RECONNECTING A LIFELINE

Agios Germanos River

Geomorphological Study

Sediment system, planning quantities and Irish-passage restoration scoping

A decision-ready reading of the river

This study follows sediment from the mountain tributaries through the lower corridor, its stores and three Irish passages to Great Prespa. It brings the field record, hydrological evidence, sediment calculations and RTK coverage into one positive basis for restoration appraisal.

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Evidence cut	10 August 2026
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Document control and submission guide

Project	*Reconnecting a Lifeline: Rehabilitation of Agios Germanos River*
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Controlling communication

This Geomorphological Study is the standalone account of the evidence, findings, planning quantities and passage-restoration implications. The separately supplied *Technical Appendices, Calculations and Evidence Archive* provide full analytical reconciliation. The main findings and their appropriate use are complete in this volume.

How the submission package works

1. **Start here.** Read this study for the river-system interpretation, headline quantities and passage-specific implications.
2. **Audit a number.** Use the Technical Appendices and calculation reconciliation register to trace each value to its released table, model state, parameter ledger and QA gate.
3. **Explore the evidence.** Use the accompanying July photograph collection and its index together with the governed image/sample registers. Module locations are shown in Figure 3.
4. **Verify the package.** Use the submission index, manifest and SHA-256 register to confirm file identity.

Issue position

This final study integrates field morphology, grain-size evidence and sediment estimates to support restoration scoping and comparison of crossing options. It explains how the assessment was adapted after two trap failures and how additional flux measurements could strengthen calibration. SPP's comments are incorporated, with the analytical baseline and uncertainty retained.

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Reader route

Sections 2 and 3 explain how the river stores and routes sediment. Section 4 translates the calculations into four clearly separated planning quantities. Section 5 places the three Irish passages and the RTK survey in their local geomorphic settings. Section 6 sets out the progression from this completed study to formal restoration design, with the limitations in Section 1.3.

All maps use north arrows and scale bars in the artwork. Module identifiers M1–M25 refer to July 2026 field-observation units; HM13–HM15 identify the three low concrete ford road crossings termed the Irish passages.

Executive summary

The Agios Germanos River carries water and sediment from its mountain tributaries to Great Prespa. This study examines how material is eroded, stored and moved along that route, and what those processes mean for possible modification or removal of three low concrete road crossings, HM13–HM15. It combines the July 2026 field observations and photographs with sediment samples, river maps, Laimos flow records, earlier studies and the topographic survey already received. Calculations then test how different assumptions about flow, sediment supply and obstructions affect possible transport.

The main finding is that sediment moves through a sequence of temporary stores. Mountain reaches are shaped by bedrock and large boulders, with smaller material held in pools and gaps. In the lower river, banks, bars, crossings and wood repeatedly retain and redirect material. Here, instream wood means trunks, branches and their accumulations in the channel; living bank vegetation is considered separately. Changing one crossing can therefore affect storage and erosion farther downstream.

The three crossings raise different questions. Below **HM13**, coarse material accumulates and is progressively sorted downstream. At **HM14**, flow divides between branches and interacts with wood, deposits, a fishway and nearby infrastructure. **HM15** leads into the final 1.76 km to the lake, where changes in sediment movement must be assessed alongside lake level and downstream habitats.

The flow record shows why the duration of strong flows matters: the two accepted water years had the same number of independent high-flow events, but high flows lasted more than twice as long in WY2022. This creates more opportunity for sediment movement; it does not demonstrate that twice as much material moved. Local calculations describe potential transport and new material from banks and damaged gabions. A separate comparison with neighbouring Prespa basins gives a planning centre of about 29,000 tonnes per year. These quantities concern different places and processes and must not be added together.

The study completes the geomorphological assessment needed for restoration scoping and comparison of crossing options. Source mapping, detailed grain-size analysis and sediment-routing estimates supply catchment context beyond a measurement at one point. Strong flows destroyed the traps twice despite repeated efforts. The estimates therefore retain explicit uncertainty and are not calibrated sediment fluxes. Functioning traps would strengthen local calibration; a closed sediment balance would also require repeated surveys and boundary measurements (Section 1.3). The assembled evidence supports option appraisal at this stage.

The next step is to compare retention, targeted modification, staged removal and full removal at each crossing and across the connected sequence. Reuse the received topographic survey after its reference and feature checks, fill specific gaps, and establish monitoring before works. Wood removal should be considered only after assessment by a researcher with relevant river-wood experience in protected areas, including its ecological value. The study supports this option comparison; it does not select or approve a final design.

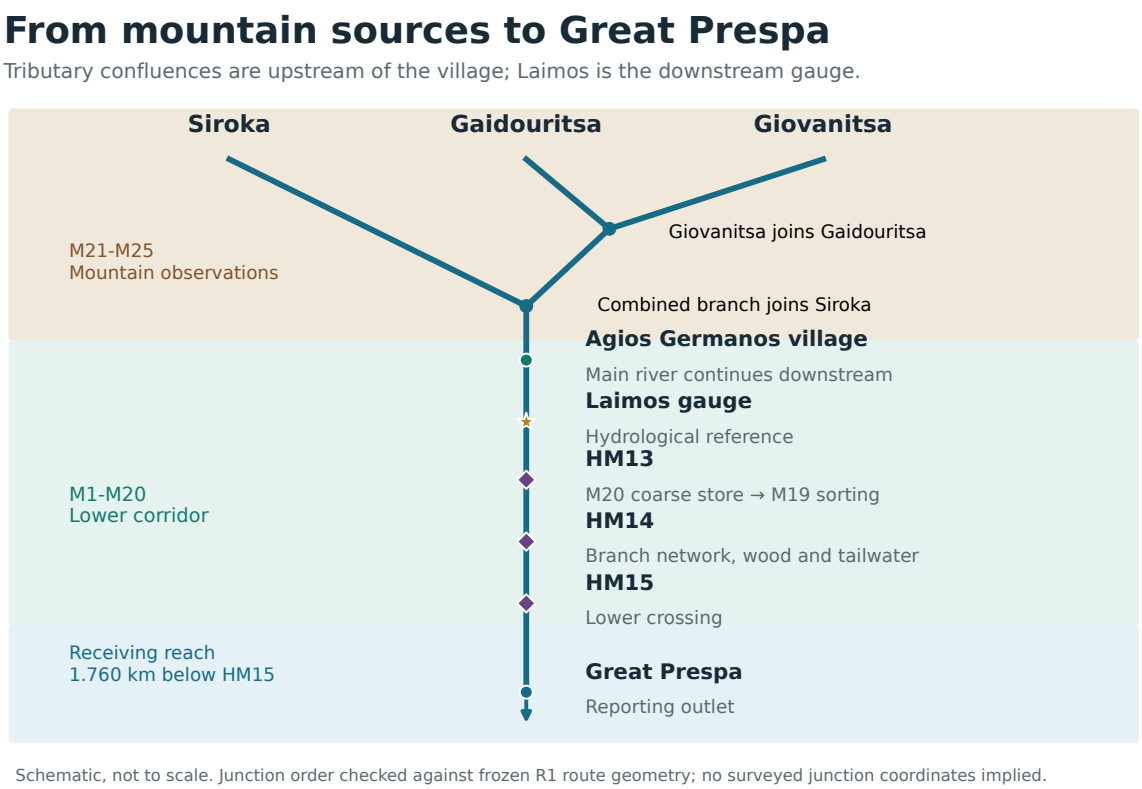


Figure 1: **MR00.** Reader orientation from the mountain tributaries to Great Prespa. The diagram defines the module and passage codes used throughout the report and follows the downstream sediment-process sequence. Full-size figure.

Progression to restoration design

This study completes the existing-evidence geomorphic baseline, quantifies the planning scales and differentiates the three passage settings. The formal design stage uses targeted geometry, hydraulics and receptor information to tighten the reported ranges, select an option and set construction and monitoring controls.

1 Study purpose, evidence and outputs

1.1 Purpose

This study establishes how sediment is produced, stored and routed through the Agios Germanos river system and applies that understanding to the potential removal or modification of the three Irish passages. It reconciles the July 2026 field archive with project GIS, grain-size evidence, accepted hydrological records, prior passage studies and the RTK packages received on 10 August 2026. The field interpretation is informed by the MoRPh framework (Gurnell and Shuker, 2022), with each record retained at its documented spatial and observational precision.

The work answers four practical questions:

1. How does river character change from the mountain tributaries to Great Prespa, and what does that mean for sediment movement?
2. When were flows strong enough to offer opportunities for sediment movement, and which river features interrupt or redirect its downstream passage?
3. What quantitative ranges are useful for local and catchment planning?
4. How do HM13, HM14 and HM15 differ, and how should restoration options progress into formal design?

Completed study outputs

The commission has produced a reconciled geomorphic baseline, a routed source–store–control interpretation, accepted-year hydrological summaries, fraction-specific connectivity scenarios, M2 carrying-potential calculations, local bank-and-gabion input estimates, catchment planning loads, passage dossiers and a governed RTK context release. Together they provide a coherent basis for restoration option appraisal.

1.2 Three scales of evidence

Observed evidence records where material, stores, erosion, wood, branches and structures occur. **Declared analytical states** quantify how alternative hydraulic and structural assumptions affect local results. **Planning analogues** place the Agios Germanos River catchment within regional and wider catchment-scale sediment-yield evidence. Each result is reported at the scale that generated it.

Use of the study

Use the observed system interpretation to compare passage options; use the local calculations to understand process sensitivity; and use the catchment planning load to size monitoring, risk allowances and the next design stage.

Evidence snapshot

Table 1: Evidence assembled for the geomorphological study.

Evidence stream	Controlled extent	Role in this study
Field morphology	26 module or source locations; 1,180 morphology observations	Defines process domains, sources, stores, controls and passage context.
Photographic archive	214 database records; 213 locally recoverable image assets	Provides geolocated evidence of river character, sampling and passages.
Sediment material	611 retained surface clasts, 606 in primary statistics; 80 bulk-sieve records, of which 74 are accepted	Characterises sampled loose facies while keeping the analytical methods distinct.
Hydrology	Accepted WY2021 and WY2022 Laimos gauge records; surveyed reference section	Establishes annual high-flow opportunity and supports declared gauge-to-site hydraulic states.
Spatial evidence	Catchment, routed topology, imagery, documentary passage locations and project GIS	Places observations and controls in a continuous mountain-to-lake sequence.
RTK survey	3,659 received points across HM13–HM15; dated context release with SA01–SA06 passed	Provides dense plan-view passage coverage and evidence-navigation context for restoration appraisal.
Prior studies	HCMR, SCIMABIO, 2025 feasibility study, catchment studies and regional analogues	Adds passage identity, option concepts and regional context; HCMR observations retain documentary precision.

Evidence coherence

Field, photographic and sediment records establish the HM13 store sequence and HM14 branch setting; the routed network connects HM15 to the receiving reach. The 10 August evidence cut defines the available field basis. Section 1.3 explains the achieved scope and the value of further measurements. The Technical Appendices reconcile the results and their separate spatial accounts.

1.3 Contractual outputs and available evidence

The completed assessment identifies sediment sources, characterises grain sizes and explains how material is stored and routed from the catchment through the restoration reach. Strong flows destroyed the sediment traps twice in 2026 despite repeated measurement efforts. The response placed greater emphasis on source identification, detailed grain-size analysis and estimation of sediment movement with explicit uncertainty. This combination provides the geomorphological evidence needed to scope restoration and compare crossing options. The table distinguishes that contribution from the local flux calibration and closed balance that additional measurements would support.

Table 2: Requested sediment outputs and the results delivered.

Requested outcome	Available evidence and delivered result	Contribution of further measurements
Empirically calibrated sediment-transport curves	Flow records, grain-size samples and declared hydraulic states support M2 transport-capacity calculations and supply/transmission scenarios (Section 4; Technical Appendix E).	Functioning traps could have measured transported material over sampled periods. Paired with flow records and documented sampler performance, these observations would support empirical calibration and testing. The estimates retain uncertainty without claiming such calibration.
Quantified erosion–deposition balance for the restoration area	Mapped erosion sources and stores; modelled local bank/gabion inputs; M20 store-transfer scenarios; separate transport and catchment planning estimates (Sections 2 and 4; Technical Appendices B, E and F).	No closed balance is established. Compatible measurements of incoming and outgoing sediment and repeated storage/erosion volumes, with density, are needed for the same defined reach and time period.

