APPENDIX D.
POND, HOUSING, AND FACILITY DESIGN REFERENCES

This appendix supplies the working checks and arithmetic behind the facilities discussed in Chapter 6. Its figures and example numbers are preliminary planning aids, not certified construction drawings. No numerical value below should be treated as a French statutory minimum, a proven hippopotamus preference, or an acceptable design load without independent verification for the animals and property concerned.

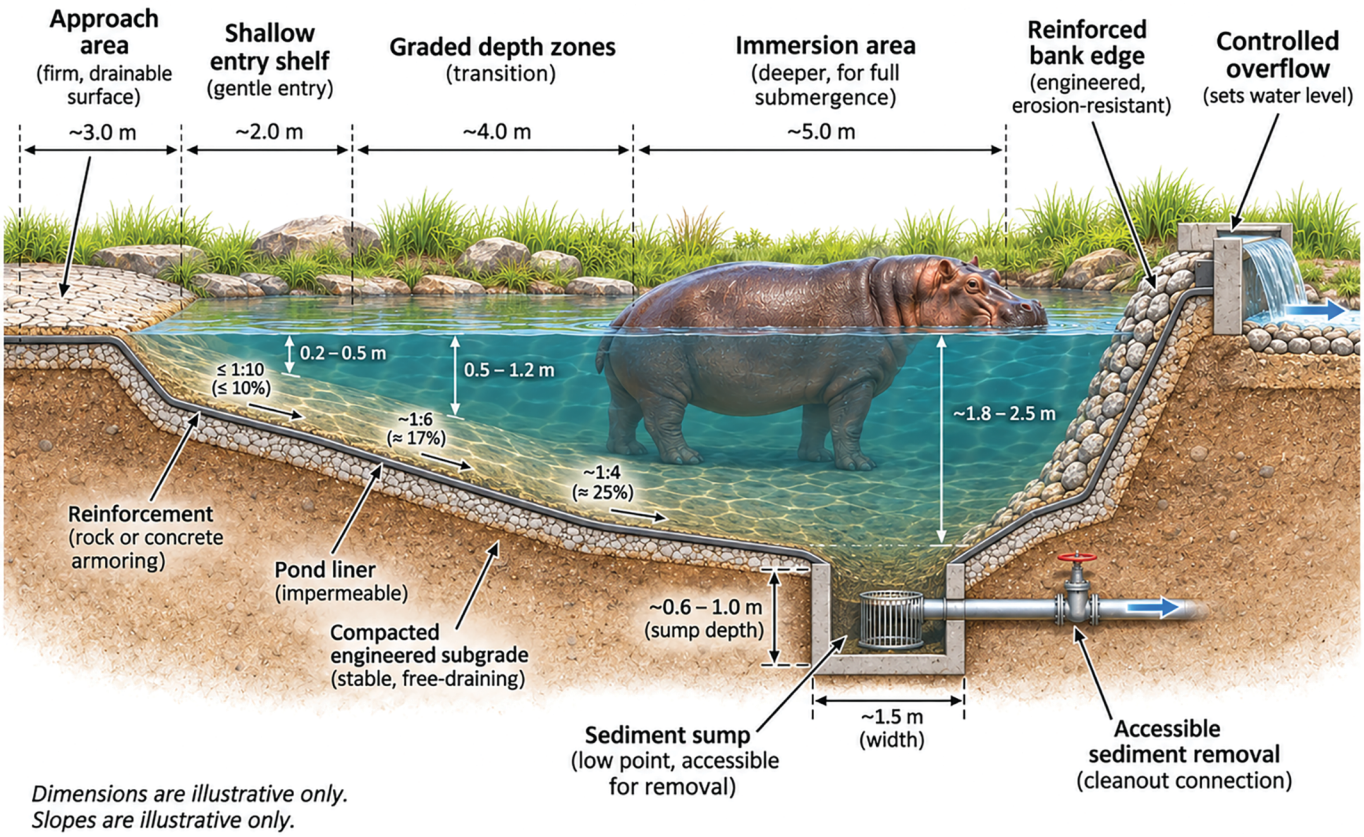
Two categories must be kept separate. Documented husbandry guidance calls for safe access to species-appropriate water, escape from crowding, secure separation, non-slip footing, suitable dry rest, maintainable drainage, and protection from temperature extremes. The example dimensions, temperatures, flow rates, and loads used here are engineering assumptions chosen to show a method; they do not establish biological standards. The farmer should record actual animal measurements, occupancy, soils, available water, winter weather, and approval conditions before anyone sizes the works.

