynamic conveyance penalties, this paper elucidates the physics dictating volumetric runoff expansion, velocity acceleration, and severe lateral overtopping. The model mathematically captures the compound realities of winter soil saturation and downstream tailwater surcharge, proving that the structural disruption of the natural continuity equation inevitably translates to catastrophic stage-discharge failures and massive uncompensated floodplain displacement.

1. INTRODUCTION: MASS BALANCE & SATURATED SOIL DYNAMICS

At its foundational level, surface hydrology is dictated by the thermodynamic and physical conservation of mass, expressed via the catchment continuity equation [1]. In an undisturbed "Greenfield" agricultural state, macro-pores and crop matrices provide substantial initial abstraction. However, the geographic area hosting the majority of these megaprojects features highly impermeable pelostagnogleys (e.g., Fladbury, Foggathorpe, and Compton associations) [2].

Under the Hydrology of Soil Types (HOST) classifications, these alluvial flats possess naturally high-water tables and reach absolute field capacity during sequential winter storm events. Once saturated, the system's latent infiltration drops to near-zero, forcing a phase transition to rapid saturation-excess overland flow. The aggregate introduction of 4,752.95 hectares of active, impermeable solar infrastructure critically ruptures this fragile equilibrium by sealing the terrain and structurally elevating the Runoff Coefficient (C) to severe limits ($C = 0.80$ to 0.90) during winter stress tests [3]. (Conversely, at the Springwell site, replacing naturally superior fen-edge loams, $C = 0.15$, with infrastructure guarantees a proportionally more violent baseline displacement).

2. VOLUMETRIC RUNOFF GENERATION & THE GEOMETRIC TILT MULTIPLIER (EQUATION 1)

To quantify the gross fluid volume generated, the ledger applies a strictly dimensional mass continuity formulation:

$$Volume\ (V) = Area\ (A) \times C \times Precipitation\ (P) \times 10 \times sec(\theta)$$

(where $sec(\theta)$ is the 1.18 panel tilt multiplier) Precipitation (P) in millimetres, multiplying their product by a strict conversion constant of 10 ensures dimensional homogeneity, yielding exact absolute cubic metres (m^3) [4].

The 1.18 Geometric Multiplier: Standard "flat earth" hydrology assumes rainfall vertically intersects a horizontal plane. However, solar panels are pitched (typically at ~32° in the UK). During severe weather systems, precipitation is wind-driven at steep angles. Trigonometry dictates that a tilted plane acts as a geometric sail, physically intercepting a significantly larger volume of angled rain than the flat horizontal footprint beneath it. The effective catchment area of the array mathematically expands by the inverse cosine of the tilt angle ($1/cos(32^\circ) \approx 1.18$) [5]. This represents an 18% volumetric expansion. Gravity rapidly coalesces this expanded sheet flow, concentrating its kinetic energy into a localized point-load at the drip-edge. Consequently, under the 100-Year (+39% Climate Change) event, combined generated runoff swells violently from 1,164,400 m^3 (Greenfield) to 3,114,011 m^3 (Post-Development).

3 KINEMATIC ACCELERATION & PEAK DISCHARGE (EQUATION 2)

The massive volumetric increase represents only a portion of the hazard; the kinetic stress transferred to receiving watercourses is dictated by Peak Discharge (Q), formulated via the Rational Method [6]:

$$Peak\ Discharge\ (Q) = \frac{C \times I \times A \times 1.18}{360}$$

First-Principle Derivation: The divisor 360 precisely converts hectares and mm/hour into standard hydraulic flow rates of cubic metres per second (m^3/s) [7].

Time of Concentration (T_c) and Topographical Fall: Fluid overland velocity is directly proportional to gravitational potential energy and inversely proportional to surface friction. Topographical surveys reveal severe relief drops across these catchments (averaging 16.57m from boundary to river, up to 22.5m at One Earth). By replacing high-friction agricultural crops with low-friction, compacted drip-trenches positioned on gravity-accelerated gradients, surface roughness is obliterated.

The mechanics of this acceleration are rigorously defined by Baiamonte et al., who proved analytically that overland flow T_c is extraordinarily sensitive to reductions in vegetative friction [8]. Because standard Intensity-Duration-Frequency (IDF) curves mathematically mandate that shorter concentration times correspond to higher intensity (I) events, the catchment is forced to respond to an extreme, accelerated pulse of water [9]. By mathematically compressing the T_c (elevating I from an unpaved 27.8 mm/hr to a formalized 80.0–140.0 mm/hr), the combined Peak Discharge across the aggregate spikes exponentially to 1,962.96 m^3/s under peak compound load.

4. WAVE THEORY AND DYNAMIC CONVEYANCE PENALTIES (EQUATION 3)

Rivers move fluid as dynamic waves governed by the Saint-Venant equations of unsteady flow [10]. In a natural catchment, variable overland travel times cause hydrographs to diffuse. However, the synchronized, low-friction discharge from 4,752 active hectares erases this natural attenuation. Governed by Kinematic Wave Theory, the trailing edge of the flood wave catches the leading edge, steepening the hydrograph into a violent, unmitigated kinematic shockwave [11].

As this overland shockwave hits open channels, it translates into vertical pressure via the open-channel specific conveyance relationship [12]:

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Theoretical Exceedance Index h = Q / k
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Dynamic Conveyance (k) Penalties: Natural floodplains possess high, unhindered specific conveyance ($k \approx 326 \; to \; 367$). However, the proposed developments intersect 4,361.95 hectares of active 100-year floodplain. The installation of kilometres of security mesh fencing physically obstructs overland flow, catching vegetation to form impermeable “debris dams” that structurally penalize the Post-Development conveyance capacity ($k \approx 205.8$). For constrained fen-edge tributaries like the River Witham interacting with Springwell, this bottleneck is natively lower at $k = 180$.

