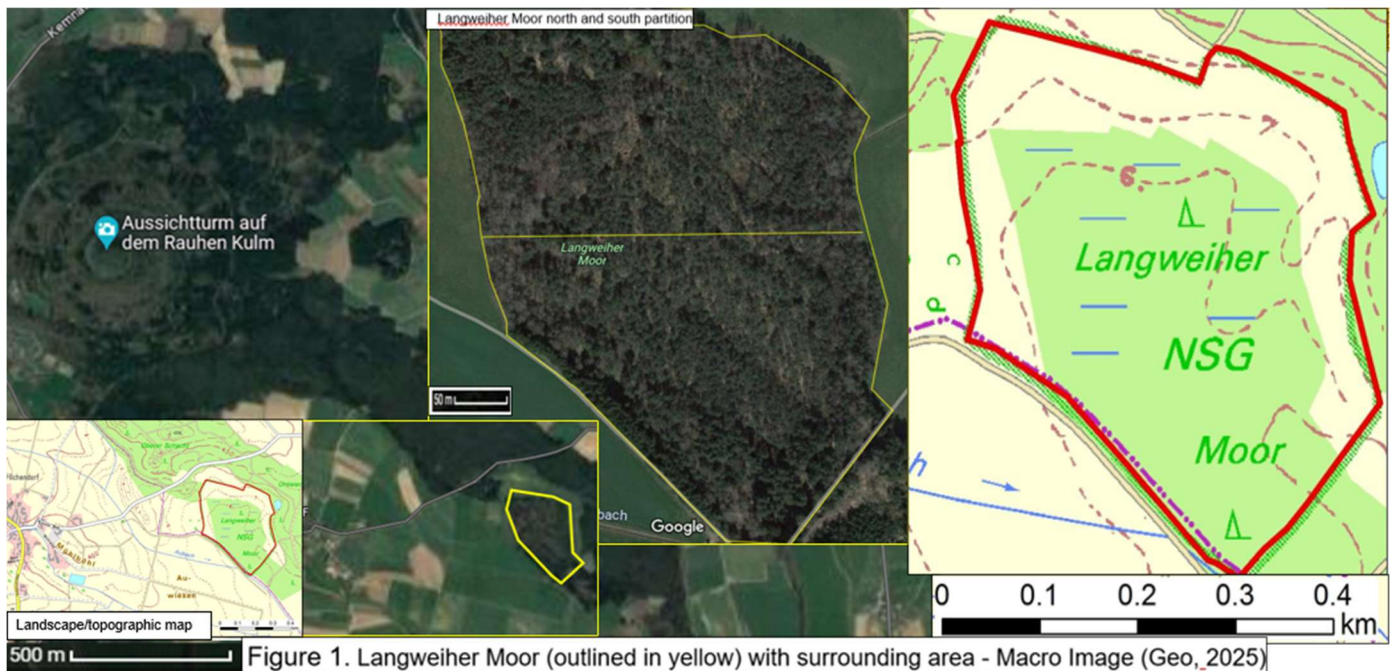


# Non-Thesis - Executive Summary

Oregon State University | Environmental Sciences Graduate Program  
Langweiher Moor Peatland Renaturation led Paludification in Bavaria, Germany  
Jorge Alexis Fuentes | MS in Environmental Science | 18 March 2026

Project Scope and Objective	Principal Findings
<ul style="list-style-type: none"><li>- Langweiher Moor is a protected transition mire in Bavaria whose function depends on shallow, persistent saturation across the peat surface.</li><li>- The capstone addresses the documented hydrologic break that occurred when the feeder stream was rerouted in 2002 and translates field evidence into a realistic restoration program.</li><li>- Rather than treating the reserve as uniformly dry, the project shows that useful water still enters the system but is not retained or distributed in ways that sustain peatland recovery</li></ul>	<p><b>Primary Problem.</b> Feeder disconnection, drainage export, and edge pressure.</p> <p><b>Preferred Alternative.</b> Active reconnection, retention, and spread of useful inflows.</p> <p><b>Success Measure.</b> Longer shallow-saturation windows and stronger wetland indicators.</p> <p><b>Program Character.</b> Phased, adaptive, and tied to review triggers.</p>



Langweiher Moor presents a well-defined, self-contained environmental system case study where the reserve is small enough that a limited number of feeder nodes, ditch segments, and edge controls can shape restoration performance, yet large enough to show a clear pattern of hydrologic decline. The planning question is therefore not whether the site can be understood, but whether restoration can be delivered in a way that matches ecological need, permit reality, and long-term stewardship capacity (Fuentes, 2026).