What the assessment enables. Source and store mapping locates where material can enter, remain within or leave the restoration reach. Grain-size analysis distinguishes material with different mobility; calculations test plausible magnitudes and sensitivities. Together these provide a scientifically supported basis for option appraisal and monitoring design. They do not measure actual sediment flux, net bed change or the quantity released by a future removal.

Keep the accounts separate. Local inputs to the M1–M20 network, M2 patch capacity, M20 store transfer and the catchment planning estimate have different boundaries and evidence. Their sum or difference would not close the restoration-area balance. Technical Appendix A explains the corresponding evidence requirements and spatial accounting.

Meaning of the uncertainty ranges. The ranges describe variation within the stated model assumptions and across specified scenarios; they are not a substitute for checking predictions against sediment measurements. Functioning traps would constrain transport at the sampled positions and periods, not by themselves close a whole-reach balance. The supplied *Responses to SPP* document links each clarification to its report location and explains the implications for interpretation.

2 The river as a sediment system

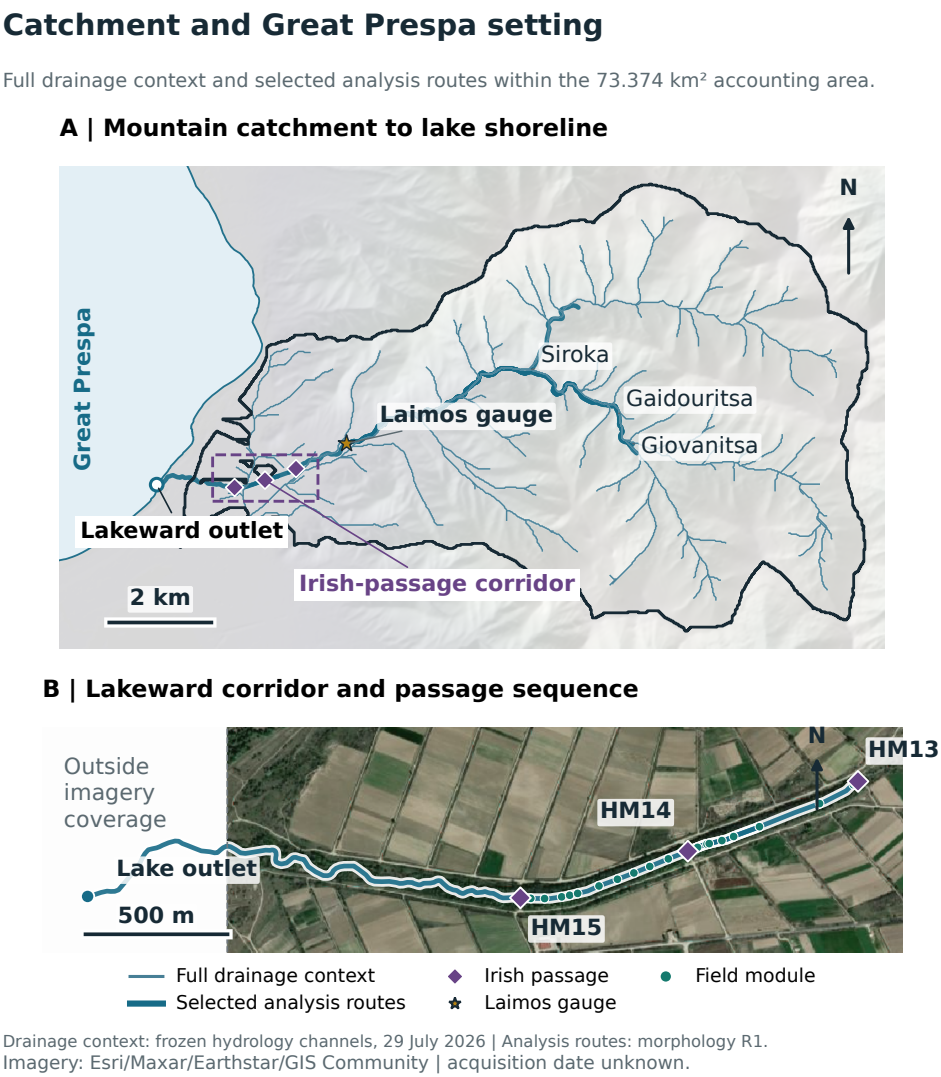


Figure 2: **MR01.** Catchment and Great Prespa setting. The three Irish passages occupy the lakeward river within the 73.374 km^2 study reference area. Giovanitsa joins Gaidouritsa, which then joins Siroka upstream of Agios Germanos village. The river passes the Laimos gauge, lower corridor and the 1.76 km reach below HM15. Pale lines show the fuller drainage network from the frozen hydrology release; darker lines identify the selected morphology analysis routes, not the upstream limits of the rivers. Full-size figure.

Catchment-scale setting

The fixed 73.374 km^2 accounting area comprises 18 subbasins; it is not the exact Laimos gauge catchment. Earlier areas of about 59.4 and 65.6 km^2 use different boundaries and reference outlets. Mapped differences include both delineation and downstream coverage; the calculations retain their original accounting area.

The **Great Prespa reporting outlet** is the river-mouth endpoint used for the catchment-scale planning account. Formal design pairs that fixed spatial endpoint with contemporaneous lake level to define a hydraulic boundary condition for option testing.

Where the field modules and passages are located

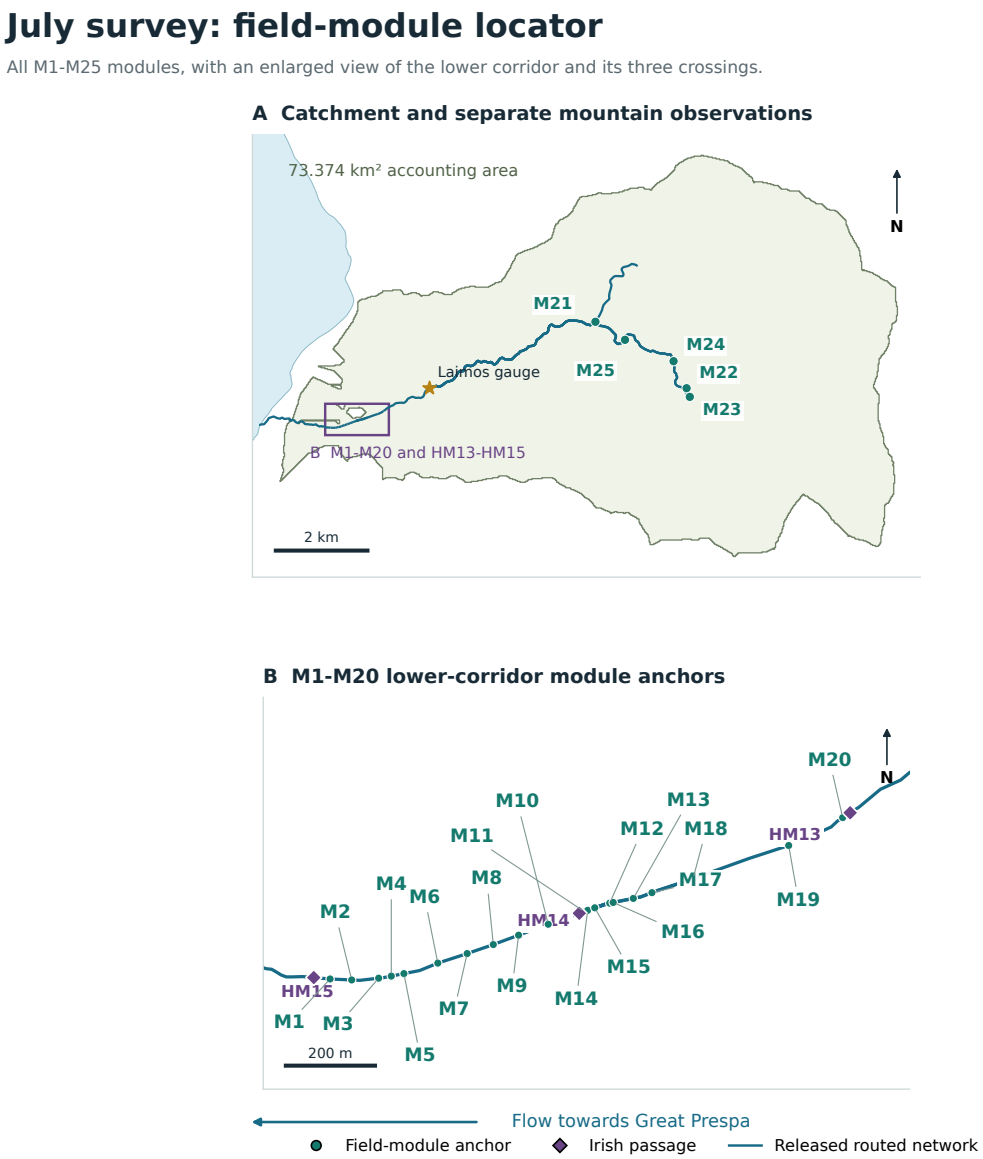


Figure 3: **MR15.** July field-module locator. M1–M20 occupy the lower corridor and M21–M25 are separate mountain observations. Labels show module anchors, not exact sample positions. Passage and route evidence retain their recorded precision. Full-size figure.

A continuous evidence frame

Each sampled module represents a distinct loose facies along the connected river. Reading the modules in downstream order reveals the coarse store below HM13, subsequent sorting and the finer mixed patches of the engineered corridor.

River character from the mountain network to the lake

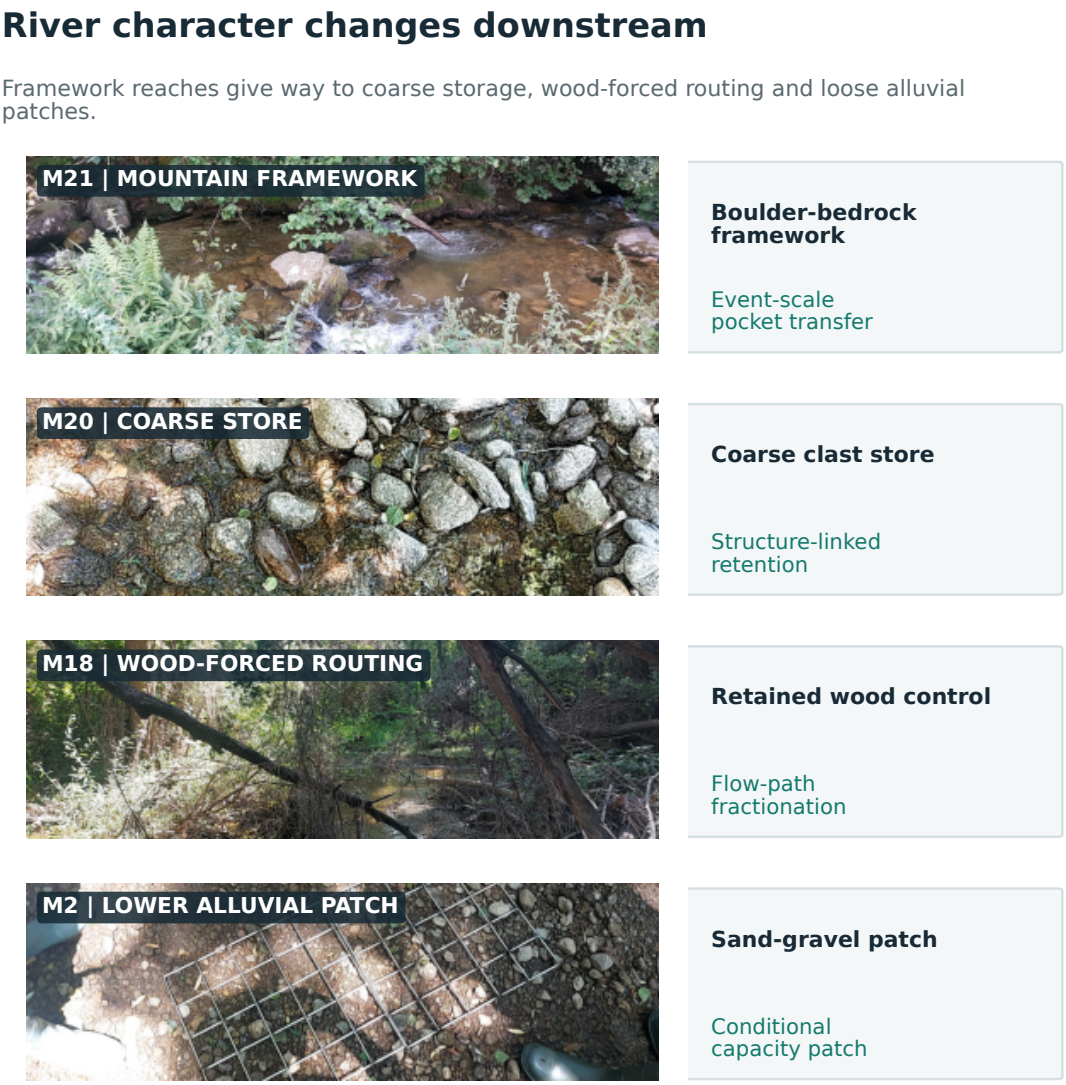


Figure 4: **MR02.** Representative field evidence for the principal sediment-process domains. Framework, structure-associated storage, wood and confinement create different sediment behaviours along the river. Full-size figure.

