

XQ⁹SKHYDREX™ — Hybrid Hydro Remediation & Environmental Recovery Engine™

Systemic Category: Hydro-Environmental Intelligence & Remediation Engine™

Architectural Position:

Water Intelligence Layer between WatchLion™ and MaindXQ12™ EOS

Version: 12.0 — Consolidated Foundational Technical Specification

Date: 2026-06-27

CHAPTER 1: PURPOSE & SCOPE

1.1 Technical Definition

XQ⁹SKHYDREX™ is the hybrid hydro-environmental engine of the MaindXQ12™ ecosystem, operating as the water submodule within **XQ⁹ — Critical Utilities Infrastructure (Water, Energy, Gas)**, which constitutes one of the twelve modules (**XQ¹ through XQ¹²**) of the **MaindXQ12™ Environmental Operation System**. Its exclusive function is to execute the public policy of water body depollution as a sovereign government functionality, through the integration of continuous sensing, ontological intelligence, and multi-mechanism active remediation, with the capacity to transform contaminated water into potable water or safe reuse water.

The system does not generate financial assets. It generates recovered and audited water.

1.1.1 Engineering Domains

XQ⁹SKHYDREX™ is architected upon three complementary engineering domains, each responsible for a distinct operational layer within the remediation lifecycle.

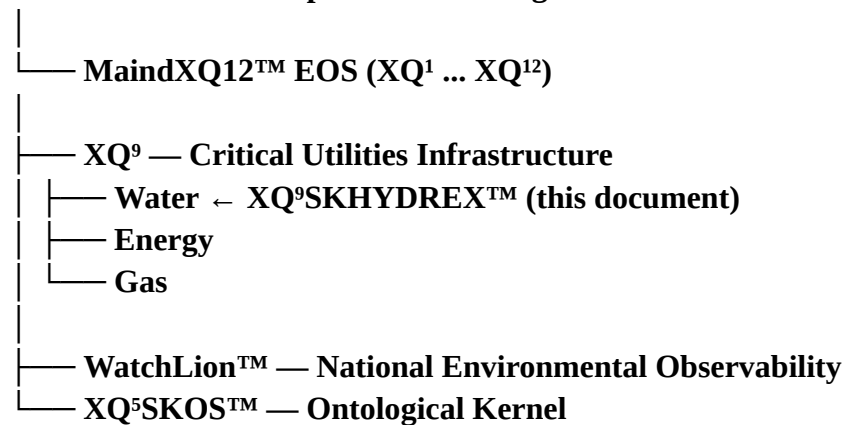
Physical Engineering: Responsible for the physical infrastructure supporting environmental intervention, including sensing devices, hydraulic structures, pumping systems, circulation networks, reaction chambers, containment systems, electromechanical assemblies, and field instrumentation.

Chemical Engineering: Responsible for contaminant transformation and removal through physicochemical and biological processes, including electrocoagulation, advanced oxidation, precipitation, adsorption, biological remediation, polishing, and future mineralization processes.

Systems Engineering: Responsible for orchestration of the complete operational lifecycle, including data acquisition, semantic normalization, ontological inference, protocol selection, command execution, interoperability, verification, audit, cybersecurity, digital records, and integration with **WatchLion™, MaindXQ12™ EOS, and XQ⁵SKOS™**.

1.2 Position of XQ⁹ within the Ecosystem

POC — Primordial Operational Configuration



1.2.1 Relationship to MaindXQ12™ EOS

XQ⁹SKHYDREX™ operates as a specialized engine within XQ⁹ — Critical Utilities Infrastructure, which constitutes one of the twelve modules (XQ¹ through XQ¹²) of the MaindXQ12™ Environmental Operation System. The sequential **architecture** follows:

POC (Primordial Operational Configuration) → XQ¹ ... XQ⁹ ... XQ¹²

Where:

- **POC** establishes the minimum pre-operational condition for all modules
- **XQ⁹** governs critical utilities (Water, Energy, Gas)
- **XQ⁹SKHYDREX™** executes the water depollution function within XQ⁹
- **XQ¹² (Survival Mode)** provides extreme ecosystem preservation

WatchLion™ operates as the National Environmental Observability Layer across all modules. **XQ⁵SKOS™** provides the Ontological Kernel for semantic protection and execution.