## 1. Site significance and degradation trajectory

Historically, persistent wetness supported bog and swamp habitats, peat retention, and specialized flora. Regional Bavarian peatland planning later reinforced the significance of minerotrophic and transitional mire systems, giving the site broader policy relevance as well as local ecological value (Bayerisches Landesamt für Umwelt [LfU], 2002; Fuentes, 2026).

The project identifies the feeder rerouting in 2002 as the decisive hydrologic turning point. After that change, the site became more dependent on weaker or less reliable inflows while remaining connected to drainage pathways that exported water too quickly (Fuentes, 2026).

Over time, drying, bushy structure, and expansion of pine and birch became more visible across the reserve. Those symptoms matter because they do not represent isolated vegetation

change; they indicate that peat surfaces are spending more time outside the shallow saturation range that supports peatland persistence (Fuentes, 2026; Kreyling, 2021).

The result is not a timeless, degraded wetland but a readable sequence of hydrologic disconnection, reduced retention, woody expansion, and a narrowing restoration window. That temporal logic matters because it makes intervention defensible. The site still retains enough structure, wet sectors, and mapped control points to justify active restoration rather than passive decline (Fuentes, 2026).

The reserve also carries significance beyond its mapped boundary. It functions within an agricultural matrix where off-site runoff, drainage, and access decisions continue to shape on-site wetness. That is one reason the project reads the case as both an ecological restoration problem and a management problem (Schulz, 2021).

If the loss mechanism is disconnection plus export, then the recovery strategy must rebuild retention and routing rather than simply wait for wet years or isolated ponding events (SER, 2004; Waddington & Day, 2007).

This history gives the project a clearer management basis than many small-wetland cases. The reserve still retains visible wet sectors, an identifiable feeder break, and a limited number of controllable ditch or trench pathways. That combination means restoration can be framed around measurable hydrologic recovery instead of a vague hope that general conservation protection alone will reverse decline (Fuentes, 2026; SER, 2004).

From an ecological standpoint, shallow water-table recovery matters because peatlands lose function when aeration becomes more frequent and persistent. Once the peat surface spends longer periods outside the preferred saturation band, decomposition accelerates, stored carbon becomes more vulnerable, and species associated with wetter conditions lose competitive ground to woody plants and disturbance-tolerant vegetation (Joosten & Clarke, 2002; Kreyling, 2021).

For that reason, site significance is not limited to rare-species protection. Langweiher Moor also represents a hydrologic storage system, a biodiversity refuge, and a climate-relevant peatland remnant whose restoration value increases when actions are taken before drying, nutrient accumulation, and woody expansion become harder to reverse (Tanneberger, 2020; Fuentes, 2026).

Temporal Changes	Ecological Significance
<ul style="list-style-type: none"> <li>- Direct feeder support weakened.</li> <li>- Ditches and trench-like routes accelerated export.</li> <li>- Agricultural and access pressures amplified edge effects.</li> <li>- Residence time became shorter and less reliable.</li> </ul>	<ul style="list-style-type: none"> <li>- Peatlands require shallow, persistent saturation.</li> <li>- Water-table decline increases oxidation and decomposition.</li> <li>- Drying margins and woody recruitment signal loss of mire function.</li> <li>- Restoration must recover storage and routing, not just add water.</li> </ul>

