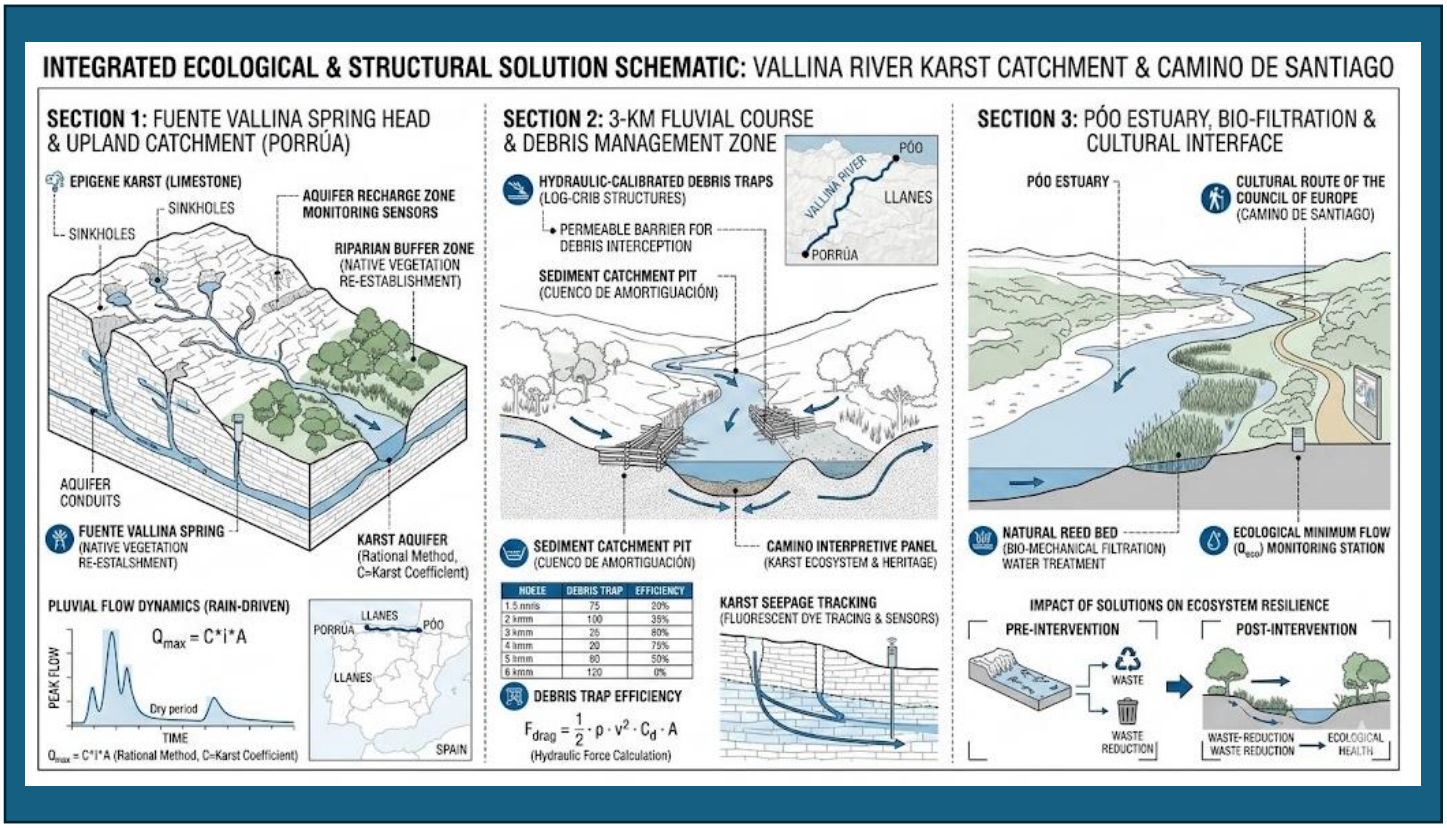
Solution Blueprint: The "Karst-Resilience" Model



Key Message

- Message 1: A specialized framework for Vallina River must address karst limestone, flash flooding, and Camino significance.
- Message 2: Connecting Porrúa to Póo, solutions must be low-impact for heritage and high-resilience for flash-flood debris.