1.3 Operational Scope

Water bodies: Rivers, lakes, reservoirs, aquifers, WWTP effluents

Contaminants: Persistent organics, heavy metals, pathogens, excess nutrients

Mechanisms: Biological, chemical, electrochemical, photocatalytic, geochemical

Engineering domains: Physical Engineering + Chemical Engineering + Systems Engineering

Scale: Municipal → State/Provincial → National → Transboundary Basin

Purpose: Environmental public policy. Sovereign government function.

Final destination: Potable water or safe reuse water

CHAPTER 2: SYSTEM MISSION

2.1 Operational Mission

Execute verifiable depollution of water bodies through:

1. **Continuous sensing** — know the real state of each segment
2. **Ontological diagnosis** — identify the exact cause of degradation

3. **Active remediation** — apply the correct depollution protocol
4. **Physical verification** — prove that depollution was effective
5. **Public accountability** — record the intervention chain for audit

2.2 Performance Metrics

WQI (Water Quality Index, modified NSF): 2-level elevation in 12 months

Pollutant load removal rate (% of contaminants removed): >95% organics, >90% metals

Detection-response time (latency between detection and remediation start): <30 seconds

Public record integrity (auditable intervention chain): 100%

CHAPTER 3: ARCHITECTURAL POSITIONING

3.1 Position within the Ecosystem

WATCHLION™ (National Environmental Observability Layer)

|
| Raw territorial sensing data



XQ⁹SKHYDREX™ (Hydro Intelligence & Remediation Engine)

|
| — SENSE — Continuous monitoring
| — DIAGNOSE — Ontological diagnosis (**XQ⁵**)
| — BIO — Biological remediation
| — CHEM — Chemical remediation
| — AQUA — Aquifer recovery
| — VERIFY — Physical verification
| — REGISTRY — Public intervention registry

|
| Processed data + depollution evidence



MAINDXQ12™ EOS (Environmental Operation System — XQ¹ ... XQ¹²)