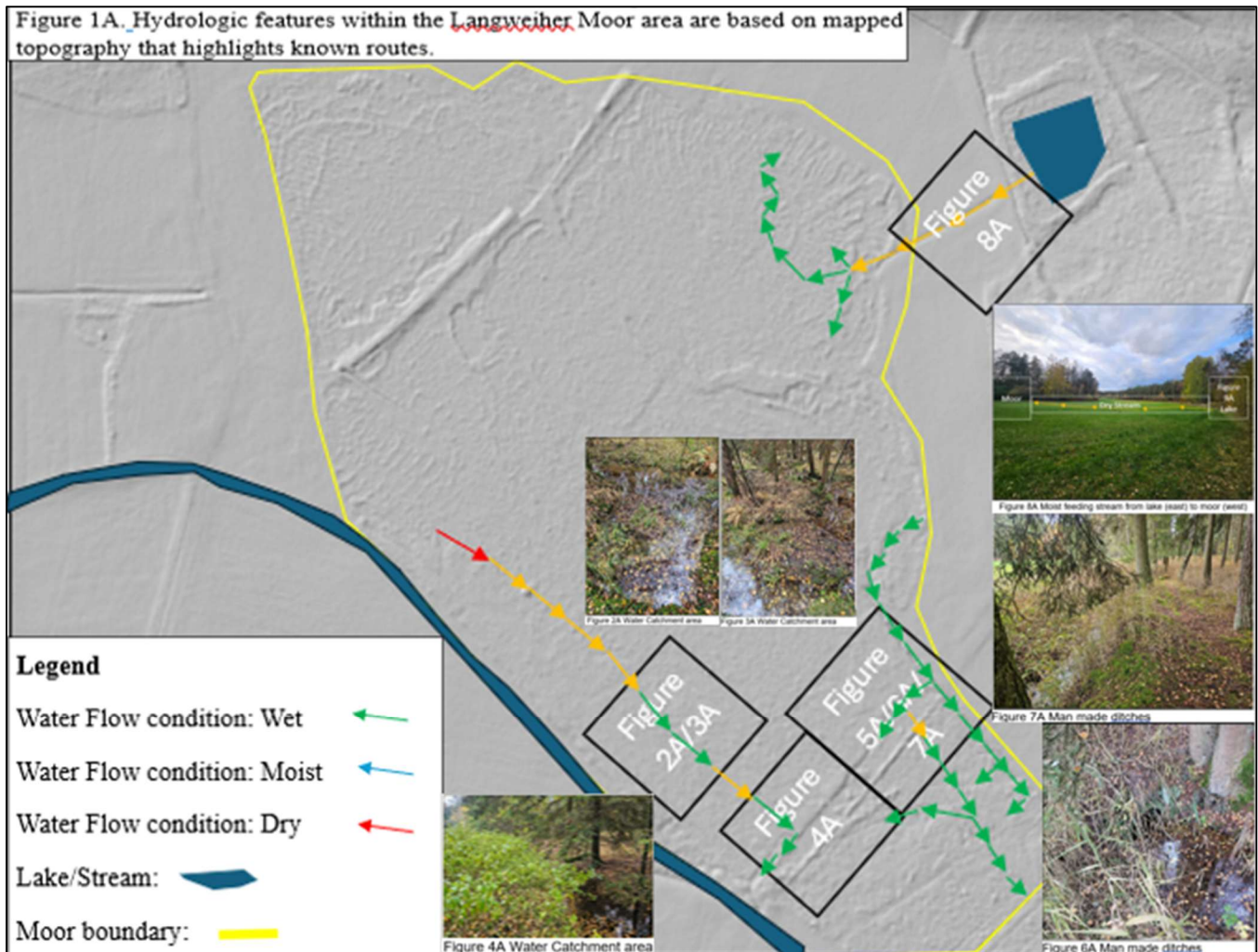
That distinction is central to the summary as the reserve remains restorable because the losses are legible, spatially concentrated, and still amenable to selective intervention.

## 2. Hydrologic diagnosis and field evidence

The hydrologic diagnosis is one of inefficiency rather than uniform dryness. The mapped baseline shows that water is still present in parts of the system, but it is not retained or distributed in ways that support peatland recovery. Some sectors continue to receive standing or slow-moving inflow, while ditch and trench features create bypass flow that shortens residence time in the peat interior (Fuentes, 2026).

This coexistence of wet evidence and drainage evidence is the project’s most important interpretive point. Scattered wet patches do not equal restored function if bypass drainage, fluctuating depth, and nutrient pulses still dominate site behavior. Langweier Moor therefore needs targeted control-point restoration, not a diffuse assumption that visible water means the system is recovering (Fuentes, 2026; Price, 2003).

Field observations also show that agricultural encroachment and motorized access can interfere with recovery by shaping margins, compaction, and site disturbance. These pressures sit partly outside the protected boundary, reinforcing the need to treat hydrology and stewardship as linked management problems (Fuentes, 2026; Wilson, 2011).



The map and field evidence show a reserve that remains hydrologically legible. Useful water is present, but current routing allows too much loss before that water can stabilize peat conditions across the interior (Fuentes, 2026).

### Diagnosis Continued. What the field evidence means for restoration design

The visible dry corridor between the northeastern water source and the peat interior matters because it turns the feeder rerouting into a landscape-scale observation rather than an abstract historical claim. Managers do not have to infer an invisible subsurface change; they can see the separation between source water and the areas that need sustained saturation (Fuentes, 2026).