This appendix is available for download at:

https://greybarnfarm.com/publishing/hippo-dairy

D.1. Pond section, gradients, and usable volume

Item to establish	Preliminary reference or method
Access and depth	Plan a firm landing, shallow margin, intermediate water, and fuller immersion; provide more than one usable exit where the group and site permit. No abrupt drop beside a regular route.
Illustrative water depths	For a drawing only: 0.3–0.5 m at a margin; 0.8–1.2 m in a transition zone; 1.5–2.0 m in a deeper section. These are not recommended standards or suitable depths for every calf or adult.
Illustrative entry grade	A 1:12 grade has 1 m vertical rise per 12 m horizontal run (8.3%). A 1:20 grade is 5%. Neither is a species-validated maximum; wet traction and animal movement govern.
Substrate and banks	Assess bearing, erosion, wet traction, seepage, buried services, cleaning access, and reinforced entry transitions. Keep sediment-removal fittings inaccessible to occupied animals.



Dimensioned conceptual pond section showing a firm approach, shallow entry, graded depth zones, an immersion area, reinforced bank, controlled overflow, and an accessible sediment sump. All displayed dimensions and slopes are illustrative only.

For a change in elevation of 0.75 m, a notional 1:12 approach occupies 0.75 × 12 = 9.0 m horizontally, excluding level landings and transitions. A short ramp drawn beside a deep basin may therefore be impossible to build at the assumed grade. The design must allow turning, a second exit when practicable, and safe exclusion of animals while water or sediment is removed.

A first-pass water volume may be written $V \approx A \times \bar{d}$, where A is plan water area (m^2) and $\bar{d}$ is the estimated

mean water depth (m). For an illustrative 16 m × 10 m pond at 1.10 m mean depth, V ≈ 160 × 1.10 = 176 m³. This does not define capacity for any particular number of hippopotamuses. Surveyed contours or a three-dimensional basin model are required for a construction estimate; volume at operating level and volume during cleaning should be calculated separately.

D.2. Water services, drainage, and sediment

Freshwater for drinking and dairy hygiene, pond make-up, recirculated pond water, contaminated washwater, sludge, and clean roof runoff are distinct streams. Pond water is not a sanitary supply for milk-contact equipment. Separate pipework, air gaps or other approved backflow protection, isolation valves, sampling points, and clear service drawings matter more than the color of a pipe on a sketch.