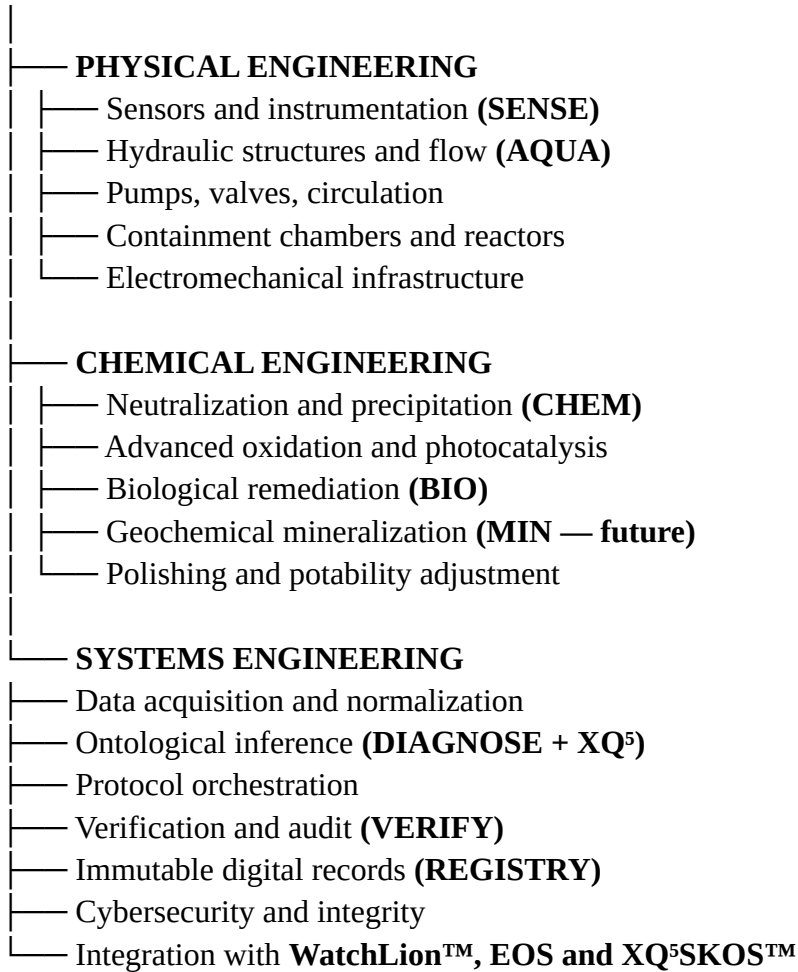
|
| Territorial governance



XQ⁵SKOS™ KERNEL (Ontological Execution & Protection Layer)

3.2 Engine Engineering Domains

XQ⁹SKHYDREX™



3.3 Interface Protocols

WatchLion™ → HYDREX (Inbound): MQTT/OPC-UA, JSON-LD with semantic annotation

HYDREX → EOS (Outbound): gRPC, Protobuf with ontological metadata

EOS → HYDREX (Command): gRPC, Signed remediation instruction

HYDREX → Public Registry (Audit): Immutable record, Verifiable evidence

CHAPTER 4: FUNCTIONAL MODULES

4.1 XQ⁹SKHYDREX-SENSE™ — Hydrological Intelligence Layer

Classification: Physical Engineering Layer

Function: Ingestion and normalization of continuous water sensing data

Parameters monitored:

- **pH:** 0-14, ±0.01, ISO 10523
- **ORP:** -2000 to +2000 mV, ±1 mV, ASTM D1498
- **Turbidity:** 0-4000 NTU, ±2%, ISO 7027

- **Conductivity:** 0-200 mS/cm, $\pm 0.5\%$, ISO 7888
- **Dissolved Oxygen:** 0-50 mg/L, ± 0.1 mg/L, ISO 17289
- **Nitrates:** 0-1000 mg/L, $\pm 5\%$, EPA 353.2
- **Phosphates:** 0-100 mg/L, $\pm 5\%$, EPA 365.1
- **Heavy metals:** 0-100 ppm, $\pm 3\%$, EPA 200.8
- **BOD₅:** 0-4000 mg/L, $\pm 10\%$, ISO 5815-1
- **COD:** 0-15000 mg/L, $\pm 5\%$, ISO 6060

4.2 XQ⁹SKHYDREX-BIO™ — Biological Remediation Layer

Classification: Chemical Engineering Layer

Function: Biological degradation of organic matter and nutrients by specialized microorganisms

Technologies:

- **Electroactive biofilms (Exoelectrogenic bacteria):** TRL 7 — Logan, B. (2008)
- **Phytoremediation (Aquatic macrophytes):** TRL 9 — Rahman, M.A. (2020)
- **Synthetic microbial consortia (Engineered communities):** TRL 5 — Lawson, C. (2019)
- **Functionalized biochar (Adsorption with microbial inoculum):** TRL 6 — Wang, J. (2021)

Specification: Moving Bed Biofilm Reactor (MBBR), hydraulic retention time 4-12h adjustable by pollutant ontology

4.3 XQ⁹SKHYDREX-CHEM™ — Chemical Remediation Layer

Classification: Chemical Engineering Layer

Function: Chemical neutralization and controlled precipitation of contaminants

Technologies:

- **Electrocoagulation (Al/Fe anode dissolution generates in-situ coagulant):** Metals, solids
- **Fenton oxidation ($\text{Fe}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{OH}\cdot$):** Pharmaceuticals, dyes
- **Struvite precipitation ($\text{Mg}^{2+} + \text{NH}_4^+ + \text{PO}_4^{3-} \rightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$):** N and P removal
- **Nanomaterial adsorption (Graphene oxide, nanotubes):** Trace metals