Policy Relevance

International policy:

- Policy 1 name: **EU Nature Restoration Law (Regulation 2024/1991)** - The Vallina River is a candidate for "lateral and longitudinal connectivity" restoration by removing debris and invasive species that block its natural flow.
- Policy 2 name: **Water Framework Directive (WFD) & 2026 Revision** - The EC is currently (Q2 2026) revising the WFD to better align with "Nature-based Solutions" (NbS).
- Policy 3 name: **EU Mission - "Restore our Ocean and Waters by 2030"** - This mission provides the specific €60,000+ co-financing for the Vallina's environmental and ethnographic recovery.

National policy:

- Policy 4 name: **National River Restoration Strategy (MITECO)** - The 2026 focus is on **"Restauraríos"**, promoting connectivity in urban/rural interfaces like the Porrúa-Póo corridor.
- Policy 5 name: **Spanish Law on Natural Heritage and Biodiversity** - Mandates the protection of "Geodiversity." The **karst system** of the Vallina is legally protected as a geological asset. Any intervention must ensure it does not alter the subterranean "aquifer conduits" or sinkholes.
- Policy 6 name: **Asturias Regional Plan (Principado de Asturias)** - Heritage Protection: Since the river intersects the Cultural Route of the Council of Europe (Camino de Santiago), the project must comply with the Ley de Patrimonio Cultural de Asturias, and Waste Management: Aligned with the regional circular economy plan to eliminate "puntos negros" (black spots) of waste accumulation in riverbeds.

What is the Challenge

This blueprint outlines the transition from traditional, high-maintenance systems to an integrated, smart infrastructure model.

An Innovative Solution

A. Flow & Debris Management (The Hydraulic Pillar)

Since the Vallina is pluvial and irregular, the goal isn't to stop the water, but to "filter" it during surge events.

- **Natural Woody Debris (NWD) Traps:** Instead of concrete dams, install strategic "log jams" made of local timber. These catch large waste/debris during floods but allow small aquatic life and base-level water to pass.
- **Riparian Buffers:** Re-planting native species (willows/alders) between Porrúa and Póo to stabilize the banks against karst erosion.

B. Smart Monitoring (The Tech Pillar)

- **Early Warning Sensors:** Ultrasonic water-level sensors at "Fuente Vallina." When the level rises rapidly (indicating a flash flood), the municipal waste team is alerted to check downstream "interceptor" points.
- **Karst Seepage Map:** Digital tracking of where the river "disappears" or "re-emerges" to ensure pollutants aren't entering the underground aquifer.

C. The Pilgrim Experience (The Cultural Pillar)

- **Eco-Signage:** Educational markers along the Santiago de Compostela route explaining the karst ecosystem.
- **Bio-Mechanical Filtration:** Using "Reed Beds" near the mouth at Póo to naturally treat runoff before it hits the coastal estuary.

The Benefits the solution produces

Benefit Category	**Primary Outcome**	**Stakeholder Impact**
Environmental	Clean, free-flowing 3km river course.	Local Ecosystem & Wildlife
Social/Cultural	Safer, more beautiful Pilgrim Route.	Inhabitants, Tourists & "Camino" Pilgrims
Administrative	Compliance with 2026 EU Water Mandates.	Llanes Municipality

How developed is the solution

SRL 1-3 (Concept & Planning): Identifying the problem, engaging with stakeholders, and evaluating societal readiness.

Where could also be applied to?

This solution can be applied in any part of the world.

Area Characteristics	Intention for applying the solution
Natural Debris Management	Using "leaky dams" or natural vegetation filters that catch debris without blocking the view or the trail.
Permeable Pathways	Using materials that allow water to sink into the karst limestone while remaining stable for pilgrims' boots.
Resilient Infrastructure	Bridges and crossings designed to allow floodwaters and sediment to pass over or through them without structural failure.

To address the sensitive nature of the Camino de Santiago while managing the Vallina River's volatility, we should prioritize **Bio-engineering** and **Nature-Based Solutions (NBS)**. These methods blend into the landscape and work with the karst geology rather than against it.

Who is this relevant to?