Crucially, the mechanics of extreme compound events (Scenario 3c/d: Surge Saturated) are not merely theoretical; they represent the documented historical reality of the region. As experienced during Storm Dennis (2020) and the devastating, sequential strikes of Storm Babet and Storm Henk (2023/2024)—whose systemic soil saturation is accurately captured within the Series 2 baselines—heavy localized rainfall is accompanied by downstream fluvial surges on the River Trent and River Witham. At their peak, these swollen rivers physically and hydraulically 'lock' local gravity drainage outfalls and flap valves. This compound reality flattens the hydraulic gradient entirely, crashing the effective evacuation capacity of the regional network down to a severely penalized bottleneck of k=84.0. Forcing artificially accelerated, solar-induced mega volumes into these already surcharged, historically proven geometric bottlenecks mathematically guarantee total systemic failure, driving the combined Theoretical Hydrostatic Exceedance Index to a catastrophic **23.37 meters**. Because dirt riverbanks cannot withstand 23 meters of hydrostatic pressure, this calculation mathematically proves that the containment will violently rupture, converting vertical pressure instantly into horizontal, lateral inundation.

5 FLOODPLAIN DISPLACEMENT & LATERAL OVERTOPPING (EQUATION 5)

When vertical stage (h) mathematically exceeds channel limits, the conservation of mass dictates lateral fluid spillage:

$$V_{lateral} = V_{post\_dev} - V_{greenfield} + V_{displacement}$$

Furthermore, the installation of tens of thousands of sub-surface steel mountings introduces an Uncompensated Stilt Storage Loss of 230,965 m^3. In strict accordance with Archimedes' principle of volumetric displacement, occupying active floodplain physically repels an equal volume of water outward [13]. When volumetric expansion, kinematic acceleration, and physical stilt displacement are combined under Stress Test 2, the combined Lateral Overtopped Volume transferred directly onto unconsenting third-party communities, balloons to a catastrophic **5,493,384 cubic metres**.

6. CONCLUSION

Analysed strictly from mathematical, hydrological, and hydraulic first principles, the data ledger proves that standard static screening models are fundamentally incapable of assessing the cumulative threat of utility-scale solar hydrology. By integrating $1/cos\theta$ wind-driven catchment geometry, HOST soil saturation limits, and Baiamonte's kinematic acceleration mechanics, this model captures the true non-linear realities of solar-induced runoff. Subjected to dynamic conveyance penalties and tailwater surcharge, these concentrated kinematic shockwaves mathematically overwhelm local SuDS networks, triggering catastrophic vertical stage rises and unequivocally breaching the National Planning Policy Framework's (NPPF) statutory prohibition on increasing third-party flood risk [14].

ACADEMIC AND STATUTORY FOOTNOTES

[1] **Chow, V. T., Maidment, D. R., & Mays, L. W. (1988).** *Applied Hydrology*. McGraw-Hill Education. The definitive academic text establishing the conservation of mass and the fundamental catchment continuity equation ($P = R + E + I + \Delta S$).

[2] **Boorman, D. B., Hollis, J. M., & Lilly, A. (1995).** *Hydrology of soil types: a hydrologically-based classification of the soils of the United Kingdom (HOST)*. Institute of Hydrology, Report 126. Establishes the naturally high groundwater tables and winter field-capacity thresholds of Trent Valley and Lincolnshire alluvial gleys, justifying the baseline phase-shift to absolute saturation-excess overland flow.

[3] **Woods Ballard, B. et al. (2015).** *The SuDS Manual (C753)*. CIRIA, London. Provides the statutory UK engineering justification for Runoff Coefficients (C) scaling from $0.15/0.25$ on arable land up to $0.80/0.90$ under severe compaction and saturated conditions.

[4] **Dimensional Homogeneity Scalar:** $1\ hectare = 10{,}000\ m^2$; $1\ mm\ rainfall = 0.001\ m$. Therefore, $10{,}000 \times 0.001 = 10$. Multiplying Catchment Area × Precipitation × 10 correctly yields absolute volume in dimensional m^3.

[5] **Blocken, B., & Carmeliet, J. (2004).** "A review of wind-driven rain research in building science." *Journal of Wind Engineering and Industrial Aerodynamics*. Provides the underlying trigonometric proof that a plane pitched into wind-driven rain intercepts a $1/cos\theta$ geometrically greater volume of water than its horizontal footprint, validating the strict 1.18 tilt multiplier for standard $32°$ UK panel angles.

[6] **Mulvaney, T. J. (1851).** “On the use of self-registering rain and stream gauges...” *Proceedings of the Institution of Civil Engineers of Ireland*. The historical first-principle derivation of the Rational Method equation.

[7] **Novak, P. et al. (2017).** *Hydraulic Structures* (4th Ed). Taylor & Francis. Derivation of the strict unit conversion scalar (360) used to translate hectares and mm/hr to standard peak metric discharge limits (m^3/s).

[8] **Baiamonte, G. (2023).** “Impact of solar panels on runoff generation process.” *Hydrological Processes*, 37(12), e15053. The contemporary academic framework proving that impermeable solar panels concentrate flow, heavily scour topsoils, and mathematically compress the time of concentration (T_c), drastically accelerating catchment hydrographs by up to 5x.

[9] **Koutsoyiannis, D., Kozonis, D., & Manetas, A. (1998).** “A mathematical framework for studying rainfall intensity-duration-frequency (IDF) relationships.” *Journal of Hydrology*. Proves that a compressed Time of Concentration (T_c) resulting from kinematic acceleration mathematically corresponds to higher statistical rainfall intensity (I) values on the storm curve.

[10] **Saint-Venant, A. J. C. (1871).** “Théorie du mouvement non permanent des eaux.” *Comptes Rendus de l’Académie des Sciences*. The foundational physics equations deriving the conservation of mass and momentum governing open-channel unsteady flow.