References: Moussa, D.T. (2017); Pignatello, J. (2006) — 3000+ citations; Le Corre, K.S. (2009); Xu, J. (2018)

4.4 XQ⁹SKHYDREX-AQUA™ — Aquifer Recovery Layer

Classification: Physical Engineering Layer

Function: Recovery of aquifers and underground water bodies

Technologies:

- **Air sparging (Air injection for oxidation):** EPA 510-B-95-007

- **Pump & Treat (Extraction, treatment, and reinjection):** EPA 542-R-14-002
- **Reactive barrier (Zero-valent iron, activated carbon):** ITRC PRB-5 (2011)

4.5 XQ⁹SKHYDREX-DIAGNOSE™ — Hydro Ontological Diagnostic Layer

Classification: Systems Engineering Layer

Function: **XQ⁹SKHYDREX-DIAGNOSE™** is the ontological decision engine responsible for transforming environmental observations into executable remediation strategies. The module receives normalized sensing information from **XQ⁹SKHYDREX-SENSE™**, queries the **XQ⁵SKOS™** ontological kernel, performs semantic classification and engineering inference, and automatically determines the most appropriate remediation workflow.

Core Functions:

- Semantic normalization of environmental observations
- Water body classification
- Pollutant source identification
- Contaminant profile analysis
- Risk assessment
- Selection of remediation protocol
- Selection of treatment strategy
- Operational planning
- Generation of remediation instructions
- Dispatch of execution commands to BIO, CHEM, AQUA and future modules

Output: The output of **XQ⁹SKHYDREX-DIAGNOSE™** consists of a digitally signed remediation instruction containing the selected protocol, operational parameters, verification requirements, and execution sequence, ensuring deterministic behavior throughout the remediation process.

4.6 XQ⁹SKHYDREX-VERIFY™ — Environmental Verification Layer

Classification: Systems Engineering Layer

Function: Immutable physical audit of each depollution intervention

Verification Flow:

DEPOLLUTION ACTION

- |
- |— Timestamp + GPS + signature record
- |— Pre-intervention SENSE reading
- |— Applied protocol parameters
- |— Post-intervention SENSE reading
- |— Intervention hash
- |— Verifiable public record

Purpose: Prove that the government executed depollution with measurable effectiveness. Public transparency, not a financial instrument.

4.6.1 Verification Evidence Package

Every verified intervention shall generate a standardized Evidence Package, permanently linked to the corresponding Hydro Digital Object™ (HDO).

Mandatory Components:

- **Sensor Dataset:** Complete pre-, during-, and post-intervention measurements
- **Equipment Identification:** Physical module and instrumentation identifiers
- **Firmware Version:** Embedded software version
- **Protocol Version:** Executed remediation protocol revision
- **Calibration Records:** Sensor calibration status
- **GPS Coordinates:** Spatial verification
- **UTC Timestamp:** Temporal verification
- **Digital Signature:** Operator authentication
- **Integrity Digest:** Cryptographic integrity verification
- **Photographic Evidence:** Images captured during intervention (when applicable)
- **Laboratory Reports:** Analytical validation (when applicable)
- **Supporting Documents:** Additional technical evidence

The Evidence Package constitutes an integral part of the **Hydro Digital Object™** and preserves the complete technical evidence chain associated with each remediation operation.

4.7 XQ⁹SKHYDREX-REGISTRY™ — Hydro Intervention Registry™ (HIR)

Official Registry of Hydro-Environmental Interventions

Classification: Official Technical Registry, Auditable and Immutable. Systems Engineering Layer.