Beneficiary	Primary Benefit
Local Residents (Porrúa & Póo)	**Flood Protection:** High-resilience designs manage debris and flash floods, protecting local property and infrastructure from water damage.
Pilgrims (Camino de Santiago)	**Safety & Access:** Improved trail conditions mean fewer washouts and "mud-baths," ensuring the route remains navigable year-round.
Local Government/Council	**Cost-Efficiency:** Nature-based solutions often require less long-term maintenance than rigid concrete structures which can crack in shifting karst soil.
The Environment	**Aquifer Health:** Low-impact materials allow water to filter naturally into the porous limestone, recharging the groundwater without contamination.
Cultural Heritage Bodies	**UNESCO Compliance:** Minimalist, bio-engineered structures preserve the "universal value" and aesthetic of the historic pilgrimage route.

What do you need to have in place:

Executing this solution for the **Vallina River** requires a mix of specialized hardware, multidisciplinary expertise, and administrative coordination. Since the river is a "pluvial karst" system, we cannot use standard "one-size-fits-all" engineering; we need tools that respect the limestone geology and the historical path of the Camino de Santiago.

1. Physical Infrastructure & Materials

- **Log-Crib Debris Traps:** Locally sourced timber (e.g., Chestnut or Oak) to create permeable barriers that catch waste but allow water and sediment to pass.
- **Bio-Filtration Media:** Gravel, sand, and native aquatic plants (Reeds/Macrophytes) for the natural water treatment zone near the Póo estuary.
- **Geotechnical Reinforcement:** Biodegradable coconut-fiber blankets (biomantas) to stabilize riverbanks where karst erosion is highest without using concrete.
- **Soterrado (Underground) Hydraulic Systems:** Modern, watertight waste containers for the nearby towns (Porrúa/Póo) to prevent runoff from leaching into the river.

2. Technology & Monitoring Tools

To handle the "pluvial" (rain-driven) nature of the river, we need a "Smart Watershed" setup:

- **IoT Level Sensors:** Ultrasonic sensors at the **Fuente Vallina** spring to detect rapid water rises in real-time.
- **Karst Seepage Tracking:** Fluorescent dye-tracing kits to map the subterranean flow and ensure restoration doesn't accidentally block an underground conduit.
- **Telemetry Dashboard:** A central software interface for the Llanes Municipal Services to monitor flow and receive "high-debris" alerts during storms.

3. Human Capital (The Team)

A project this complex requires a "Living Lab" approach—bringing together experts and the community:

- **Hydrogeologist:** Specializing in Karst systems to ensure we don't interfere with the limestone aquifers.
- **Environmental Engineers:** To design the "Nature-based Solutions" (NbS) and calculate hydraulic loads.
- **Ethnographers/Historians:** To oversee work near the **Camino de Santiago**, ensuring all "Lavaderos" (historic wash-houses) are restored according to cultural laws.
- **Citizen Scientists:** Local volunteers from Porrúa and Póo to help with "Passive Restoration" (manual debris removal and planting).

4. Administrative & Regulatory Needs

- **Budgetary Allocation:** A mix of municipal funds and European grants (specifically from the **A-AAGORA** project or **Mission Ocean**).
- **Inter-Agency Permits:** Formal clearance from the *Confederación Hidrográfica del Cantábrico* (Water authority) and the *Principado de Asturias* (Cultural & Environmental departments).

- **EU Compliance Audit:** Verification that the project meets the **Nature Restoration Law (2026)** standards for "Good Ecological Status."

Key components of implementation:

Phase 1: Preparation & Technical Design (Q1 - Q2 2026)

Focus: Finalizing the technical project and securing permits.

- **Budget Finalization.** Approval of the 2026 Municipal Budget (€23M total), ensuring the allocated funds for the Vallina project (approx. €20,000 municipal + €60,000 A-AAGORA) are ring-fenced.
- **Technical Drafting.** Completion of the "Hydromorphological Restoration Plan" by engineering teams. This includes the exact placement of the log-crib debris traps and the design of the **Póo Estuary** bio-filtration reed beds.
- **Permit Coordination.** Secure approval from the *Confederación Hidrográfica del Cantábrico* and the *Principado de Asturias* (Culture Department) due to the river's intersection with the **Camino de Santiago**.

Phase 2: Community Engagement & Bidding

Focus: Transparent communication and contractor selection.