Why the domain distinction matters

Mountain pocket material is interpreted within a resistant framework. Lower corridor sand, gravel and cobble are interpreted through local bars, banks, wood and engineered controls. Domain-matched evidence keeps each calculation at the scale and process it represents.

Surface-clast measurements

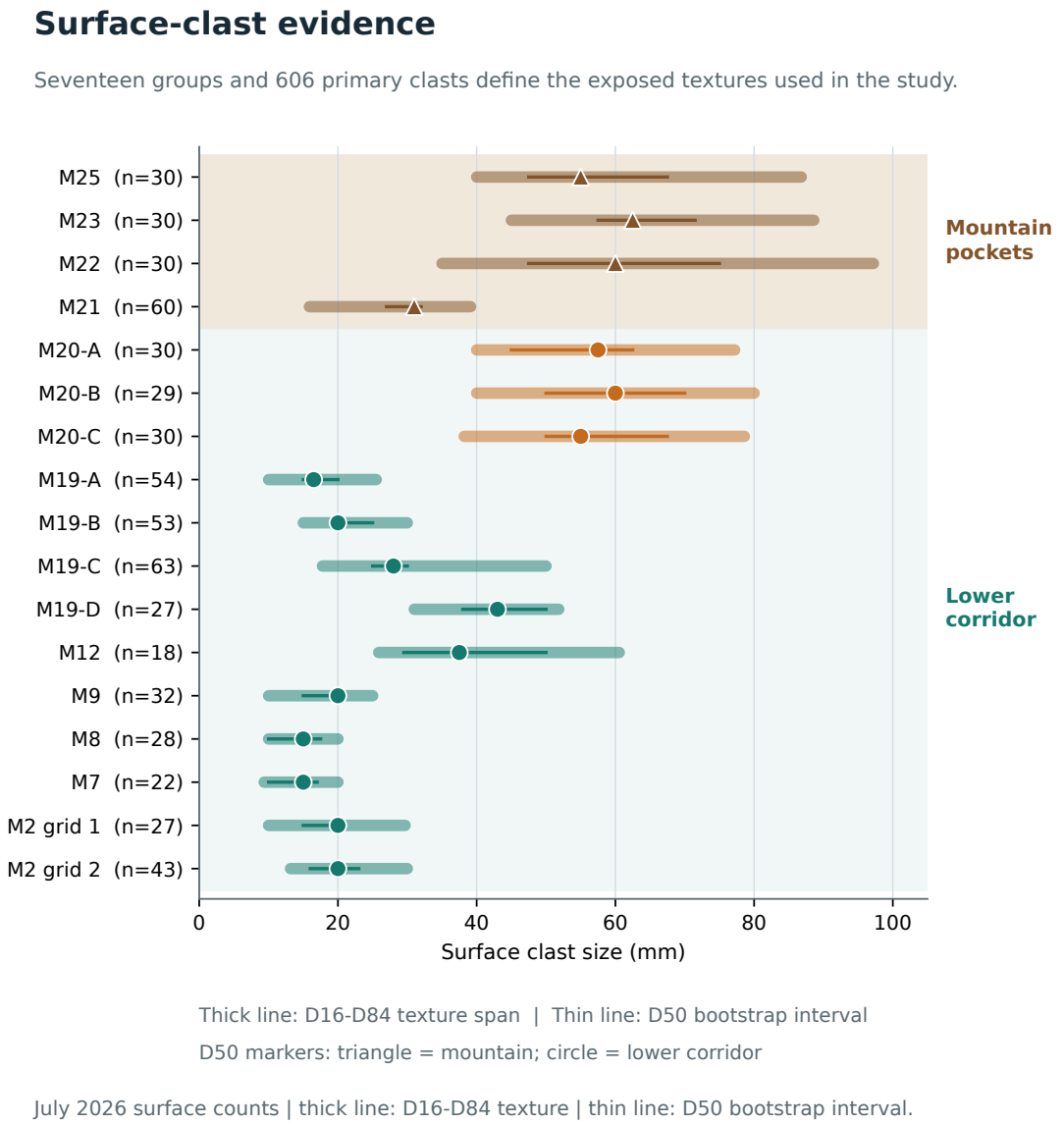


Figure 5: **MR03.** Surface-clast evidence. The retained archive contains 611 clasts, with 606 used in the primary statistics. Points show sample D_{50} and intervals describe within-sample texture; the samples remain grouped by facies and domain. Full-size figure.

For a surface count, D_{50} is the intermediate-axis diameter exceeded by half of the measured clasts by number. The wider D_{16}–D_{84} span shows how mixed each exposed surface is. This count-based evidence supplies the bed texture used by the M2 sampled-patch calculation and resolves the HM13 store sequence.

What the surface samples establish

The proximal M20 store has consistently cobble-rich sample medians, while the downstream M19 store contains a broader and generally finer set of exposed facies. Lower-corridor patches are finer again. The measured pattern supports selective storage and sorting downstream of HM13.

Bulk-sieve measurements

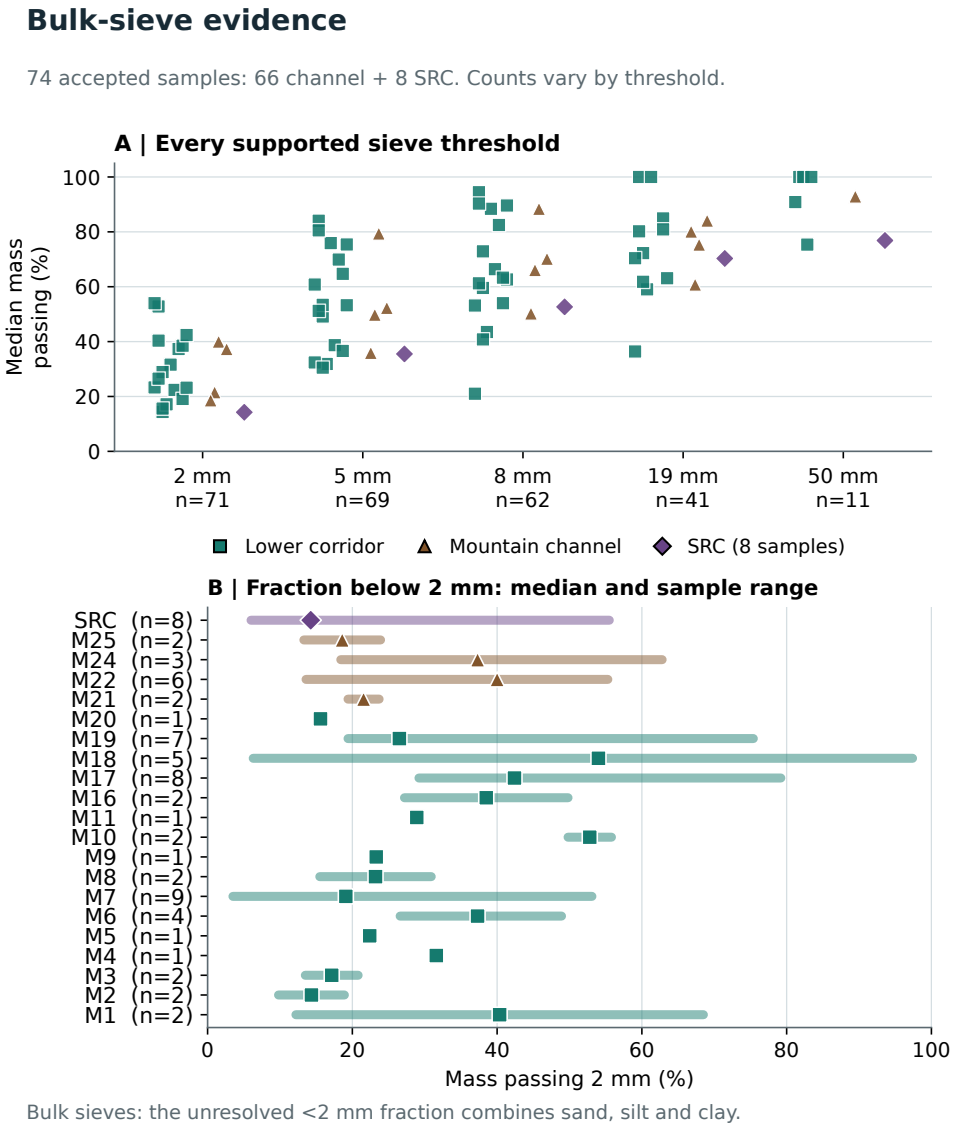


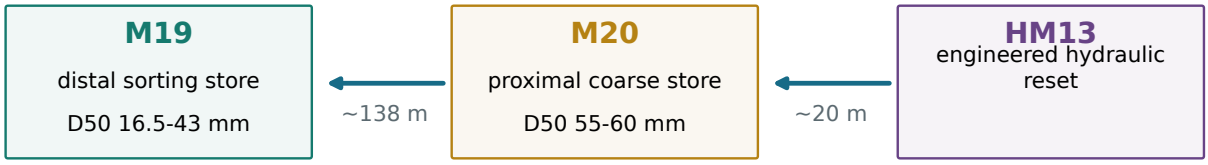
Figure 6: **MR14.** Bulk-sieve evidence. The archive contains 80 records; 74 meet the analytical checks, comprising 66 channel samples and 8 source-material records. Cumulative mass passing supported thresholds describes material within each sampled grab. Full-size figure.

Sieve analysis separates a collected sediment sample through meshes of different sizes and weighs the resulting fractions. These are samples of material already present in the river, including finer grains below the exposed surface. They are not sediment-trap measurements of material passing a point over time and cannot provide a sediment-flux calibration. The channel samples characterise loose river facies; the SRC records characterise source material for the regional texture allocation.

Use in the study

Surface counts provide clast-size inputs for surface-based transport and store interpretation. Sieved sediment samples identify finer material within sampled deposits and support fraction-aware source and connectivity scenarios.

The clearest passage-associated store sequence



3 surface counts

M20 is the cobble-rich accumulation immediately downstream of HM13. Its sample medians cluster between 55 and 60 mm.

4 surface counts

M19 is a stratified, mixed-fraction store farther downstream. Its surface medians range from 16.5 to 43 mm.

What the study establishes

The mapped order, distances, descriptions, photographs and 7 facies-specific samples establish a proximal coarse store followed by downstream sorting. This is the strongest observed passage-to-store relationship in the study.

How formal design develops this result

Reviewed passage and store geometry, a defined mobile-sediment inventory and event-linked observations will translate the spatial baseline into an option-specific adjustment prediction.

Integrated geomorphic interpretation

Figure 3 locates every field module discussed below. Its points are observation anchors, not surveyed module boundaries or cross-sections.