4.7.1 Objective

The Hydro Intervention Registry™ (HIR) constitutes the official registry of all interventions executed by the **XQ⁹SKHYDREX™** system. Each completed intervention generates a **Hydro Digital Object™** (HDO), considered an Immutable Auditable Digital Object, containing all technical evidence of the operation performed. The HDO establishes complete intervention traceability, enabling technical audit, chain of custody, integration between sovereign systems, and permanent preservation of environmental record integrity.

4.7.2 Hydro Digital Object™ (HDO) Structure

A. Record Identification

- **Registry ID:** Internal record identifier

- **Hydro Digital Object ID:** XQHDO://{COUNTRY}-{STATE}-{BASIN}-{SEGMENT}-{UTC}-{OBJECT_ID}
- **Date/Time (UTC):** ISO 8601
- **Schema Version:** Registry Specification Version
- **Status:** Preliminary · In Progress · Verified · Closed

B. Water Body Identification

- **Type:** River · Lake · Aquifer · Reservoir · Canal
- **Hydrographic Basin:** Basin Identifier
- **Segment:** Segment Identifier
- **Jurisdiction:** Sovereign State / Regional Authority
- **Water Body Class:** According to applicable regulation
- **Predominant Use:** Public Supply · Industrial · Agricultural · Environmental Protection · Navigation
- **Geographic Coordinates:** Latitude / Longitude (WGS84)

C. Pre-Intervention Environmental Condition

Physical Parameters: Temperature (°C), Turbidity (NTU), Electrical Conductivity (µS/cm), TDS (mg/L)

Chemical Parameters: pH, Dissolved Oxygen – DO (mg/L), ORP (mV), BOD (mg/L), COD (mg/L), Nitrate (mg/L), Phosphate (mg/L), Ammonia (mg/L), Total Organic Carbon (mg/L), Heavy Metals (per protocol)

Biological Parameters: Water Quality Index (WQI), Coliforms (when applicable), Bioindicators, Biomass, Microplastics (when applicable)

D. Remediation Protocol

- **Operational Protocol:** HNE Standard
- **Protocol Version:** Revision Identifier
- **Treatment Strategy:** Chemical · Biological · Hybrid
- **Operational Mode:** Continuous · Batch
- **Physical Module:** XQ⁹AS-AC⁹XHIDREX™
- **Executed Stages:** Chemical · Biological · Electrochemical · Mineralization
- **Total Operation Time:** hh:mm:ss
- **Processed Volume:** m³
- **Energy Consumed:** kWh
- **Operational Status:** Completed · Interrupted · Partial

E. Post-Intervention Environmental Condition

All parameters recorded in the pre-intervention stage are measured again after process completion, ensuring direct comparability between the initial and final states of the water body.

F. Performance Assessment

- **WQI Improvement:** Water Quality Index evolution
- **Turbidity Reduction:** Turbidity reduction
- **DO Recovery:** Dissolved Oxygen recovery
- **Contaminant Removal Efficiency:** Contaminant removal efficiency
- **Overall Treatment Efficiency:** Overall intervention efficiency

G. Audit and Verification

- **VERIFY-PRE:** Pre-operation verification
- **VERIFY-DURING:** During-operation verification
- **VERIFY-POST:** Post-operation verification
- **WatchLion™ Audit ID:** Audit identifier
- **Audit Timestamp:** Audit date/time
- **Verification Status:** Verified · Pending · Rejected
- **EOS Transaction ID:** MaindXQ12™ EOS platform record

H. Chain of Custody

- **Competent Authority:** Environmental Authority
- **Technical Responsible:** Professional Registration
- **System Operator:** Operator Identifier
- **Digital Signature:** Digital Signature
- **Integrity Digest:** Current cryptographic algorithm
- **Record Integrity:** Verified

4.7.3 Digital Record Classification

Each **Hydro Digital Object™** (HDO) constitutes a permanent digital record of the **MaindXQ12™** EOS ecosystem, maintaining continuous linkage with the monitored water body, its audit chain, the executed protocols, and the official records produced throughout the entire operational cycle.

