River Refugium Project (RRP)

CERNUNNOS FOUNDATION

BRIGHT MEADOW GROUP

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RIVER REFUGIUM PROJECT Cernunnos Foundation Bright Meadow Group	**RRP3 — Water Treatment ****&**** Biofiltration** Document No: RRP0002.4	Version: 2.0	01 April 2026 Status: Published — Version 2.0	Supersedes: Version 1.0 (2025) *Contact: robert@brightmeadowgroup.com	www.cernunnosfoundation.com*

Abstract This document describes the water treatment and biofiltration architecture of the River Refugium Project — the first functional engine of the system, where river water transitions from uncontrolled natural flow into a structured, measurable industrial process. The forebay intake, pump house, central cistern, six-tank biofiltration train, solids handling, and off-gas management are described in terms of their architecture, engineering rationale, and role within the integrated node. Key quantitative parameters are flagged as provisional pending pilot data collection.

1. Forebay Intake

The forebay is the RRP's hydraulic gateway — a protected capture pool that draws river water into the system at a controlled, measurable rate.[1] It performs sediment and debris pre-removal through settling and coarse screening, hydraulic buffering against river level fluctuations, and provides a clean inflow measurement point. Finance partners require predictable throughput; engineers require predictable hydraulics. The forebay delivers both.

2. Pump House **&**** Flow Architecture**

From the forebay, variable-frequency drive pumps with redundant trains (N+1 minimum) move water into the controlled zone.[2] In some deployments a gravity-fed water tower provides backup hydraulic head, passive aeration, and surge absorption. This increases resilience during power interruptions without adding operational complexity.

3. Central Cistern

The cistern is the hydraulic brain of the node — a volume buffer sized to hold approximately three times daily throughput.[3] It acts as a central testing node for chemistry, flow, and solids characterization, and as a dispatch hub routing water into the biofiltration sequence. Its role is analogous to a clock: it regulates the system's internal tempo so downstream stages receive water on predictable cycles.

Key parameter — cistern capacity: **⚑ TBD pending site engineering and pilot calibration.**

4. Six-Tank Biofiltration Train

The biofiltration block performs biological nutrient processing at industrial scale through a six-tank sequence: four aerobic tanks for nitrification and four additional functions, and two anaerobic tanks for denitrification.[4] This mirrors the nitrogen cycle found in natural wetlands but delivers it year-round in a controlled, measurable, programmable environment.

4.1 Aerobic Tanks

The aerobic tanks convert ammonia to nitrite to nitrate, oxidize dissolved organics, reduce biochemical oxygen demand, break apart suspended solids, and promote flocculation. Oxygen levels are managed via dissolved oxygen sensors tied to the SCADA/PLC system. Aeration is non-wasteful — the system does not run blowers at fixed rates but responds to actual demand.

4.2 Anaerobic Tanks

The anaerobic tanks complete the nitrogen cycle by converting nitrate to nitrogen gas under oxygen-starved conditions. They operate in a separate hydraulic loop from the aerobic sequence and can be isolated individually without interrupting overall flow.

Key parameters — hydraulic residence time per tank, loading rates, target effluent quality per stage: **⚑ TBD pending pilot measurement and engineering drawings.**

5. Solids Handling **&**** Off-Gas Management**

Settled solids from the biofiltration train are routed to the biomass preparation module for HTC/HTL processing — the same pathway as greenhouse biomass harvest, ensuring no accumulating waste streams.[5] Off-gases (CO_2-rich, some methane fraction) are captured and routed back to the greenhouse complex for enrichment and as a partial energy input to the thermochemical plant. See RRP5 for the thermochemical integration of these streams.

Notes

Citations follow Chicago Notes-Bibliography style. Internal Bright Meadow Group / Cernunnos Foundation documents are cited by document title and year. Figures marked ⚑ are provisional academic proxies pending replacement by RRP pilot data per RRP8.

- **1. ***USACE, River Intake **&** Forebay Design Standards; Bright Meadow Group, **"**Intake Architecture Notes,**"** CF/BMG Internal, 2025.*

- **2. ***Bright Meadow Group, **"**Pump House Redundancy **&** VFD Logic,**"** CF/BMG Hydraulic Team Draft, 2025.*

- **3. ***Bright Meadow Group, **"**Central Cistern Analytical Protocol,**"** CF/BMG Water Quality Framework, 2025.*

- **4. ***U.S. EPA, Nutrient Removal — Biological and Tertiary Processes. EPA/625/R-10/001, print edition. Adapted for RRP six-tank configuration.*

- **5. ***Bright Meadow Group, **"**Sludge Management **&** Solids Routing,**"** RRP Process Integration, 2025.*