That interpretation shifts the restoration objective. The goal is not permanent inundation or a dramatic visual transformation in one season. The nearer-term target is more consistent shallow saturation, reduced export through ditches and trench-like routes, slower woody recruitment, and a gradual return of vegetation associated with wetter conditions (LfU, 2002; SER, 2004).

A stronger management reading of the site is that the reserve did not fail everywhere at once. Instead, it shifted from a peatland sustained by distributed shallow inflow to one governed by a few weakened or redirected control points. That distinction matters because restoration does not depend on uniform treatment across the site (Fuentes, 2026).

The field record also supports pairing hydrologic work with edge controls. If nutrient and sediment delivery continue from adjacent land uses, then even a better water table can be accompanied by chemical conditions that slow ecological recovery (Mayer, 2007; Wilson, 2011).

In addition, the site still shows hydrologic memory. Wet sectors, slow-moving inflows, and identifiable control points indicate that restoration does not require rebuilding the peatland from nothing. It requires recovering storage and routing where the system still has the capacity to respond (Ketcheson & Price, 2011; Price, 2003).

The practical design lesson is one of selective intensity, with stronger intervention focused on the limited number of locations that control flow routing and lighter intervention maintained elsewhere to allow site response with minimal broad-scale disturbance (SER, 2004).

From an applied perspective, that means design work should focus on maintaining longer shallow-saturation periods instead of chasing visually dramatic open-water conditions. Peatland recovery is better served by spreading retained water through the upper peat profile and keeping drawdown events shorter than by creating isolated ponded cells that leave surrounding peat dry for the rest of the season (LfU, 2002; Waddington & Day, 2007).

The field evidence also argues for sequencing edge interception with inner-core rewetting. Where inflow corridors continue to carry nutrient or sediment pressure, managers should treat those margins as part of the restoration unit because external loading can blunt vegetation recovery even when water-table conditions improve. Hydrologic repair and water-quality protection therefore need to advance together rather than as separate programs (Mayer, 2007; Wilson, 2011).

This is also why the case is well suited to adaptive implementation. The reserve has enough visible structure for managers to compare pre- and post-intervention flow paths, check whether retention is increasing in the intended sectors, and revise structures or routing if water continues to bypass the peat interior. The site remains manageable precisely because the control points are few enough to inspect and interpret directly in the field (Fuentes, 2026).

Evidence	Interpretation	Design implication
Wet patches remain	Useful inflow still reaches parts of the reserve	Protect and redistribute retained water
Ditch and trench export	Residence time is being shortened	Target control nodes and bypass routes first
Dry margins and woody spread	Peat surfaces are outside the preferred saturation band	Use shallow-water restoration targets, not deep flooding