[11] **Lighthill, M. J., & Whitham, G. B. (1955).** “On kinematic waves. I. Flood movement in long rivers.” *Proceedings of the Royal Society of London*. The seminal physics paper proving how unsynchronised waves travel, stack, and steepen into destructive kinematic shockwaves under reduced friction profiles.

[12] **Henderson, F. M. (1966).** *Open Channel Flow*. Macmillan Publishing. Provides the mathematical derivation of stage-discharge geometries, justifying the dynamic reduction of the Conveyance Coefficient (k) due to structural floodplain impedance (debris screens) and hydraulic tailwater surcharge.

[13] **Archimedes of Syracuse (c. 250 BC).** *On Floating Bodies*. The fundamental physical law of fluid displacement, proving that sub-surface solid steel installations within the 100-year active floodplain mathematically mandate a volumetric displacement of floodwater into adjacent topography.

[14] **Ministry of Housing, Communities & Local Government.** (Department for Levelling Up, Housing and Communities (DLUHC)) **(2023).** *National Planning Policy Framework (NPPF)*. UK Government. Sets the strict policy directive made relevant under Section 104 of the Planning Act requirement prohibiting any national infrastructure development from displacing uncompensated flood volumes or transferring hydrostatic risk onto third-party off-site receptors.

Appendix 4: Defence of the Hydrologic Methodology

The Independent Hydrological & Hydraulic Assessment, which evaluates the cumulative hydrological impacts of the One Earth Solar Farm and six adjacent Nationally Significant Infrastructure Projects (NSIPs) across the conjoined Trent and Witham valleys, represents a rigorous, evidence-based technical intervention in the planning process. Its primary value lies in its objective exposure of “regulatory lag” and the systemic vulnerabilities inherent in standard environmental impact assessments [13].

Specifically, the document’s critique of static national mapping frameworks is scientifically and forensically sound. The Environment Agency’s (EA) Flood Map for Planning and National Flood Risk Assessment (NaFRA2) models are built as discrete, single-source datasets. They simulate pluvial and fluvial risks as isolated hazards, structurally omitting the physical reality of “compound flooding” [2]. The mechanism of downstream tailwater surcharge (hydraulic locking), where high river levels physically block gravity drainage outfalls and flap valves, is an empirically documented reality in the Trent Valley [9]. This mechanism causes localized runoff to back up and accumulate vertically on the dry side of flood embankments.

Furthermore, the assessment's critique of the “Distinct Cell” hypothesis is entirely robust. By artificially dividing continuous floodplains into isolated spatial cells, standard development methodologies inherently fail to capture the cumulative volume of water displaced into conjoined catchments over prolonged wet periods [13].

From an advanced hydraulic and forensic engineering perspective, during DCO examinations the developers and commercial consultancies relied on conventional, simplified textbook hydrology guidelines to contest this macro-scale argument. Rather than dismissing these conventional approaches, this framework proactively anticipates these standard industry assumptions and addresses them with scientifically robust, first-principles rebuttals. This objective methodology ensures that the Secretary of State is equipped with the comprehensive technical data required to evaluate the true systemic risk, demonstrating exactly why standard small-scale assumptions mathematically fail when applied to an 8,844-hectare industrialization.

2. Hydrological Counter-Audit and Defence Framework

2.1 Volumetric Runoff Formula & The Mass Balance Fallacy

- **Community Formulation:** $V = A \times C \times P \times 10 \times 1.18$ (where 1.18 is the panel tilt multiplier and P is the Precipitation depth)
- **The Developer Attack:** Developers’ consultants will argue that applying a tilt multiplier directly to the gross volume calculation implies that tilting panels physically creates more precipitation falling over the site, violating the conservation of mass. They will assert that wind-driven rain intercepted by the windward face is perfectly balanced out by a wider “rain shadow” directly behind the panels.

- **The Forensic Rebuttal (Micro-Scale Hortonian Amplification):** This attack relies on the hydrologically obsolete assumption of gentle, vertical rain falling in a vacuum. Our methodology explicitly tests Severe Winter Storms, where rain is horizontally advected by high winds (Wind-Driven Rain or WDR) [8]. Tilted panels act as geometric glass sails, physically intercepting oblique lateral precipitation vectors that would otherwise bypass the flat footprint of the site.

Furthermore, the developer's "rain shadow" argument confirms our kinetic dumping model: the panels collect 100% of the intercepted rainfall and concentrate this mass into parallel, high-velocity drip-lines [3]. On Trent Valley alluvial clays (Fladbury and Compton associations) naturally at absolute field capacity (C = 0.80 to 0.90) during winter storm seasons [1], this localized kinetic point-loading instantly exceeds the soil's micro-infiltration limit. It converts the rain directly into immediate Hortonian (saturation-excess) overland flow before the hydrologically bypassed dry soil in the "rain shadow" can offer any compensatory absorption.

2.2 Countering the "Good Soil" Fallacy: The "Baseline Shock"

To counter developer claims of "hydrological neutrality" based on favourable existing soils, the "Baseline Shock" framework serves as a mathematical trap for developers.

On the surface, a developer may argue: *"Idyllic sites like Springwell have excellent, absorbent loam soil, unlike the heavy clay elsewhere. Therefore, our site naturally handles water better and poses less flood risk."*

The model turns this exact argument entirely against them. The "Baseline Shock" quantifies the sudden, violent hydrodynamic shift in how the landscape behaves once its permeable surface is paved over. The core scientific principle is paradoxical but exact: **The better the natural soil is at absorbing water at baseline, the more catastrophic the net volumetric impact when it is destroyed.**

Think of the ground as a sponge. If you cover a poor sponge with plastic, you do not lose much functionality. If you cover a super-absorbent sponge, you lose immense environmental utility.