- **Public Participation Meeting.** Present the "Target Image" of the restored river to the neighbors of Porrúa and Póo, gathering feedback on the new walking trails and ethnographic elements (wash-houses/bridges).
- **Tender Launch.** Open the public bidding process for the specialized environmental work (invasive species removal) and the small-scale construction (restoring the "lavaderos").
- **EU Policy Alignment.** Submission of the local project data to the Spanish Ministry (MITECO) for inclusion in the **National Restoration Plan** draft, due to the EU on September 1st.

Phase 3: Physical Execution

Focus: Groundwork during the low-tourist season.

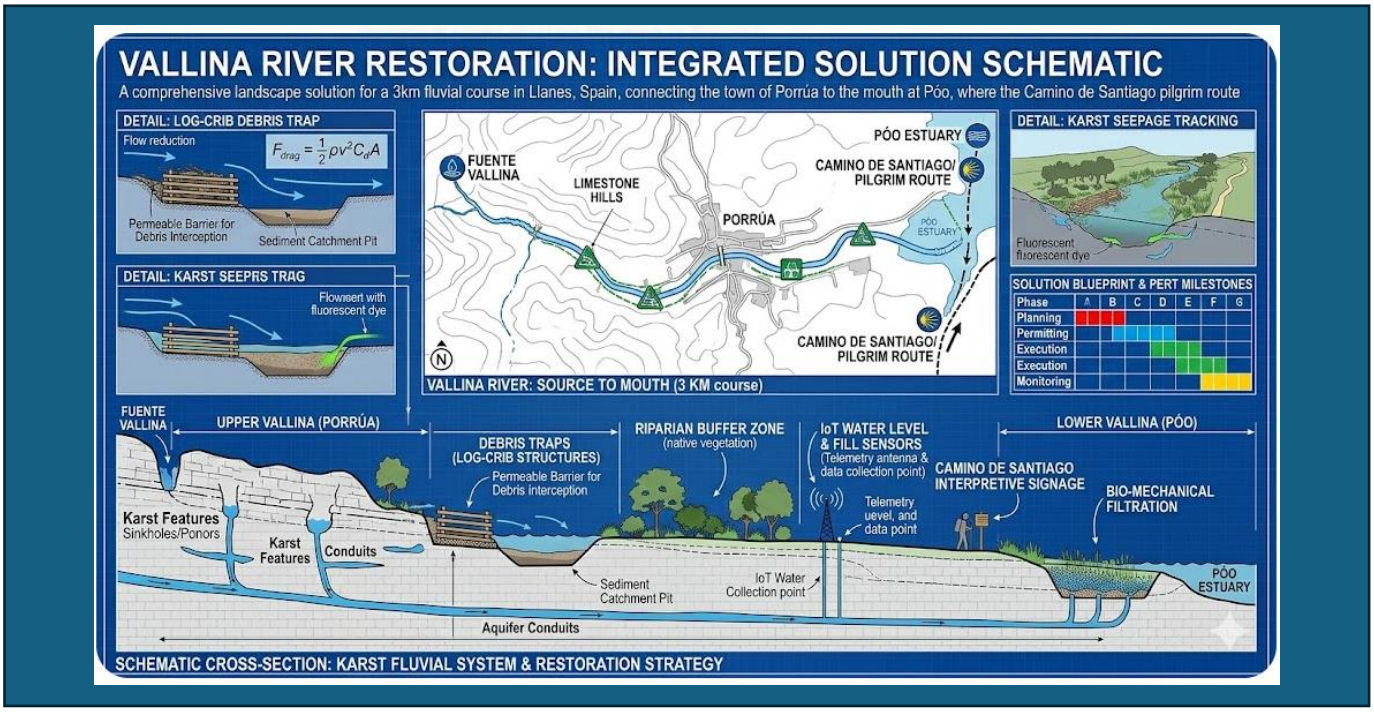
- **Invasive Species Cleansing.** Targeted removal of *Tradescantia fluminensis* and damaged trees along the 3km course. This is timed before the heavy winter rains.
- **Infrastructure Install.** Construction of the debris traps and the sediment catchment pits. Installation of the **IoT level sensors** at "Fuente Vallina" for flood monitoring.
- **Riparian Reforestation.** Planting of *Alnus glutinosa* (Alder) and other native species during the dormant winter period to ensure high survival rates.
- **Cultural Heritage Touch-ups.** Finalizing the restoration of stone bridges and installing the "Eco-Signage" for pilgrims.