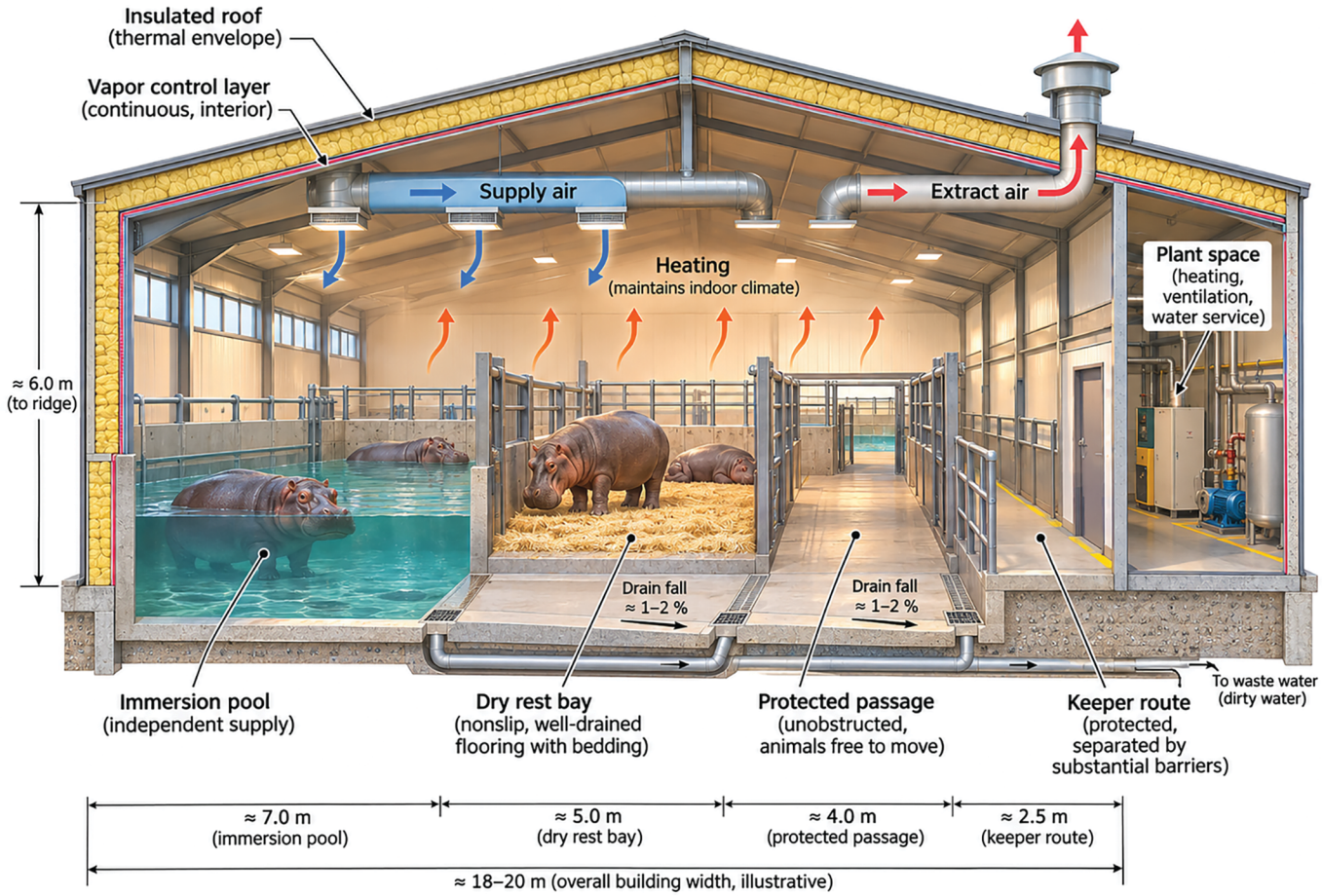
Calculation / check	Worked method and design consequence
Refilling after cleaning	A 176 m³ pond refilled in 12 h requires 176 ÷ 12 = 14.7 m³/h (approximately 4.1 L/s) at the point of delivery; add real losses, friction head, and supply restrictions before selecting a pump.
Evaporation example	At an assumed 3 mm/day from 160 m², loss is 0.003 × 160 = 0.48 m³/day. This excludes seepage, splash, cleaning, overflow, and actual seasonal variation.
Drainage falls	Show each wet-room and service-yard fall to an accessible collection point. Confirm with level surveys that a closed gate or isolated pen does not redirect dirty water into a dry resting bay.
Treatment and discharge	Allow for coarse screening, sediment settling, optional recirculation treatment, off-line isolation, sludge removal, controlled overflow, and legally authorized wastewater disposal.

A hypothetical recirculation rate of 4 m³/h would turn over 176 m³ in 44 h (176 ÷ 4), but turnover alone says nothing about whether solids, bacterial load, and water quality are controlled. Intake protection, screening capacity, suspended-solids capture, filter backwashing, hydraulic head, and safe disposal of removed material govern treatment selection. Clean roof runoff can often be kept apart from animal washwater, whereas water from occupied yards must be assessed as potentially contaminated. Storm storage and overflow routes require a site-specific rainfall and catchment calculation.

The engineer must establish water balance under drought as well as routine use: permitted abstraction, refill demand, storage, rainfall, evaporation, seepage, and cleaning frequency. An emergency water source must be deliverable by the available road and connection, not merely named in the plan. Under French “loi sur l’eau” procedures, a pond, abstraction, discharge, or wetland alteration may trigger one or more IOTA categories; the local authority must determine the applicable requirements for the complete project.

D.3. Winter housing and movement spaces

A winter barn requires separate indoor immersion and dry resting areas, a protected staff/service side, secure gates that remain locked on loss of power, and an alternate enclosure when one pool or pen is unavailable. Avoid blind dead ends and routes dependent upon passage through another animal group. The clear width of doors and passages must be checked against the largest expected animal in normal movement, plus the clearance, equipment, and turning requirements determined by the facility designer.



Conceptual winter-housing section showing an insulated and vapor-controlled envelope, independently served immersion pools, dry rest bays, protected keeper circulation, sloped drains, supply and extract airflow, and safely accessible plant space. Dimensions and heating arrows are illustrative.