Table 1: The Baseline Shock Displacement Trap

Soil Type	Greenfield Runoff Coefficient (C)	Post-Development Runoff (C)	The "Baseline Shock" (Net Increase in Displaced Runoff)
Trent Valley Clay	0.25 (Sheds 25% / Absorbs 75%)	0.90 (Sheds 90%)	+0.65 (A 65% net increase in water dumped on neighbours)

Soil Type	Greenfield Runoff Coefficient (*C*)	Post-Development Runoff (*C*)	The "Baseline Shock" (Net Increase in Displaced Runoff)
Springwell Loam	0.15 (Sheds 15% / Absorbs 85%)	0.90 (Sheds 90%)	+0.75 (A 75% net increase in water dumped on neighbours)

By conceding that the loam is "better local soil" at baseline, the developer mathematically demonstrates that their disruption to the local water cycle is maximized, not minimized. Because the Springwell site is currently doing so much heavy lifting for the local environment by absorbing 85% of rainfall, destroying it creates a far worse volumetric shock to the downstream system than paving over clay.

The Double Whammy (Winter Stress Test):

This dynamic is further exacerbated when stress-tested against winter conditions:

- **Summer/Autumn:** The loam soil absorbs water beautifully.
- **Winter Lock-Up:** The regional water table rises, and the soil profile reaches absolute field capacity, filling up like a sponge left in a bucket. It becomes completely saturated ("locks up").
- **The Displacement:** At this point, the baseline pre-development sponge can offer no further absorption. If the developer has formalized the surface with compacted tracks and glass arrays, there is nowhere for the newly amplified rainfall volume to go. The development shifts the site from a highly efficient natural drain into a massive, impervious concrete funnel.

2.3 Peak Discharge Formula & Kinematic Synchronization

- **Community Formulation:** $Q = (C \times I \times A \times 1.18)/360$ (Metric Rational Method)
- **The Developer Attack:** Developers will argue that using the simple Rational Method across individual sites ranging from 474 ha to 1,765 ha, and a cumulative total of 8,844 ha, is a major hydrological error. They will cite UK guidelines restricting the method to catchments smaller than 150 to 200 hectares to account for natural wave routing and attenuation [6].
- **The Forensic Rebuttal (Loss of Fractal Attenuation):** The standard restriction applies to natural, unpaved agricultural basins where varied surface roughness and tortuous flow paths naturally diffuse the flood wave over time and distance [4]. However, the developers are physically industrializing the landscape. By installing thousands of kilometres of formalized glass drip-lines, highly compacted access tracks [5], and engineered linear drainage channels, they entirely short-circuit natural fractal attenuation.

Because the “Baiamonte effect” compresses the Time of Concentration (T_c), identically across every parallel array, these localized micro-peaks violently synchronize [3]. We are not presenting this as a steady-state routed main-river outfall flow; the calculated 1,962.96 m^3/s is the Aggregate Instantaneous Runoff Potential (AIRP). The Rational Method is precisely the correct deterministic stress-test to calculate the simultaneous, unattenuated aggregate discharge of thousands of formalized urban/industrial micro-grids hitting the surcharged system at once [7].

2.4 Transient Stage-Discharge Constriction ($h = Q/k$)

- **Community Formulation:** The Exceedance Index (*h*) is formulated as a strictly linear function of discharge (*Q*) and a conveyance penalty (*k*).
- **The Developer Challenge:** Developers will challenge our linear exceedance index, arguing that natural river flow is highly non-linear (Manning’s Equation) [10] and that wide floodplains naturally allow floodwaters to spread horizontally, making extreme vertical stacking pressures physically impossible.
- **The Forensic Rebuttal (Surcharged Backwater Modelling):** This is a strategic trap. The developers are arguing about an empty, natural floodplain using static volumetric mass balance integration. We are modelling an industrialized floodplain under Surge Saturated conditions [2]. When downstream river surges hydraulically lock the gravity outfalls, the forward hydraulic gradient drops to zero [9]. Simultaneously, lateral spread is severely prevented by hundreds of kilometres of security mesh fencing forming semi-permeable debris dams [12].

Our formula $h = Q/k$ is intentionally deployed as a transient boundary penalty function representing dynamic backpressure. We freely concede the water will not physically stack 23 meters high in the air. Because the water physically cannot stack vertically to satisfy this immense hydrostatic pressure spike, it absolutely must blast sideways. By attacking our vertical depth as impossible, developers mathematically confirm our primary physical conclusion: unattenuated lateral containment failure.

The Requirement for Dynamic 2D Modelling: We formally acknowledge that while the linear exceedance index **($h = Q/k$)**provides undeniable mathematical proof of a catastrophic systemic rupture, mapping the precise horizontal footprint and velocity of the lateral breakout requires advanced dynamic simulation. Therefore, this proven mathematical failure serves as the explicit technical trigger mandating the Examining Authority to compel the developers to fund and execute a catchment-wide 1D/2D backwater curve analysis (e.g., TUFLOW or HEC-RAS, as defined in Work Package 1). Until the developers produce this dynamic 2D simulation to prove exactly where their displaced volume will flow, their localized safety claims remain technically invalid.

2.5 Dynamic Floodplain Storage Loss and the “5mm Loophole”

- **Community Formulation:** 230,965 m^3 combined uncompensated storage loss (39,900 m^3 for One Earth).
- **The Developer Challenge:** Presenting CAD drawings, developers will claim slender steel mounting stilts occupy a negligible (less than 0.1%) physical

volume of the floodplain. They will also rely on EA procedural agreements that any regional flood level increase under 5 mm is “negligible” [11].

- **The Forensic Rebuttal (Dynamic Conveyance Exclusion):** The focus on static Archimedean solid-steel displacement demonstrates a fatal misunderstanding of open-channel hydrodynamics [10]. Floodplain functionality is dictated by dynamic conveyance, not just static empty space. The introduction of tens of thousands of piles, security mesh, and inverter plinths drastically increases macroscopic hydraulic drag, generating a pronounced backwater wedge (quantified by their own models as a 5 mm to 5.7 mm regional rise) [11].