Mountain network

M21–M25 are cascade and step-pool settings where bedrock and boulders organise the bed. Loose sand, gravel and cobble occupy pools, interstices and local patches. Transport is episodic and conditioned by each structural step and the next storage opportunity.

Upper passage and branch complex

HM13 creates a hydraulic reset followed by M20 and M19 storage. Farther downstream, M15–M18 form a wood-influenced multithread domain. HM14 sits in the branch complex: M13 and M14 are parallel upstream limbs, M12 is the immediate tailwater and M11 follows downstream.

Lower embanked corridor and outlet

Between HM14 and HM15, the confined channel contains mixed alluvial patches, bars, erosion, wood and local protection works. HM15 then connects the observed corridor to the 1.76 km receiving reach and Great Prespa reporting outlet.

The resulting intervention logic is passage-specific. HM13 is principally a store-and-sorting question; HM14 is a branch-routing and asset-context question; HM15 is a downstream-boundary and receptor question. Instream wood may redirect flow, stabilise a bar, retain material or interact with an asset; its recorded function informs the local option comparison.

Management meaning

Compare each passage option first against its local process setting and then against the connected response of the three-passage sequence.

3 Flow, storage and connectivity

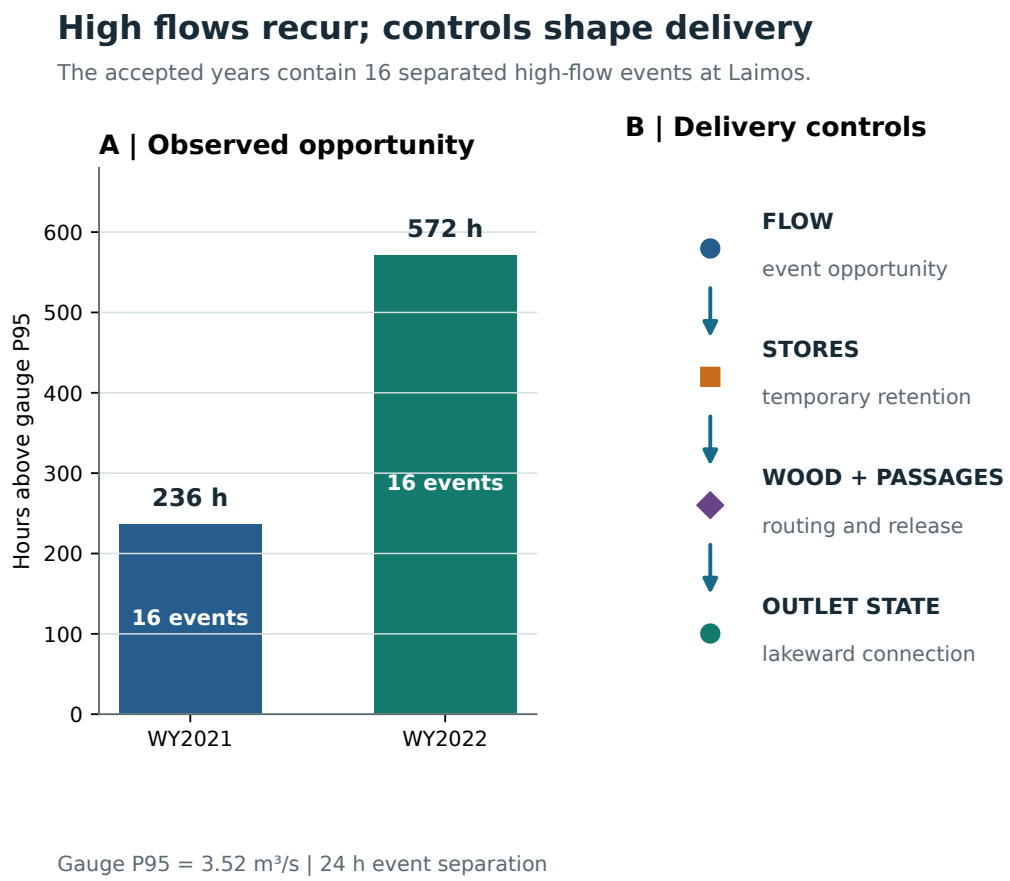


Figure 7: **MR04.** Accepted high-flow opportunity and principal controls on connectivity. Both accepted years contain 16 independent events under the 24-hour rule; supported high flow lasts about 236 hours in WY2021 and 572 hours in WY2022. Full-size figure.

The accepted Laimos record was screened by water year, coverage, rating range and gap structure. A pooled threshold of 3.52 $m^3\ s^{-1}$ identifies the upper 5% of discharge values greater than zero; the separation rule distinguishes independent events. WY2022 combines a similar event count with more than twice the supported high-flow duration. It therefore provides the stronger observed opportunity for repeated mobilisation and store reworking.

What the gauge establishes

The accepted record supplies a reproducible forcing comparison at Laimos: event count, supported duration, integrated discharge excess and event peaks. It also supplies the hydrographs used by the declared M2 hydraulic states.

Structural connectivity as a routed comparison

The connectivity model represents the river as directed source, transfer, store and control units. Separate scenarios are evaluated for 4 sediment fractions. Low, central and high states describe alternative configurations of passages, wood, bars and stores; source-zone-equal weighting prevents densely observed modules from dominating the catchment comparison. This follows established source–store–barrier practice (Fryirs et al., 2007; Borselli et al., 2008; Heckmann et al., 2018).

The central scenario retains approximately 0.032 of equal source-zone units as a dimensionless comparison index. It is not the measured fraction of sediment delivered to the lake. Opening one named control at a time identifies where the routed result is most responsive. The strongest or near-strongest responses occur around the M2 wood/bar complex, HM15, M5 and the serial M7–M10 wood/storage sequence. HM13 and HM14 remain important because they organise the local coarse store and branch routing, even where their single-control sensitivity is more modest.

What the connectivity calculation establishes

Several controls act in series, creating a segmented pathway rather than one dominant barrier. The sensitivity comparison identifies the controls whose state most changes the routed interpretation and explains why the passages must also be assessed as a sequence.

How the result is used

Use the sensitivity ranking to prioritise evidence and monitoring. Use the common appraisal framework in Section 5 to select an action. The ranking strengthens the evidence base; the broader criteria select the restoration option.

Finer material retains more potential routes through local stores than coarse material. Fraction-aware monitoring can therefore record fine-material transmission at a site while a cobble-rich store remains locally retained.

How formal design tightens the routed model

Verified passage state, branch distribution, influential wood geometry and receiving-reach response replace the declared structural states that have the greatest effect on the option comparison.

Storage and connection in management practice

Passages

Each passage combines an access structure with a local hydraulic reset. Its effect depends on approach level, slab geometry, downstream drop, stored material and the next receptor. HM13, HM14 and HM15 therefore retain individual dossiers within a shared system model.

Wood and bars

Wood, bars and vegetated margins are active geomorphic and habitat infrastructure. They create pools, divert flow, store sediment and support channel diversity. A proposed wood register would give each influential feature a stable identifier and record its position, size, anchoring, mobility, associated store and nearby assets. Before removal is recommended, a researcher with relevant experience of river wood in protected areas should assess each feature. The assessment must consider habitat value and geomorphic function alongside hydraulic behaviour and risks to assets, and compare retention, securing, repositioning and selective treatment. Living bank vegetation is a separate feature.

Serial effects

A change at HM13 may alter the material reaching HM14; a change at HM14 may redistribute water and sediment between limbs; and a change at HM15 may change the downstream boundary experienced by the lower corridor. Staging allows these interactions to be observed before the next action.

The present baseline supports management of the observed route and store inventory now. Formal design adds verified local geometry and hydraulic response where those data most improve the intervention comparison.

Design-stage objective

Select and size works by testing conveyance, sediment release, scour, deposition, ecological continuity, structural stability and access for each site and for the combined passage sequence.

4 Quantities for planning

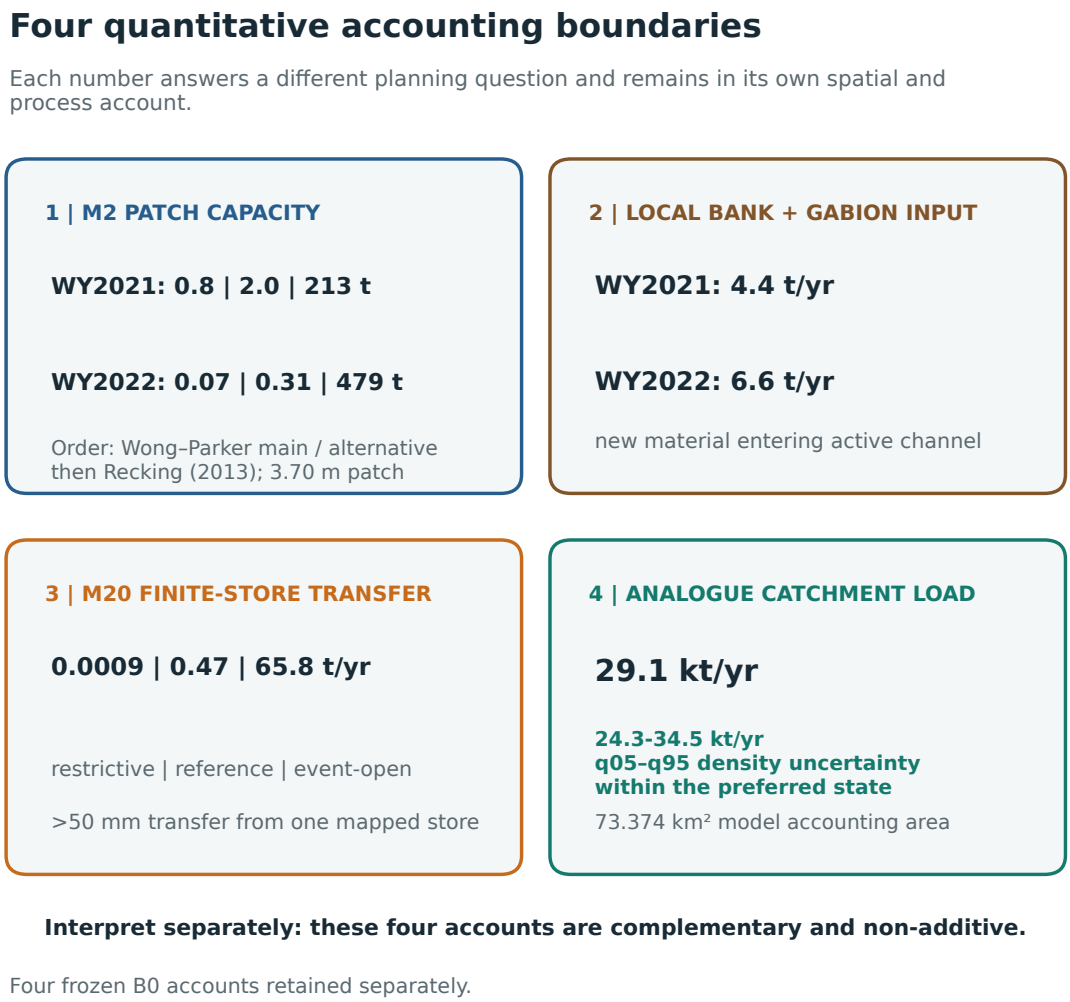


Figure 8: **MR16.** Four quantitative accounting boundaries. The calculations are complementary, but each answers a different question at a different spatial and material scale. They are interpreted side by side and are never added. Full-size figure.

The essential distinction

The 4.4 and 6.6 t/yr values quantify material entering the active lower corridor from local banks and failing gabions. Transport through the engineered corridor and the catchment-scale annual load are represented by separate accounts. The 29.1 kt/yr result is the analogue-conditioned catchment planning estimate.