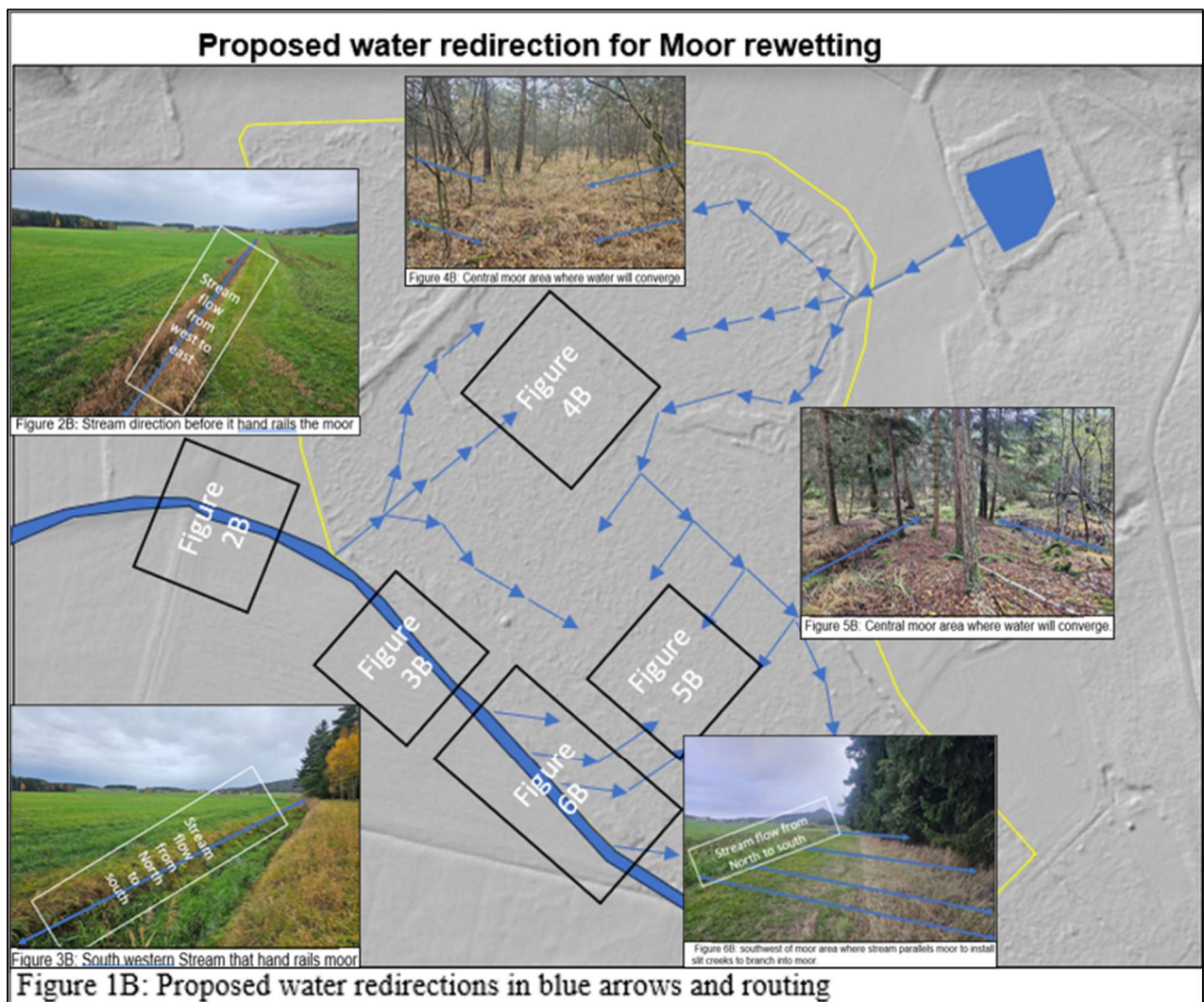
### 3. Preferred alternative and restoration logic

The project compares three alternatives such as passive no action, a hybrid buffer-focused approach, and active restoration. Passive management is useful only as a baseline because it is unlikely to restore peat-forming conditions within a practical horizon. The hybrid option can improve selected nodes and margins, but it generally acts too slowly where feeder disconnection and bypass drainage remain unresolved (Fuentes, 2026).

The preferred alternative is active restoration because it scores best on hydrologic leverage, ecological gain, feasibility, and adaptive value. The plan is practical rather than dramatic. It aims to reduce loss at priority ditch nodes, reconnect or redirect useful inflows, and spread retained water more effectively across the peat interior (Fuentes, 2026; Tanneberger, 2020).

The restoration logic can be summarized as reconnect, retain, and spread water. Reconnection addresses the hydrologic break. Retention increases residence time in the mire. Distribution matters because a peatland is not restored when only isolated depressions remain wet while margins continue to dry (Price, 2003; Waddington & Day, 2007).

This conceptual framework is also compatible with the project's governance arrangements. High-leverage nodes can be installed, inspected, and revised without pretending that one construction phase will permanently settle the system (Schulz, 2021).



Alternative	Hydrologic	Ecological	Monitoring	Interpretation
Passive	Low	Low	Moderate	Comparison only
Hybrid	Moderate	Moderate	High	Improves nodes, slower overall
Active	High	High	High	Best fit for project goals

#### 4. Phased implementation and monitoring

The implementation sequence should move from outer controls to inner recovery. First, access is confirmed and the nodes with the highest hydrologic leverage are surveyed in detail. Second, retention or redirection structures are tested where they can influence the largest peat surface with the least construction footprint. Third, margin interception, low-disturbance buffers, and routine maintenance are expanded only after the initial response is understood (Fuentes, 2026).

Monitoring is built to change management rather than simply describe the site. Hydrology remains the primary performance domain, supported by water-quality measurements, repeat vegetation plots, peat and soil observations, fixed photo points, and seasonal wildlife records. Each domain has a review trigger so managers know when to inspect, revise, or scale interventions (SER, 2004; Fuentes, 2026).

The design therefore treats monitoring as part of the restoration mechanism, not an afterthought. Water-level logging provides the primary signal, but it should be interpreted alongside nutrient observations, photographic repeat points, vegetation plots, and field notes on bypass flow or erosion. That combined record helps separate true hydrologic recovery from short-lived wet periods driven only by weather (SER, 2004).