The calculated 39,900 m^3 figure is the Effective Compensatory Mitigation Deficit—the exact physical water volume displaced across the boundaries by this dynamic conveyance drag. Salami-slicing this impact via a “5mm loophole” hides immense cumulative displacement across 8,844 ha, directly violating the absolute “No Net Loss” of floodplain storage mandated by National Policy Statement EN-1 [16].

Table 2: Unified Summary of Developer Attack Vectors and Forensic Defences

Developer Attack Vector	Technical Parameter	Forensic Rebuttal Argument	Statutory / Policy Leverage
1. Mass Balance Conservation	Rainwater volume is constant; rain shadows balance catch.	Panels act as sails intercepting oblique WDR [8]. Kinetic driplines instantly exceed micro-infiltration limits on saturated clays [1].	Local Strategic Flood Risk Assessments (SFRAs).
2. Invalidation of Scale	Rational Method used on basins greater than 8,844 ha [6].	Greenfield rules do not apply to industrial land. Compacted, partitioned arrays behave as synchronized grids (AIRP) [3].	NPPF Paragraph 35 (cross-boundary priorities) [13].
3. Non-Linear Floodplain Flow	Wide floodplains naturally prevent vertical stacking [10].	Cannot stack vertically due to locked outfalls [9] and mesh	NPS EN-1 Paragraph 5.8.12 (management of flow

Developer Attack Vector	Technical Parameter	Forensic Rebuttal Argument	Statutory / Policy Leverage
		debris dams [12], forcing unattenuated lateral overtopping.	constriction) [16].
4. The “5mm Loophole”	Steel stilts occupy less than 0.1% volume; rises less than 5 mm are negligible.	Deficit represents true physical water displaced by the 5.7 mm dynamic conveyance drag [11]. Volume cannot disappear.	NPS EN-1 Paragraph 5.8.12 (“No Net Loss” of storage) [16].

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3. Re-Aligned Cross-Examination Reference Index

To ensure these dynamic counterarguments map directly to the formal evidence bundle, the following reference index explicitly anchors our defence to the One Earth Solar Farm Library (EN010159) and statutory design authorities:

- **Dynamic Volume Loss & 5.7 mm Afflux:** Evaluated directly against the One Earth Hydrological Audit and the modelled tolerance impact boundaries in Appendix 7.2 (PINS Document Ref: EN010159-000604) [11].
- **Aggregate Instantaneous Runoff Potential (AIRP):** Framed as a deterministic stress-test countering the greenfield assumptions in the Applicant’s Outline Drainage Strategy (PINS Document Ref: EN010159-000143) [4], utilizing the peak compression frameworks established in Baiamonte, G. (2023) [3].
- **Fencing Impedance & Debris Dam Constriction:** Cross-referenced with the design layouts scrutinized in Stephen Fox’s Closing Position Statement (PINS Document Ref: EN010159-001214) [11] and the JVR Hydrology Technical Memorandum under NPS EN-1 Paragraph 5.8.12 [12], [16].
- **WDR Catch Mechanics:** Grounded in the aerodynamic velocity vectors and boundary definitions of Blocken, B., & Carmeliet, J. (2004) and Hens, H. (2010) [8].
- **Rational Method Scaling Exceptions:** Methodological limits extracted directly from BS EN 16933-2:2017 and the HR Wallingford (1981) Modified Rational Method [6], [7].

4. Sequential Forensic Field and Computational Research Plan

To replace the developers' "hydrological neutrality" assumptions with an unassailable scientific case, this sequential research plan details five core work packages designed to collect localized field data, perform advanced 2D hydrodynamic modelling, and establish a robust, standard-compliant technical challenge.

Work Package 1: Integrated 2D Hydrodynamic Modelling (FEH/ReFH2 & TUFLOW)

Establish a single, continuous 2D hydraulic model domain encompassing all seven projects (8,844 ha). Access the UKCEH FEH Web Service and run ReFH2.2 to generate dynamic runoff hydrographs applying the EA's "Upper End" climate change allowance (+39%). Apply high-stage downstream boundary conditions on the River Trent/Witham based on historical flood profiles (e.g., Storm Henk, Storm Babet [2]) to simulate "hydraulic locking" [9].

Work Package 2: Localized Infiltration and Soil Compaction Field Investigations

Perform double ring infiltrometer testing across Fladbury, Foggathorpe, and Compton soils [1] to establish natural saturated hydraulic conductivity. Conduct post-construction auditing on active construction tracks subjected to heavy machinery to quantify long-term permeability reductions [5], calibrating post-development runoff coefficients (C).

Work Package 3: Micro-Channelling and Dripline Kinetic Energy Field Testing

Establish a localized physical testing plot equipped with tilted glass panels over native clay soils. Measure the kinetic energy of water falling from the 3m drip-edge to quantify topsoil scour [3]. Map micro-channels and rills to calculate the reduction in Manning's n and the resulting reduction in (T_c)[3].

Work Package 4: Spatial GIS Floodplain Constriction and Fencing Impedance Analysis

Import detailed layouts of BESS compounds, inverter platforms, and security fencing into GIS. Map exact lengths of security mesh fencing crossing the 4,361 ha of active floodplain [12]. Apply blockage factors (50% to 100%) to simulate debris accumulation and quantify the reduction in floodplain conveyance (k) [10] to integrate into the 2D hydrodynamic framework.

Work Package 5: Sediment Transport and Water Framework Directive (WFD) Risk Assessment

Model the soil shear stress generated by the accelerated, high-energy dripline flow. Analyse bed sediments for priority hazardous substances, specifically PFOS and Mercury [15]. Run sediment transport models showing mobilized silt re-suspending toxic contaminants, establishing a clear breach of WFD Regulation 17 [15].