M2 sampled-patch carrying potential

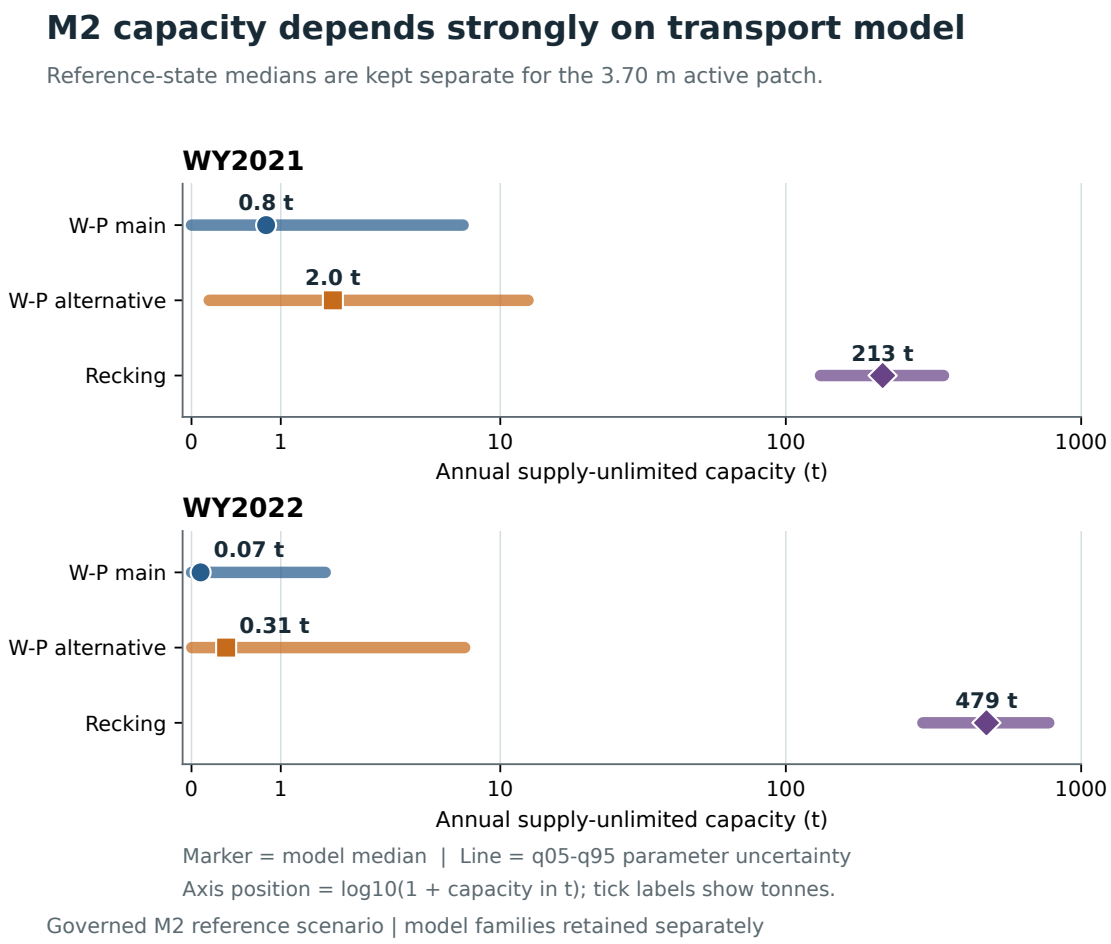


Figure 9: **MR05.** M2 carrying potential over the 3.70 m active patch. Model-specific medians are retained separately: 0.8, 2.0 and 213 t in WY2021; and 0.07, 0.31 and 479 t in WY2022. Full-size figure.

How to read the M2 result

M2 is a field module, not a fully surveyed cross-section. The calculation represents its sampled active patch, with a reference width of 3.70 m. It combines the accepted Laimos hydrographs with a declared gauge-to-site flow transfer, local slope state, hydraulic geometry, active width, measured surface texture and three established bedload equations. For each equation and outer hydraulic state, 20,000 draws propagate the measured and declared input ranges (Wong and Parker, 2006; Recking, 2013; Rickenmann and Recking, 2011; JCGM, 2008).

Principal analytical result

Under the reference hydraulic state, the two Wong–Parker formulations give low annual medians and Recking gives much higher medians. Equation form and local hydraulic representation therefore dominate predicted carrying potential. The report therefore presents all three model families separately and gives each family equal visual weight.

For WY2021, the model medians are 0.8, 2.0 and 213 t. For WY2022 they are 0.07, 0.31 and 479 t. Figure 9 shows q05–q95 parameter variation within each fixed reference model; model-to-model contrast is a structural comparison rather than a probability interval.

Planning meaning

M2 demonstrates potential carrying capacity under the declared state at one sampled patch. Its large model contrast identifies local hydraulic geometry and threshold representation as the highest-value measurements for design.

How formal design tightens M2

Surveyed energy slope, inundated width, roughness and water level, tied to a verified gauge-to-patch transfer, replace the declared hydraulic states. Co-located texture and event observations then test which equation represents the reach most effectively.

How observed banks and gabions become a local-input estimate

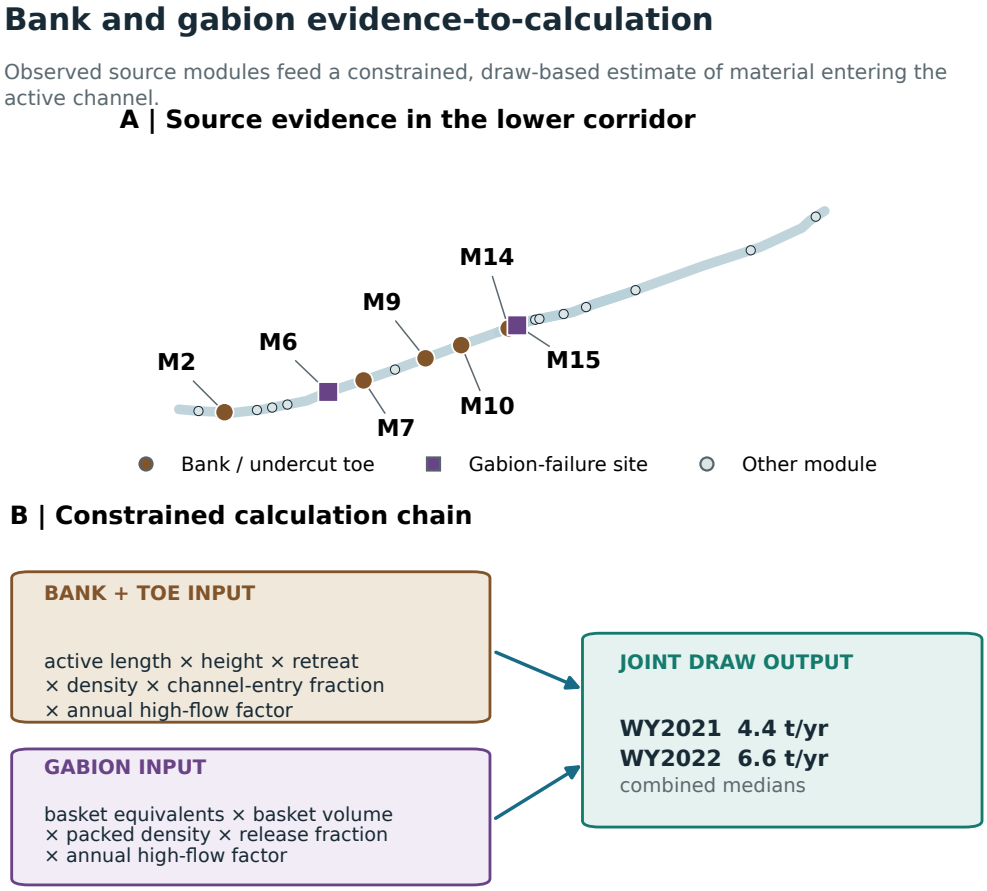


Figure 10: **MR17.** Bank and gabion evidence-to-calculation pathway. Field observations anchor the source mechanisms and locations; declared, bounded geometry and rate terms convert those anchors into a conditional estimate of material entering the active M1–M20 network (about 1.54 km, including both HM14 limbs). Observations cover selected locations; declared coverage scaling extends their representation to the network. Full-size figure.

The earth-bank and gabion components retain different physical formulations:

$$M_y^{\mathrm{bank}} = \sum_i k_{\mathrm{cov}} L_i f_{\mathrm{active},i} n_{\mathrm{bank},i} H_i R_{i,y} \rho_{b,i} \eta_{\mathrm{rec},i},$$

$$M_y^{\mathrm{gab}} = \sum_g N_{\mathrm{be},g} V_{\mathrm{be},g} f_{\mathrm{loss},g,y} \rho_{\mathrm{pack},g} \eta_{\mathrm{rec},g}.$$

The bank term represents active bank length, face height and annual retreat, converted to dry mass and the fraction entering the channel. The gabion term represents basket-equivalent volume, annual fill loss, packed density and the fraction entering the channel. The accepted hydrograph allocates the declared annual rate between the two water years; source presence and type come from the field record.

Modelled annual input from lower-corridor banks and gabions

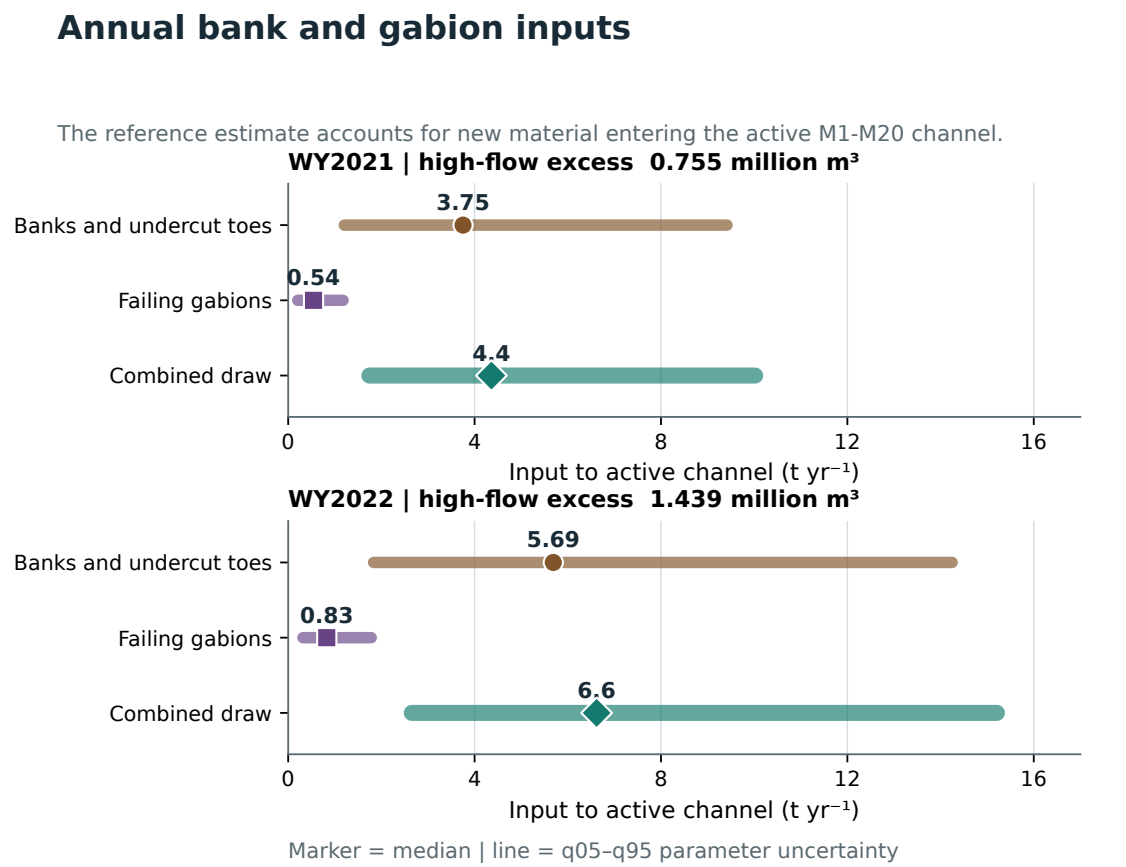


Figure 11: **MR06.** Modelled annual input from lower-corridor banks and failing gabions. The total median is 4.4 t/yr in WY2021 and 6.6 t/yr in WY2022; q05–q95 parameter ranges are 1.7–10.0 and 2.7–15.2 t/yr. Full-size figure.