The implementation sequence also reduces delivery risk. Early phases concentrate uncertainty in a small number of pilot nodes, allowing teams to test installation methods, inspect post-flow performance, and revise details before investing across the wider reserve (Fuentes, 2026).

Domain	Indicator	Review Trigger	Predicted Response
Hydrology	Water-table depth and saturation duration	No improvement after initial structure installation	Inspect nodes and revise routing
Chemistry	Nutrients, conductivity, turbidity	Persistent inflow pressure or elevated loading	Strengthen edge interception
Vegetation	Wetland indicators and woody cover	Woody expansion despite wetter conditions	Reassess moisture distribution

A phased program also improves budget discipline. Early spending should favor baseline monitoring, site confirmation, and the first high-leverage control points. Later expenditures should shift toward maintenance, data review, and selective reinforcement where performance remains below target (Fuentes, 2026).

A useful management rule is to treat the first monitoring cycle as a design test rather than as mere documentation. If loggers, piezometers, repeat photographs, and vegetation plots show that water is not remaining in the target sectors, then managers should revise routing or retention details before investing in broader expansion. That approach lowers the risk of scaling an ineffective design across the reserve (SER, 2004; Fuentes, 2026).

Success thresholds should therefore remain explicit. Examples include shallower median growing-season water tables, fewer prolonged drawdown periods, reduced signs of bypass export, and stronger wetland-indicator cover in monitored plots. These indicators give

implementation teams a basis for deciding whether they should reinforce structures, adjust margins, or maintain the current configuration (Fuentes, 2026; Ketcheson & Price, 2011).

## 5. Governance, budget logic, and implementation risk

The project treats restoration as both a hydrologic and a governance challenge. Technical insight alone does not guarantee delivery. The design must fit permits, maintenance capacity, landholder cooperation, and public understanding. This is why implementation is framed inside a policy stack that ranges from EU and German restoration context to Bavarian peatland guidance, local permits, and site-access agreements (Schul, 2021).

Budget logic follows the phased implementation sequence. Early costs concentrate on monitoring, site confirmation, and the first control points. Later costs emphasize maintenance, performance review, and targeted adjustment. This is more credible than treating restoration as a one-time construction expense because effort and cost will change as the site responds (Fuentes, 2026).

Risk management is approached with the same practical orientation. The main risks are permitting delays, structure underperformance, persistent nutrient loading, unexpected bypass flow, and maintenance burden. The mitigation strategy is to pilot high-leverage nodes first, inspect after high-flow periods, pair hydrologic work with edge interception, and keep structures as simple and maintainable as possible (Fuentes, 2026; SER, 2004).

Principal Risks	Mitigation Intervention
<ul style="list-style-type: none"> <li>- Permitting or access delay</li> <li>- Structure underperformance</li> <li>- Persistent nutrient loading</li> <li>- Unexpected bypass flow</li> <li>- Maintenance burden</li> </ul>	<ul style="list-style-type: none"> <li>- Engage agencies and landholders early.</li> <li>- Use pilot nodes before scaling.</li> <li>- Pair retention work with source-focused edge controls.</li> <li>- Inspect controls seasonally and simplify designs where possible.</li> <li>- Assign ownership for inspection, data review, and upkeep.</li> </ul>

## 6. Conclusions and management implications

The capstone supports three linked conclusions. First, the Langweiher Moor problem is fundamentally hydrologic, where the reserve lost direct feeder support, remained connected to drainage pathways, and became increasingly exposed to edge effects from surrounding land use. Second, the stronger response is active restoration centered on reconnection, retention, and distribution of water rather than passive reliance on isolated wet patches. Third, monitoring must stay tightly coupled to management so the plan can adapt when site response diverges from expectations (Fuentes, 2026).

The case has broader relevance beyond a single mire because it shows how small peatlands can be governed by a limited number of control points and by pressures that originate partly outside the mapped reserve boundary. It also shows why adaptive restoration is stronger than static restoration (Schulz, 2021; Tanneberger, 2020).

From an implementation perspective, the path forward is direct since restoring connectivity is where feeder routing and ditch nodes offer the greatest leverage; reducing external nutrient and sediment loading before those inputs reorganize the peat interior; tracking hydrology, chemistry, vegetation, peat condition, and stewardship performance as a connected system. Pursued together, those actions can move Langweiher Moor back toward peat-forming conditions rather than continued decline where restoration success should be measured by sustained hydrologic improvement and ecological response over time, not by a single construction milestone (Mayer, 2007; SER, 2004).

## 7. References

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