System	What the design record must demonstrate
Containment and access	Surveyed animal widths and heights; robust connections and foundations; protected gate controls; safe stopping and locking positions; maintenance access from outside occupied spaces.
Dry and wet areas	No pond overflow into bedding; nonslip but nonabrasive surfaces; drainage safe for four-toed feet; covered and load-rated grates; room to lie and rise without obstruction.
Climate envelope	Envelope insulation, condensation control, corrosion resistance, air sealing, fresh-air distribution, extract location, and separate controls for vulnerable calves or recovering animals.
Service and isolation	Plant and electrical rooms outside animal reach; isolatable pools; independent or safely separated isolation drainage; accessible repairs without entering occupied pens.

For a corridor opening, a useful early check is clear width = measured body width + required side clearance. For example, a hypothetical 1.7 m body width plus 0.4 m each side produces 2.5 m; neither the assumed animal width nor the allowance is a standardized design value. Actual clearance must accommodate shoulder and head swing, calf position, turning behavior, gate leaves, and emergency movement without exposing a keeper. Passage design is a sequence of turning, viewing, stopping, and

separating spaces, not just one opening measurement.

D.4. Heating, ventilation, and moisture calculations

Preliminary heat loss through an envelope is $Q_e = \Sigma(U \times A \times \Delta T)$, in watts, where U is thermal transmittance ($W/m^2 \cdot K$), A is area (m^2), and ΔT is indoor-to-outdoor temperature difference (K). As arithmetic only, 620 m^2 of combined envelope at U = 0.45 and 23 K difference gives about 6.4 kW. Doors, thermal bridges, ground contact, water heating, and intermittent occupancy are not included.

For sensible ventilation heating, a useful first estimate is $Q_v \approx 0.33 \times q \times \Delta T$ watts with air flow q in m^3/h. At an assumed q = 1,500 m^3/h and ΔT = 23 K, $Q_v \approx 11.4$ kW before heat recovery. These assumed operating conditions are neither a recommended room temperature nor a hippopotamus-specific air-change rate. Air flow must instead be set from moisture generation, air quality, occupancy, ammonia and odor control, and the required absence of chilling drafts.

Indoor water contributes a separate latent load. For perspective, evaporating 10 kg of water per hour produces roughly 6.8 kW of latent load at a vaporization enthalpy of about 2.45 MJ/kg; this is an example rate, not a prediction for a hippopotamus pool. Water-surface area, activity, water temperature, room dew point, air movement, and splashing determine actual evaporation. HVAC and envelope specialists must calculate this load together; swimming-pool design methods offer a framework but not animal-specific setpoints.

D.5. Backup services and emergency accommodation

List essential electrical loads separately from thermal output. A sample schedule of 8 kW water pumps, 5 kW ventilation, 6 kW electrically supplied critical heating equipment, and 1 kW alarms and lighting totals 20 kW running demand. An illustrative 30% allowance gives 26 kW, but generator selection also requires starting current, motor sequencing, power factor, fuel availability, transfer equipment, and any electric heat actually in service. Generator nameplate power must not be chosen from this sum alone.

The emergency accommodation check is physical: a secure alternate pen or pool, protected route to it, working drainage, water delivery, heat, access for the veterinarian, and a way to keep incompatible animals separate. Record which gates close or stay closed when power stops; which pumps can be bypassed; the battery duration of alarms and controls; and the number of hours that verified fuel and water reserves can support the essential loads. A contingency plan without a usable animal space is not a contingency.

D.6. Project handover and source basis

Before construction or acceptance, retain dimensioned as-built plans; surveyed drainage levels; geotechnical and bank-stability assessments; animal and service traffic diagrams; water-supply rights; discharge permissions; certified barrier and gate design; electrical safety and generator test records; ventilation and heat-loss calculations; and maintenance and isolation procedures. Revisit the assumptions when groups, animals, water supply, or winter operating arrangements change.

Technical basis (not French dairy-hippopotamus codes): Global Federation of Animal Sanctuaries,

Standards for Rhinoceros, Hippopotamus and Tapir Sanctuaries (2019), especially housing, pools, containment, and temperature provisions; ASHRAE Handbook—HVAC Applications, "Indoor Swimming Pools" (2023), for moisture/evaporation methodology; and the French IOTA "loi sur l'eau" nomenclature, notably rubrique 3.2.3.0, subject to current local interpretation. The calculations and numerical examples in this appendix are expressly provisional.