In the reference state, the earth-bank and gabion component medians are 3.75 and 0.54 t/yr in WY2021, and 5.69 and 0.83 t/yr in WY2022. The total median is evaluated from the summed components in every simulation draw, preserving their joint parameter structure; the separately reported component medians describe each source mechanism.

The year-specific scaling follows observed integrated high-flow excess of 0.755 million m^3 in WY2021 and 1.439 million m^3 in WY2022. The higher-excess year therefore receives the larger reference annual input under the declared hydrological response.

Accounting endpoint

This calculation begins at mapped lower-corridor bank and gabion sources and ends when detached material enters the active channel. Subsequent storage, remobilisation, passage transfer and outlet delivery are separate process questions represented by the store, capacity and catchment accounts.

Prespa-derived catchment planning estimate

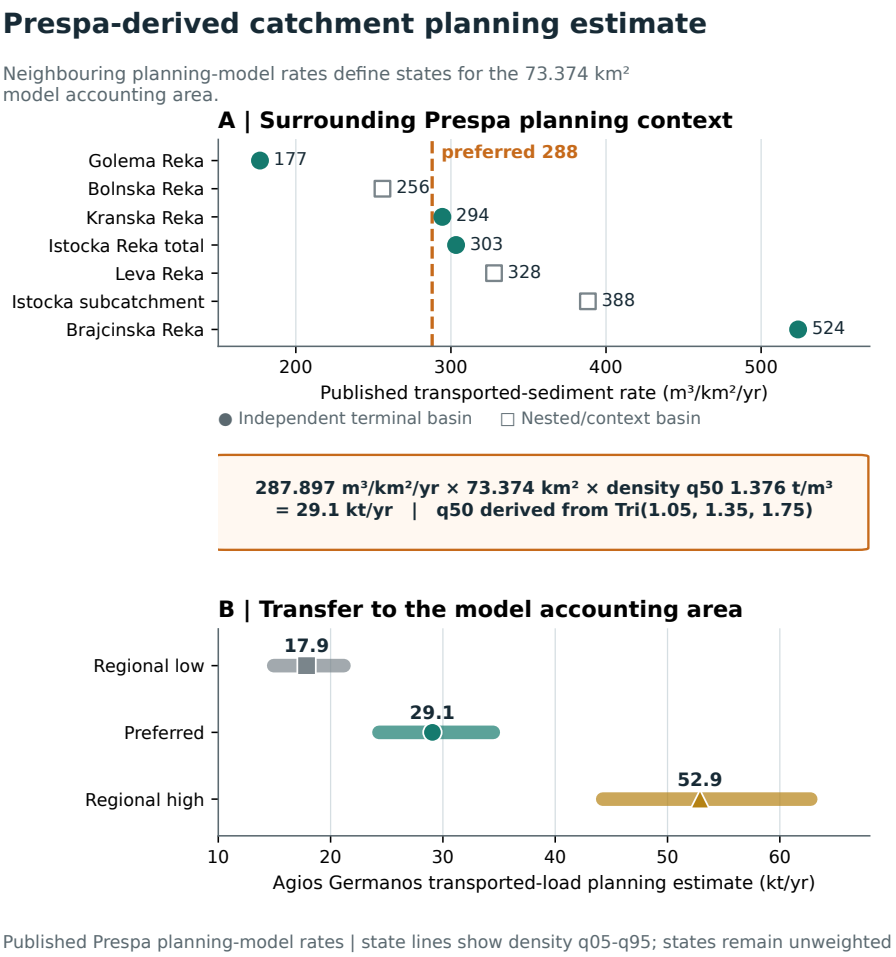


Figure 12: **MR07.** Prespa-derived catchment planning estimate. A preferred specific transported-sediment rate of 287.897 $m^3\ km^{-2}\ yr^{-1}$ is applied to 73.374 km^2 and converted using the governed dry bulk-density distribution, giving a working centre of 29.1 kt/yr. Full-size figure.

The top-down planning equation is

$$Y_{\mathrm{tot}}^{\mathrm{plan}} = A_{\mathrm{AG}}\, r_v\, \rho_b.$$

The preferred rate is area-weighted across the independent Golema, Brajčinska, total Istočka and Kranska basins. The area and rate produce an annual volume of 21,124 m^3/yr; the density median of 1.376 t/m^3 converts that volume to dry mass. Within this fixed state, the q05–q95 density range is 24.3–34.5 kt/yr. Alternative Prespa rate states widen the structural planning span to 14.9–62.7 kt/yr; this wider span has no probability weighting and is not a confidence interval.

The closest-area Brajčinska comparison has a density-converted median of 51,676 t/yr. It is already represented in the Prespa structural family and acts as a regional scale check rather than an additional estimate.

Planning use. This is an analogue-based planning estimate, not measured lake export or a predicted release from passage removal.

Surrounding Prespa and Alpine context

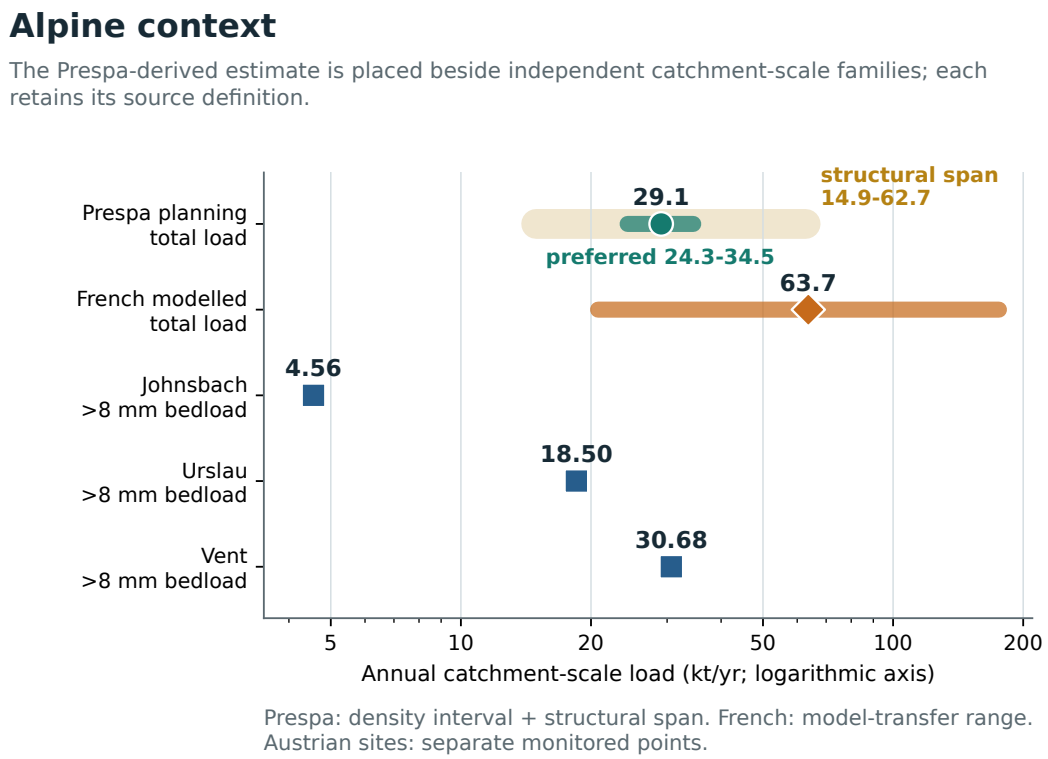


Figure 13: **MR18.** Catchment-scale context. Neighbouring Prespa rates establish the preferred planning family. The French Alpine scaling point and its transferability range, and Austrian monitored bedload at similar drainage areas, remain separate contextual families rather than pooled observations. Full-size figure.

The French Alpine total-load relation gives a scaling point of 63,655 t/yr at the Agios Germanos area, with a geographical- transfer sensitivity of 20,769–175,767 t/yr. Nearby-area Austrian monitoring spans 4,560–30,684 t/yr for bedload larger than its stated monitoring threshold.

What the comparison adds

The Agios Germanos River catchment planning centre lies within a credible regional order of magnitude. The comparison also shows why method and sediment fraction matter: Prespa transported-sediment planning values, French modelled total load and Austrian monitored coarse bedload provide distinct checks and remain unpooled.

What the quantities establish together

A strong quantitative hierarchy

Accepted hydrographs quantify forcing; M2 quantifies local carrying potential and model sensitivity; the bank/gabion model quantifies local material entering the active corridor; M20 explores transfer from a mapped coarse store; and the Prespa analogue supplies a representative annual catchment planning scale.

M2 sampled patch. The model-specific medians answer how much material the declared state could carry across one measured active patch.

Local banks and gabions. The 4.4 and 6.6 t/yr medians answer how much material may enter the active lower corridor annually from the mapped source mechanisms.

M20 coarse store. The reference and event-open medians of 0.47 and 65.78 t/yr explore transfer from one finite observed > 50 mm store.

Catchment planning load. The 29.1 kt/yr centre answers what representative annual transported mass is suitable for catchment- scale planning under the preferred Prespa analogue state.

Uncertainty language used in the figures

- A **median** is the central result within one specified model and state.
- A **thick interval** is q05–q95 parameter variation while that model or state remains fixed.
- A **pale span** compares alternative structural states or model families; it has no probability weighting.
- Separate cards identify different spatial or material accounts.

Decision meaning

The calculations support planning and option screening now. They also focus design-stage measurement on the variables with greatest leverage: local hydraulics for M2, source geometry and rate for local input, store geometry for release response and fixed-section monitoring for catchment export.

Formal design hand-off

The design team receives reference values, declared alternative states, parameter ledgers, spatial accounts and reproducible calculations. Targeted measurements replace the most influential declared states and tighten the corresponding design allowance.

5 Irish passages and RTK evidence

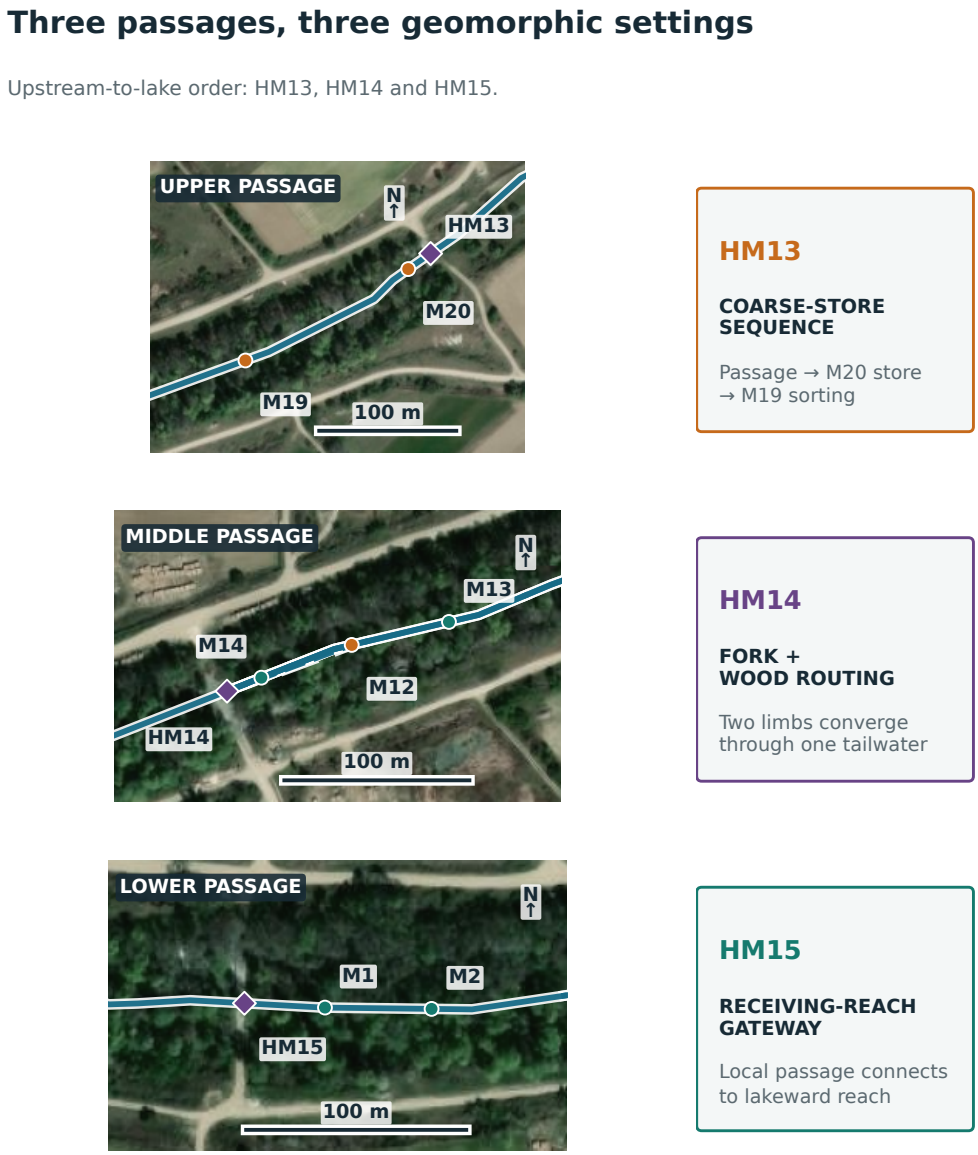


Figure 14: **MR08.** Three-passage location atlas. HM13 is followed by the M20 and M19 stores; HM14 lies within the fork and tailwater complex; and HM15 marks the transition from the observed corridor to the lakeward receiving reach. Full-size figure.