Table 3: Forensic Research Plan Task Matrix

Work Package	Core Research Task	Applied Scientific Standard	Expected Technical Output
WP 1: 2D Modelling	Build conjoined 2D TUFLOW model of Trent/Witham catchments	FEH Web Service; ReFH2.2	Dynamic, routed hydrographs capturing tailwater surcharge [9].
WP 2: Infiltration	Double-ring testing on Fladbury/Compton clay soils [1]	BRE Digest 365; CIRIA C753	Verified runoff coefficients (*C*) reflecting soil compaction [5].
WP 3: Dripline Scour	Laser disdrometer monitoring of rainfall shedding	Baiamonte et al. (2023) [3]	Quantification of topsoil shear stress and *T_c* compression.
WP 4: Blockage	GIS mapping of security fence clogging [12]	Manning's specific conveyance [10]	Quantified reduction in conveyance (*k*) and actual stage rise.
WP 5: WFD Siltation	Chemical analysis of bed sediments for PFOS and Mercury [15]	WFD Regulation 17 [15]	Models proving mobilized silt will trigger ecological deterioration.

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5. Strategic Policy and Procedural Interventions

The structural data generated through this forensic research plan must be deployed within the statutory planning framework to maximize its legal impact during the DCO examinations.

- **Leveraging Section 104 of the Planning Act 2008:** Under Section 104 [13], local development plan frameworks and Strategic Flood Risk Assessments (SFRAs) remain “important and relevant” matters. Since local SFRAs assume the valleys remain uniform agricultural land, the developers’ models are anchored to a fictional baseline [4]. Submitting the verified 2D cumulative model will legally prove non-compliance with local strategic policies.
- **Enforcing NPPF Paragraph 35 “Effectiveness” Tests:** Paragraph 35 requires joint, cross-boundary working on strategic priorities [13]. Developers have avoided cumulative scrutiny by using artificially limited “Zones of Influence”. The conjoined 2D model will demonstrate that the seven projects hydraulically interact, providing the host LPAs with the technical justification to object sequentially.
- **Exposing EIA Regulation 14 Failures and Evidential Weight Traps**: While transitional provisions shield the Applicant from active LURA 2023 Environmental Outcomes Report (EOR) checklists, the application faces a terminal statutory breach under Regulation 14 of the Infrastructure Planning (EIA) Regulations 2017, which mandates that environmental assessments consider current knowledge and modern science. The conjoined 2D model and WFD Sediment Study provide unassailable empirical proof that synchronized kinetic runoff will compress the time to concentration (Tc), spike peak discharge$(Q_p)$and actively mobilize catchment sediment banks bound with legacy PFOS and Mercury directly into the River Trent. Omitting these physical and chemical kinetics renders the Environmental Statement statutorily defective under the 2017 Regulations. Furthermore, because the government's 2026 policy updates and the 28 May 2026 EA NaFRA2 release have now formally enshrined these exact cumulative parameters and data-driven mandates, they stand as authoritative proof of what constitutes a highly material environmental consideration. Having been put on direct, personal notice via the October 2025 served paper on cumulative risk, any attempt by the Secretary of State to dismiss this empirical proof of active environmental regression, or to afford it less than considerable weight, triggers a textbook Wednesbury irrationality barrier, rendering the final decision ultra vires and immediately vulnerable to being quashed.
- **Compelling a Joint, Catchment-Wide Model:** The community must petition the Examining Authority (ExA) to issue a Rule 17 request. This will compel the developers to fund and run a joint, catchment-wide model to test for peak flow synchronization across the entire 8,844-hectare cluster, effectively shifting the burden of proof back onto the developers.

6. References and Technical Footnotes

- **[1]** Soil profile descriptions and Hydrology of Soil Types (HOST) classifications for the Trent Valley and Lincolnshire floodplains (Fladbury, Foggathorpe, and Compton associations) are derived from the Cranfield University National Soil Resources Institute (NSRI) Soilscapes index and Boorman, D. B., Hollis, J. M., &

Lilly, A. (1995), "Hydrology of soil types: a hydrologically-based classification of the soils of the United Kingdom", Institute of Hydrology Report No. 126.

- **[2]** Antecedent catchment wetness data and historic compound flooding parameters are analysed with reference to the specific winter storm hydrographs experienced by the local catchments, including the prolonged regional flood events of 2000, Storm Dennis (2020), Storm Babet (2023), and Storm Henk (2024).
- **[3]** Peak discharge amplification factors, micro-channelling metrics, and time-to-peak compression are derived from the empirical proofs in Baiamonte, G. (2023), "Impact of solar panels on runoff generation process", *Hydrological Processes*, 37(12), e15053, establishing the 11.7x peak discharge multiplier and 5x flow acceleration on sloped test plots.
- **[4]** Hydrological baseline metrics, short-grass runoff assumptions, and site baseline limitations are evaluated against the numerical modelling frameworks in Cook, L. M., & McCuen, R. H. (2013), "Hydrologic Response of Solar Farms", *Journal of Hydrologic Engineering*, 18(5), 536-541, as contrasted with the Applicant's Outline Drainage Strategy (PINS Document Ref: EN010159-000143).
- **[5]** Soil structural degradation, bulk density increases, and topsoil macropore collapse under heavy construction machinery wheel-loads are assessed in accordance with the field data in the Green Hill Engineering Report: Flood Risk (2025) (PINS Document Ref: EN010170-001242) and East Stour Solar Farm Environmental Statement Appendix 9.1.
- **[6]** Catchment scaling thresholds and application limits for the Rational Method are derived from BS EN 16933-2:2017 (Drainage systems outside buildings), the CIRIA C753 SuDS Manual, and the statutory design constraints maintained by the Lead Local Flood Authorities (LLFAs).
- **[7]** Modified Rational Method formulation parameters, routing variables, and volumetric runoff coefficients (C) are evaluated against the HR Wallingford (1981) Modified Rational Method (Wallingford Procedure Volume 4) guidelines.
- **[8]** Wind-driven rain (WDR) aerodynamic catch ratios, oblique vector calculations, and spatial mass concentration mechanics are derived from Blocken, B., & Carmeliet, J. (2004), "A review of wind-driven rain research in building science", *Journal of Wind Engineering and Industrial Aerodynamics*, 92(13), 1079-1130, and Hens, H. (2010), "Wind-Driven Rain Striking a Building Enclosure".
- **[9]** Gravity drainage outfall blockage profiles and backwater tailwater surcharge mechanisms (hydraulic locking) are evaluated against the Environment Agency's (2013) Flood Estimation Guidelines and local internal drainage board outfall records.
- **[10]** Non-linear channel rating parameters, open-channel roughness coefficients, and unsteady flow dynamics are governed by Henderson, F. M. (1966), *Open Channel Flow* (Macmillan) and the differential boundary formulations in Saint-Venant, A. J. C. (1871), "Théorie du mouvement non-permanent des eaux".
- **[11]** Dynamic volumetric displacement calculations, the 39,900 m^3 volumetric storage deficit, and modelled tolerance boundary afflux (PINS Document Ref:

EN010159-000604) are derived from the official examination submissions: Stephen Fox, “Forensic Hydrological Audit and Regulatory Rebuttal” (EN010159-001208, Deadline 7) and “Closing Position Statement of Stephen Fox” (EN010159-001214, Deadline 7).

- **[12]** Security fencing blockage factors, mesh hydraulic resistance indices, and agricultural debris accumulation parameters are evaluated against the specifications in the JVR Hydrology Technical Memorandum and Stephen Fox’s “Hydrological Audit” (EN010159-001307, Deadline 8).
- **[13]** Strategic planning criteria and cross-boundary cumulative assessment frameworks are anchored to Section 104 of the Planning Act 2008, Paragraph 35 of the National Planning Policy Framework (NPPF).
- **[14]** Environmental target regression and flood resilience outcomes are assessed in accordance with the statutory framework of the Levelling-up and Regeneration Act 2023 (LURA) and the 2026 Environmental Outcomes Report (EOR) guidelines.
- **[15]** Sediment mobilization pathways, chemical status target progression, and legacy contaminant re-suspension parameters (PFOS/Mercury) are evaluated against the metrics in Stephen Fox, “The Examining Authority; Case Team; One Earth Solar Farm Applicant: Submission of Technical Reports” (EN010159-001291, 20 December 2025) and WFD Regulation 17 compliance criteria.
- **[16]** National Policy requirements for floodplain safety, layout constraints, and the absolute requirement for “no net loss” of floodplain storage are derived from the National Policy Statement for Energy (EN-1) Paragraph 5.8.12 and local LLFA drainage strategy conditions.

7. Supporting DCO Data Sources & Works Cited

- **[12]** Hydrological Audit - Planning Inspectorate. EN010159-001307
- **[11]** One Earth Solar Farm (EN010159) FROM: Stephen Fox - Planning Inspectorate. EN010159-001208
- **[15]** The Examining Authority; Case Team; One Earth Solar Farm Applicant From: Stephen Fox - Planning Inspectorate. EN010159-001291
- **[Ref]** Stephen Fox By email 19th September 2025 - Planning Inspectorate. EN010159-001182
- **[4]** Hydrologic Response of Solar Farms - County of San Diego. (Appendix I - Drainage Report)
- **[Cum]** 7000 Acres Response to the West Burton Solar Project Ltd Application - Planning Inspectorate. EN010132-001179
- **[11]** One Earth Solar Farm - FRA & Drainage Strategy (Clean) (Rev 3) - Planning Inspectorate. EN010159-000604
- **[1]** Estimating flood peaks and hydrographs for small catchments: Phase 1 - NERC Open Research Archive / GOV.UK
- **[5]** Engineering Report: Assessment of Surface Water Runoff from Proposed Green Hill Solar Farm - Planning Inspectorate. EN010170-001242

- **[Cum]** 7000 Acres Response to the Cottam Solar Project Ltd Application - Planning Inspectorate. EN010133-000911
- **[Comp]** Frodsham Solar Outline Drainage Strategy - Planning Inspectorate. EN010153-000573
- **[11]** CLOSING POSITION STATEMENT OF STEPHEN FOX - Planning Inspectorate. EN010159-001214
- **[Cum]** Summary: The Collapse of the "Critical Friend" - Planning Inspectorate. EN010159-001308

APPENDIX 5: METHODOLOGICAL SENSITIVITY ANALYSIS AND THE "CONSERVATION OF MASS" CONCESSION

1. INTRODUCTION: THE FALLACY OF COMPOSITION AND LINEAR AGGREGATION A fundamental scientific and methodological flaw is embedded in standard utility-scale infrastructure applications: the fallacy of composition. Developers erroneously assume that the physical behaviour of a single, isolated element scales linearly when replicated across a vast, contiguous landscape. By treating an 8,844-hectare environmental intervention as merely the sum of its micro-parts, applicants commit a profound error in scale.

To definitively settle the dispute between the reductionist empirical models of the developers and the systemic kinematic models of this Independent Assessment, this Appendix formally evaluates the extremes of volumetric generation. It juxtaposes the Community's *Macro-Mathematical Systemic Reality* against the Developers' strict *Atmospheric Mass-Balance Constraint*, calculating the exact mathematical delta between the two positions.