Phase 4: Monitoring & Handover

Focus: Ensuring long-term sustainability.

- **Inauguration.** Formal opening of the "Vallina Green Corridor" connecting Porrúa and Póo.

- **A-AAGORA Project Closure.** Final reporting to the European Commission on the success of the pilot. The project moves from "Pilot" status to a permanent municipal asset.
- **Smart Maintenance.** The municipal "Plan de Desbroces" (Clearing Plan) now includes a specific line item for the annual inspection of the Vallina debris traps.



Workflow Summary Table

Phase	Key Milestone	Dependency
I. Planning	Technical Project Signed	Karst Mapping Completion
II. Legal	CHC & Culture Permits	Technical Project Approval
III. Bidding	Contractor Awarded	Permit Reception
IV. Action	3km Debris Removal	Low-tourist Season (Oct-Jan)
V. Closing	EU Mission Ocean Report	Post-restoration Data

Monitoring your success:

What to monitor	What to monitor?
Connectivity	3.0 km Continuous flow from Source to Sea
Waste Reduction	>80 % Volumetric measurement at Debris Traps
Cultural Impact	High Visual survey of the Camino de Santiago path
Bio-health	Improved Macro-invertebrate sampling in the Póo Estuary

The challenges you may encounter

Activity	Challenge 1	Challenge 2
Assemble a core committee with diverse groups	Lack of people with an interest or awareness of the issue or core group	Competing interest groups, power dynamics
Monitor biodiversity impact, societal Impact and volunteer community	Maintaining volunteer community over time	Availability of scientific skills and knowledge to enable effective and appropriate monitoring.

Key Contact – who to talk to about your application idea

Person 1: Jesus Carbajosa M.

Further information (reading/resources box)

To build this solution blueprint for the **Vallina River**, I have synthesized official municipal strategies, regional Spanish environmental laws, and European Union directives that govern the **A-AAGORA** project and the **Llanes** territory as of 2026.

European Union Policy & Funding

- **EU Nature Restoration Law (Regulation 2024/1991):** The core mandate requiring the restoration of free-flowing rivers and the removal of longitudinal barriers by 2030.
- **A-AAGORA Project (Horizon Europe):** Specifically, the "Atlantic-Arctic Lighthouse" initiatives which fund the Llanes "Living Lab" for coastal and fluvial resilience.
- **EU Water Framework Directive (WFD):** The standard for achieving "Good Ecological Status" in European water bodies, including karstic aquifers.
- **EU Mission: Restore our Ocean and Waters by 2030:** The overarching framework for the "ridge-to-reef" management of the Vallina-Póo corridor.

Spanish National & Regional Frameworks

- **Estrategia Nacional de Restauración de Ríos (MITECO):** The Spanish Ministry for Ecological Transition's guidelines on "Nature-based Solutions" (NbS) and river connectivity.
- **Confederación Hidrográfica del Cantábrico (CHC):** The regulatory body governing all interventions in the riverbeds of Northern Spain (Asturias).
- **Ley de Patrimonio Cultural de Asturias:** The legal framework protecting the **Camino de Santiago** (North Route) and associated ethnographic elements like the *lavaderos* (wash-houses).
- **Plan General de Ordenación Urbana (PGOU) de Llanes:** The municipal urban plan that dictates land use and protection zones along the Vallina River.

Technical & Project Management Standards

- **PMBOK Guide (Project Management Institute):** Used to structure the PERT diagrams, Critical Path Analysis, and Work Breakdown Structures (WBS).
- **Rational Method for Hydrology:** Used for calculating the pluvial flow dynamics ($Q = C \cdot i \cdot A$) specific to the Asturian coastal climate.
- **Hydrogeology of Karst Terranes:** Academic principles for managing "ponors" and subterranean conduits in limestone regions to prevent groundwater contamination.

Local Municipal Records

- **Llanes Municipal Budget (2025/2026):** For estimating the allocation of the €23M+ municipal funds toward "Obras y Servicios" (Works and Services).
- **Ayuntamiento de Llanes - "Plan de Desbroces":** The local maintenance schedule used to integrate the new "Smart" waste management routes.