Passage-system conclusion

The passages share a serial pathway but occupy different process settings. One common appraisal framework can therefore retain passage-specific evidence, risk controls and design responses.

RTK coverage and quality-assurance context

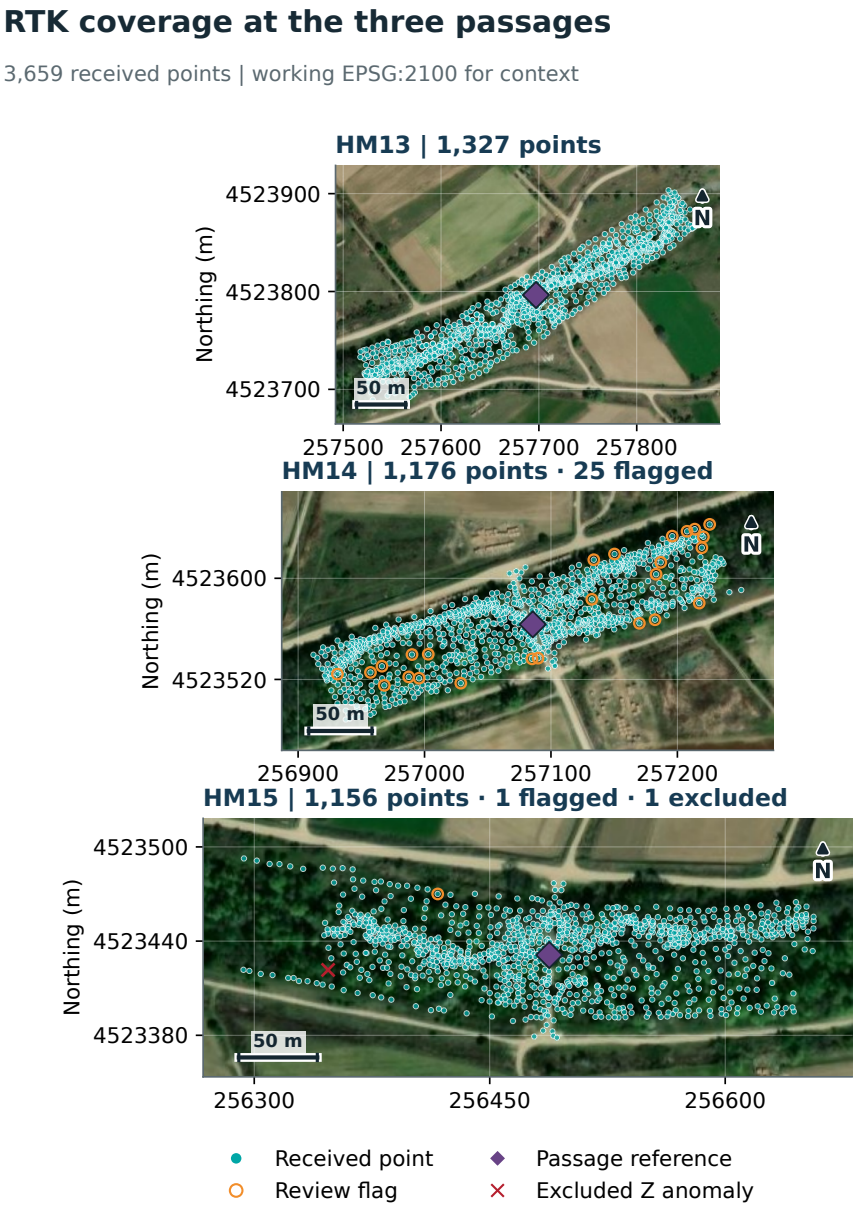


Figure 15: **MR09.** RTK coverage at HM13–HM15. The 3,659 received points provide dense local spatial context. The dated context release passed 6 of 6 controlled checks for identity, provenance, context use, association integrity, report-safe content and reproducibility. Full-size figure.

Current contribution

The survey improves passage-scale orientation, confirms broad footprint alignment and supports navigation between maps, photographs, sediment samples and field observations under the working EPSG:2100 interpretation.

RTK QA status and appropriate use

Table 3: RTK survey coverage and controlled QA status at the evidence cut.

Passage	Points	QA handling	Contribution to this issue
HM13	1,327	27 redundant exact XYZ records isolated in source QA; report context retains identity and provenance	Dense plan-view support around the upper passage and HM13 evidence navigation.
HM14	1,176	25 review-sensitive records identified and visibly distinguished	Dense plan-view support across both visible limbs and the middle-passage vicinity.
HM15	1,156	1 review-sensitive record retained; 1 severe elevation anomaly excluded	Dense local plan-view support around the lower passage and ford–drop vicinity.

QA status: approved for spatial context

The controlled release records an assumed EPSG:2100 horizontal interpretation and records reference-system confirmation and feature review as promotion requirements at the 10 August evidence cut. This issue uses the existing survey for receipt, broad passage alignment, coverage and evidence navigation; B0 calculations retain their governed inputs.

Canopy makes the embankment boundary a manual feature-review task. The mapped support footprint is the area supported by received points. Feature review and reference-system confirmation provide the controlled route to accepted relative geometry. HM15's local footprint represents the passage vicinity; the 1.76 km receiving reach is a separate design survey unit.

Route to quantitative geometry

First check the received survey and any later provider documentation, then confirm coordinate references and classify bed, margin, structure, crest, toe and road points. Reuse valid coverage and survey only specific remaining gaps; a blanket repeat survey is not required by this study.

HM13: coarse storage and downstream sorting

HM13 | storage sequence anchors the appraisal

The strongest observed passage-to-store relationship is HM13 → M20 → M19.





Passage → store → sorting

WHAT THE STUDY ESTABLISHES

Hydraulic reset, coarse storage and downstream sorting.

TRACK STORE RESPONSE

Relative geometry and repeat store evidence refine release timing.

Passage photograph: SCIMABIO, March 2025 | interpretation: July 2026 synthesis

Figure 16: **MR10.** HM13 evidence-to-action synthesis. The observed HM13–M20–M19 sequence makes stored-material response, sorting and downstream adjustment space the principal geomorphic tests for each option. Full-size figure.

Formal design focus

Define crest, approach and tailwater geometry; map the mobile-sediment inventory; and test where released fractions deposit or remobilise. Existing photographs and 7 surface counts provide the starting material baseline.

HM14: two limbs, tailwater, wood and assets

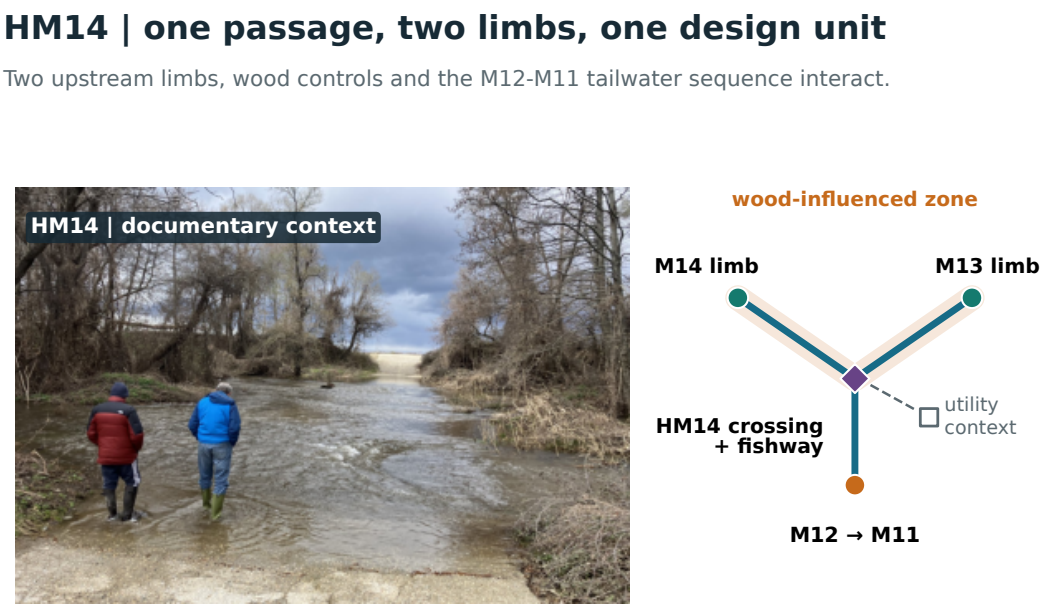


Figure 17: **MR11.** HM14 evidence-to-action synthesis. Passage geometry, branch routing, wood, the M12–M11 tailwater sequence, fishway and nearby utility form one local design unit. Photograph: SCIMABIO reference archive (HM_14.1), not the July 2026 survey; it supplies structure context rather than a fish-passage test. Full-size figure.

Formal design focus

Use the existing survey to review both main limbs and the passage geometry, then fill gaps and measure the flow split. The model has two main limbs with local additional splitting. The 2025 feasibility study assesses the fishway as inadequate (p. 58); performance still requires species- and flow-specific verification. Retain fish passage in the ecological appraisal.

HM15: lower passage and receiving reach

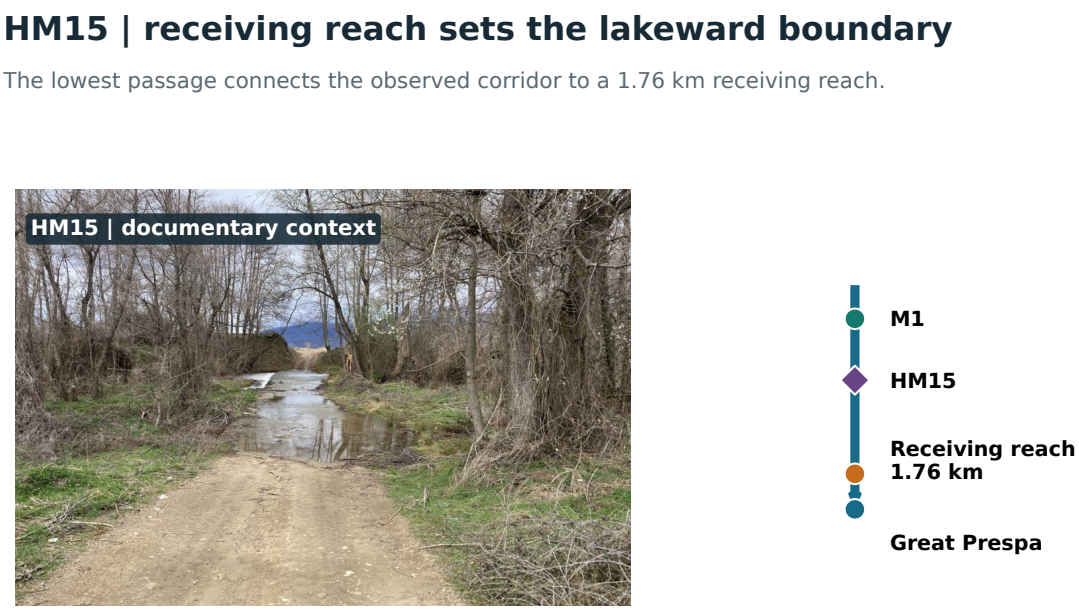


Figure 18: **MR12.** HM15 evidence-to-action synthesis. HM15 marks the transition between the observed lower corridor and the receiving reach, making downstream erosion, deposition, grade response and monitoring locations central to appraisal. Full-size figure.