2. POSITION A: THE COMMUNITY'S SYSTEMIC REALITY (The Uncapped Volumetric Argument) The initial framework of this Reconciled Master Model calculated that under Stress Test 2 (Surge Saturated + Wind Driven Rain), the combination of a 0.90 runoff coefficient and the 1.18 panel-tilt geometric multiplier yielded an effective volumetric output of 106.2%. This position is grounded in the non-linear realities of massive infrastructure deployment:

- **Hydrological Mechanics (The Point vs. The Catchment):** When applicants assess a single solar panel, they treat it as an isolated drainage problem (Micro-Physics). When scaled to 8,844 hectares, it becomes a systemic catchment transformation (Macro-Mathematics). Replicated across thousands of hectares, individual drip lines become a synchronized network of macro-concentrated flows. Because panels act as geometric sails intercepting oblique wind-driven rain (WDR), they concentrate 100% of the intercepted volume, bypass the leeward rain shadow, and violently saturate the underlying clay soil.
- **Boundary Layer Meteorological Alterations:** The conflation extends into atmospheric physics. A single PV panel radiates negligible sensible heat (Micro-Physics). An 8,844-hectare dark, artificial canopy fundamentally changes the surface roughness and albedo of an entire region, creating a massive Photovoltaic Solar Heat Island (PVHI) effect (Macro-Mathematics). This establishes a macro-scale thermal engine capable of altering regional convective patterns and localized precipitation behaviours.

Under Position A, the systemic loss of effective site infiltration, combined with PVHI meteorological alteration and WDR interception, justifies scaling the gross volume beyond standard flat-earth baselines, resulting in over 5.49 million cubic metres of lateral overtopping.

3. POSITION B: THE APPLICANT'S REDUCTIONIST DEFENCE (The Atmospheric Constraint) In response, the developers and standard regulatory authorities invoke a strict interpretation of the First Law of Thermodynamics: The Conservation of Mass.

Evaluated across a 3D atmospheric bounding box encompassing the 8,844-hectare cluster, the absolute total mass of water H_2O entering the system is strictly limited by the localized Precipitation Depth (P). The developer will argue that while the arrays undoubtedly redistribute, kinematically concentrate, and dynamically accelerate the fluid—triggering non-linear flow velocities—they cannot mathematically *manufacture* an absolute gross volume ofH_2Omolecules that exceeds 100% of the statistical atmospheric envelope.

It is here that the distinction between mass and behaviour must be explicitly clarified: **while the atmospheric envelope is bounded, it is the ground-level conversion efficiency that fundamentally shifts.** By maximizing the Runoff Coefficient (C) to 0.98 for compacted clay—a devastatingly realistic setting for a heavily trafficked site under winter storm stress—the model acknowledges near-absolute conversion of this bounded atmospheric mass into surface runoff, achieving catastrophic yields without violating thermodynamic limits.

4. THE BOUNDING CONCESSION AND MATHEMATICAL DELTA To definitively eliminate the developers' procedural escape route and ensure the Examination is not distracted by pedantic debates over atmospheric thermodynamics, this Independent Assessment formally subjects its Master Model to a **Bounding Case Concession**.

Strictly *arguendo*, the Community concedes the developer's Bounding Mass Constraint for Gross Volume (V):

- **The Volumetric Yield is Capped:** The 1.18 geometric multiplier is removed from Equation 1. To accurately represent the Hortonian flow, heavy machinery compaction, and bypassed rain shadow described in Position A, the ground-level conversion efficiency (C) is maximized to its absolute physical limit ($C = 0.98$ for clay; 0.90 for fen loams).
- **The Kinematic Acceleration is Retained:** The 1.18 multiplier remains fundamentally preserved within Equation 2 (Peak Discharge Q). The non-linear synchronization, kinetic intensity, and flow velocity of the fluid are empirically accelerated by the panel geometry, as flow rate (m^3/s) is a measure of kinetic intensity, not static mass.

Table A5.1: The Concession Delta Calculation (Scenario 3c/d: Surge Saturated)

Hydrological Metric (Combined 7-Project Total)

Position A: Systemic Reality (Uncapped Mass Yield)

Position B: Mass-Balance Concession (Capped $\leq 100\%$)

Mathematical Delta (The Variance)

Equation 1: Gross Generation Volume (V)

$6{,}309{,}541.13\ m^3$

$5{,}760{,}063.75\ m^3$

$-549{,}477.38\ m^3$

Equation 5: Lateral Overtopped Volume

$5{,}493{,}384.25\ m^3$

$4{,}943{,}906.88\ m^3$

$-549{,}477.37\ m^3$

Equation 2: Peak Discharge Rate (Q)

$1{,}962.96\ m^3/s$

$1{,}962.96\ m^3/s$

$0.00\ m^3/s$ (Unchanged)

Equation 4: Theoretical Exceedance Index (h)

$23.37\ meters$

$23.37\ meters$

$0.00\ meters$ (Unchanged)

5. CONCLUSION: THE APOCALYPTIC REALITY OF THE CONCESSION The results of this Sensitivity Analysis are definitive. By undertaking this bounding concession, the model deliberately surrenders approximately 549,000 cubic metres of theoretical fluid volume to satisfy the strictest, most rigid limits of atmospheric mass conservation demanded by the developer.

However, this mathematical concession provides absolutely no salvation for the applicants' drainage strategies.

Even when fully bound by the developer's preferred empirical mass-balance limits, the conjoined industrialization of the Trent and Witham valleys mathematically forces **4.94 million cubic metres of unattenuated lateral overtopping** onto unprotected, third-party environments.

Crucially, because the non-linear kinetic velocity ($Q = 1{,}962.96\ m^3/s$) and spatial synchronization remain artificially compressed by the continuous glass catchment, these 4.94 million cubic metres will not act as a slow-rising flood; it will be blasted laterally as a **highly destructive kinematic shockwave**. Driven by a synchronized, compressed time-to-peak hydrograph, this guarantees an unrecoverable stage-discharge failure.

The core systemic failure remains: the applicant cannot mitigate a macro-mathematical system failure using micro-physics tools (e.g., standard localized swales). Ultimately, whether the system generates 5.49 million or 4.94 million cubic meters of uncompensated floodwater is academically irrelevant to the residents of the Trent and Witham Valleys. Both figures represent a regional disaster. By proving that the extreme hazard persists even when conceding the applicant's strictest theoretical mass-balance defence, this model renders the developers' claims of "hydrological neutrality" entirely indefensible.