Formal design focus

Reuse verified local RTK coverage through the ford–drop–pool sequence. Check coverage along the receiving reach and survey identified gaps and receptors, so the design baseline is continuous to the outlet.

Common options and serial sequencing

The October 2025 feasibility study advances collective removal of the three fords, restoration of the HM15 erosion drop and replacement of three road connections with one bridge as a preliminary concept (Demertzi et al., 2025). This study places that concept alongside retention, targeted modification, staged removal and full removal, using the same evidence and criteria.

Table 4: Options and common criteria for passage appraisal.

Option	Question addressed	Common appraisal criteria
Retain and monitor	Can present function and risks be managed through inspection, maintenance and defined triggers?	Geomorphic response; sediment release; hydraulics and stability; habitat and fish passage; access and assets; monitoring and contingency.
Targeted modification	Can passability or conveyance improve while useful grade and sediment control are retained?	Apply the same criteria to existing and modified geometry, including construction response.
Staged removal	Can one intervention be observed before the next, with agreed pause and progression thresholds?	Add sequence, observation period, responsibility and repair or contingency triggers.
Full removal	Do collective connectivity and ecological benefits justify sediment, adjustment, construction and access consequences?	Test each passage and the combined sequence, including the receiving reach.

Passage-specific tests within one framework

At HM13, compare how options retain, mobilise or redistribute the M20–M19 store sequence. At HM14, preserve both limbs and test water and sediment distribution around wood, fishway and utility assets. At HM15, test receiving- reach grade, erosion, deposition and monitoring response.

Option-selection and sequencing rule

Advance the option that performs best across the full criteria set. Because the structures act in series, staging is a substantive option: record the baseline, implement the first action, observe agreed flow, bed, habitat and asset indicators, then use the thresholds to progress or adapt the sequence.

6 Progression to formal restoration design

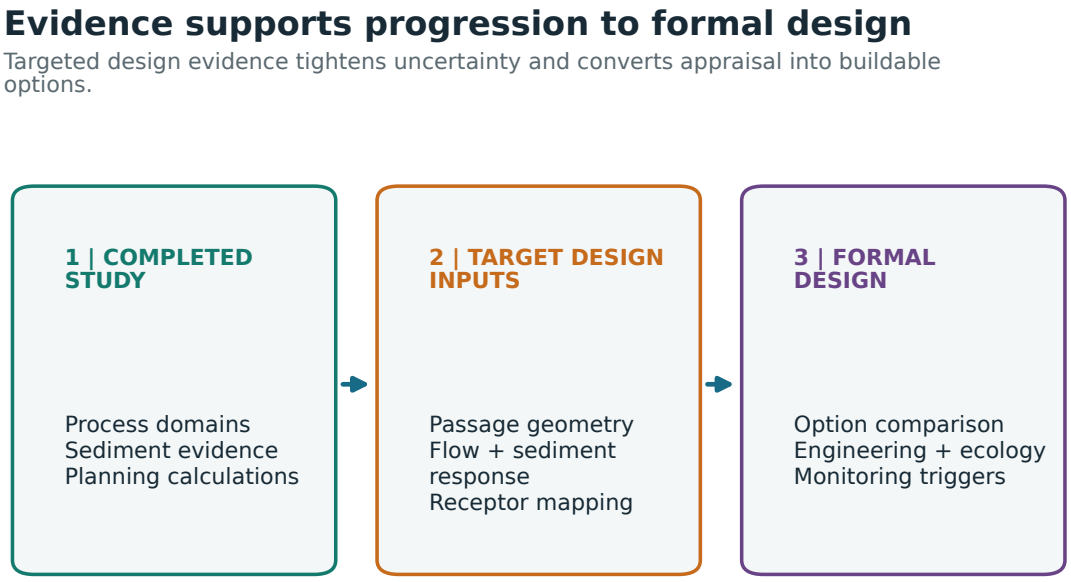


Figure 19: **MR13.** Progression from the completed study to formal restoration design. New information targets the assumptions with greatest design influence, converting the current bounded planning basis into selected, sized and monitored works. Full-size figure.

Current position

The project has a reconciled evidence archive, process-domain model, planning calculations, passage priorities, RTK coverage and reproducible analytical record. The next stage uses these products to focus measurement and option development efficiently.

Targeted inputs that tighten the design

1. **Passage and store geometry.** Reuse and validate the received RTK data, then fill specific gaps in crest, slab, approach, toe, tailwater, pool, bank and stored-material surfaces for each candidate site, tied to declared control and reference data.
2. **Hydraulic response.** Connect gauge forcing to local water levels, width, slope and roughness. Test present and proposed configurations for conveyance, afflux, velocity, stress, scour and stability.
3. **Sediment response.** Define mobile inventory, fraction range and adjustment space. Apply the existing M2, local-input, store and catchment calculations as bounded inputs to option-specific testing.
4. **Receiving reaches and assets.** Extend the baseline below HM15, map erosion and deposition receptors, verify the HM14 fishway and utility setting, and confirm access, ownership and structural constraints. Check damaged gabions case by case for maintenance, repair or another suitable treatment, supported by condition and stability review.
5. **Ecology and permissions.** Combine habitat, species, seasonal working, access, waste and regulatory requirements with the geomorphic and hydraulic comparison.

Efficient refinement

Each measurement serves a decision. Local hydraulics tighten M2; source and store geometry tighten release response; branch surveys tighten HM14 redistribution; and the receiving-reach survey tightens HM15 receptor response.

Design output

For each passage and the combined system, issue a selected option, drawings and work quantities (such as excavation volumes and construction materials), modelled hydraulic and sediment response, access and construction strategy, ecological and permitting route, monitoring thresholds and funded contingency actions.

Monitoring and delivery sequence

Establish monitoring before works so subsequent change is compared with the baseline created here. A compact programme combines fixed photographs and repeat sections at each passage, store and downstream receptor; water level and discharge tied to Laimos; mapped bed, bar, erosion, deposition and grain- size response after defined events; a stable-ID wood ledger; habitat and fish- passage indicators; and a fixed downstream section for sediment-flux calibration.

Adaptive monitoring principle

Retain wood where its ecological and geomorphic functions are compatible with safety, assets and hydraulic performance. Before removal is recommended, a researcher with relevant river-wood experience in protected areas must assess those functions and risks. A monitoring trigger starts that review; it is not an automatic instruction to clear the channel. Compare retention, securing, repositioning and selective treatment, and document the reasons for the chosen action.

1. **Confirm the controlled baseline.** Review the system model, passage roles, planning quantities and calculation reconciliation; agree the reference conditions for design and monitoring.
2. **Complete the option comparison.** Confirm evidence associations and carry retention, targeted modification, staged removal and full removal through the common criteria.
3. **Target the shortlisted design.** Focus geometry, hydraulics, sediment inventories, receptors, ecology, utilities and access on the differences that select and size the preferred intervention.
4. **Implement and learn.** Establish the monitoring baseline, complete the first action and use agreed response thresholds to progress, pause or adapt subsequent stages.

Value carried forward

The current governed calculations remain the quantitative baseline. Their defined estimands, spatial accounts, parameter ledgers and uncertainty meanings allow each design measurement to update the relevant result without restarting the analysis.

7 Conclusions

The Agios Germanos River carries sediment through a connected sequence of sources and temporary stores. Field observations show a clear change from the bedrock and boulder framework of the mountain channels to the deposits, banks, wood and engineered controls of the lower river. Material retained at one location may move again during stronger flows. Restoration decisions therefore need to consider both the immediate crossing and the reaches that receive water and sediment from it.

The July survey, photographs, sediment samples, flow records and received topographic data together establish an evidence base for comparing options. The accepted Laimos records show longer high-flow duration in WY2022 than WY2021, despite the same number of independent events. This explains why the duration and timing of strong flows matter. It does not measure how much sediment passed through the restoration reach or entered the lake.

The quantitative results help frame that comparison at distinct scales. Modelled new input from banks and damaged gabions is about 4.4 t/yr in WY2021 and 6.6 t/yr in WY2022 for the M1–M20 network. M2 calculations describe potential carrying capacity at a sampled patch, while M20 scenarios concern a finite store. The separate Prespa analogue gives a catchment planning centre of 29.1 kt/yr, with a preferred-state range of 24.3–34.5 kt/yr and a wider scenario span of 14.9–62.7 kt/yr. These results retain their original definitions and uncertainty; they are neither additive nor measurements of actual lake delivery.

The study completes a coherent geomorphological assessment for restoration scoping and comparison of the crossing options. After strong flows destroyed the traps twice despite repeated efforts, source identification, detailed grain-size analysis and estimates of sediment movement provided the planning basis. This spatial evidence explains the causes and pathways of sediment movement across the catchment, complementing the local flux information that traps would provide. The estimates retain their stated uncertainty and lack empirical flux calibration. Additional trap data and compatible repeat surveys would refine the quantities and support a closed balance; the assembled evidence already supports the present appraisal scope (Section 1.3).

At HM13, option comparison should establish which stored material could move and where it could accumulate next. At HM14, it should examine the division of flow, wood and habitat functions, fish passage and nearby infrastructure together. At HM15, it should extend through the receiving reach to the lake, considering erosion, deposition, habitats and lake level. Wood removal requires a prior assessment by a researcher with relevant protected-area river-wood experience; its presence alone is not a reason for clearance.

The practical next step is a common comparison of retention, targeted modification, staged removal and full removal. Reuse the received RTK survey after reference and feature checks, and measure specific remaining gaps. Establish repeat photographs, sections and sediment observations before works, with agreed thresholds for reviewing subsequent changes. This allows the existing evidence to inform a staged decision while keeping final option selection and engineering design explicit.

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Abbreviations and digital package

B0	Existing-evidence analytical baseline retained from R1
CRS	Coordinate reference system
HM13–15	SCIMABIO identifiers for the upper, middle and lower Irish passages
M1–25	July 2026 field-observation modules
MoRPh	Modular River Survey framework
q05/q50/q95	Fifth percentile, median and ninety-fifth percentile within a named model state
RTK	Real-time kinematic satellite positioning
SA01–06	Survey-association release audit gates
SPP	Society for the Protection of Prespa
WY	Water year

Controlled holdings and final handover

R7 contains the English study, Technical Appendices, Greek report and three-page summary, July photographs, review responses and editable sources. The package manifest verifies the files. Numerical inputs retain the dated analytical release and their original units, scales and uncertainty. The response document explains the corrections, their locations and their implications for interpretation.

Opening the photographic and GIS evidence

Keep the package folders together and open the package browser (`index.html` in the package root). The following local links open the supplied evidence:

- July photo browser: filter by date, module or filename and open the full-resolution original.
- master_photos.csv and master_reconciled.gpkg: original photo register and GIS layers for modules, photos and observations.
- Photo_Manifest.csv: joins source filenames and master rows to the portable image paths, module, date and recorded location basis.

If a PDF viewer blocks local links, use the package browser or the folder `04_July_Survey_Photographs`. The CSV and GeoPackage are in its `03_Source_Registers` subfolder; the portable manifest is in `02_Registers`. Open the GeoPackage in GIS software. Its original source paths are preserved; use the portable manifest to find the packaged images. Module or waypoint associations do not establish a surveyed camera footprint. There are 213 distinct photographs in 214 original files (one metadata variant), covering 213 of 214 master records. M15/Garmin 058 remains unavailable.

Key release identifiers

Evidence cut	10 August 2026
Analytical release	2026-08-17_R1
Publication inputs	2026-08-17_R1_revised
Hydrology	2026-07-29_v3_18
Topography context	2026-08-10_R1_context_only

Final issue dated 30 September 2026. SPP comments and the trap-failure clarification are incorporated; no new analytical or survey release is implied.