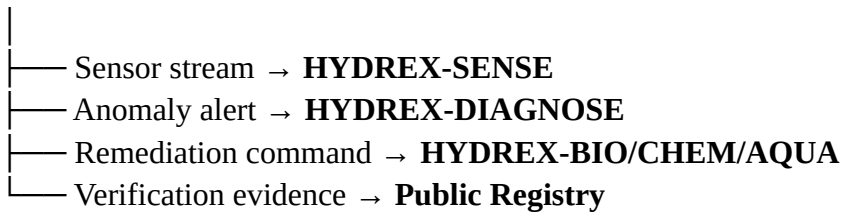
4.7.4 Interoperability

The **Hydro Digital Object™** may be serialized in different computational formats for system interoperability, including JSON, XML, Protocol Buffers, CBOR, or other equivalent formats. All formats shall fully preserve the semantic structure, traceability, cryptographic integrity, and compatibility with the **WatchLion™**, **MaindXQ12™** EOS, and **XQ5SKOS™** ecosystem, ensuring consistency between computational representation and official technical record.

CHAPTER 5: WATCHLION™ INTEGRATION

5.1 Data Flow

WATCHLION™



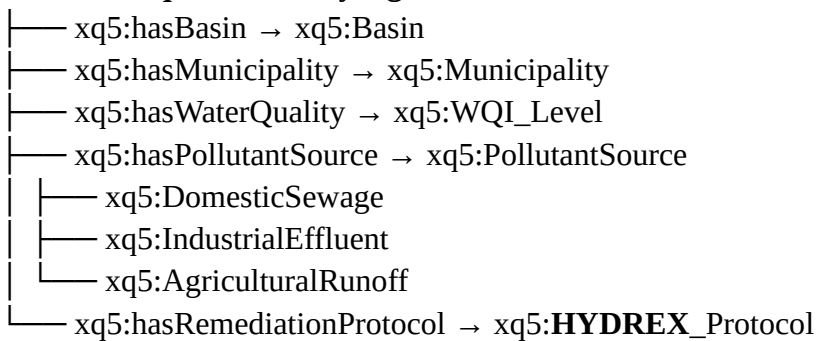
5.2 Communication Topics

- **watchlion/sensor/water/{id}/telemetry**: Raw water quality data
 - **watchlion/alert/anomaly/{severity}**: Degradation alert detected
 - **watchlion/command/remediate/{target}**: Signed depollution order
 - **watchlion/verify/intervention/{id}**: Verifiable intervention record
-

CHAPTER 6: XQ5SKOS™ KERNEL INTEGRATION

6.1 Water Body Ontology

owl:Class xq5:WaterBodySegment



6.2 Inference Engine

XQ5 RULE:

IF pollutant.type = "TextileDye" AND water.turbidity > 100 NTU AND [water.pH](#) < 6.0

THEN RECOMMEND **HYDREX_Protocol** = "HNE-TXT-03"

WITH stages = [CHEM-EC, BIO-MBBR]

WITH verification = [VERIFY-PRE, VERIFY-DURING, VERIFY-POST]

CHAPTER 7: XQ⁹SKHYDREX-MIN™ — GEOCHEMICAL STABILIZATION LAYER (ETG)

7.1 XQ⁹SKHYDREX-MIN™ — Geochemical Stabilization Layer (ETG)

Classification: Chemical Engineering and Process Physical Engineering Module (Waste Transformation Layer).

Function: To execute the thermochemical conversion and controlled stabilization of solid residues, sludge, and precipitated contaminants derived from water remediation processes (BIO, CHEM) into a Stable Mineral Matrix (SMM).

Technical Foundation: The process operates through the application of controlled chemical thermodynamics to convert environmental liabilities (sludge, precipitates, and retained contaminants) into stable mineral structures, preventing the re-mobilization of contaminants into the ecosystem. The resulting Stable Mineral Matrix (SMM) consolidates the waste into an inert, non-leachable solid suitable for safe disposal or reuse.

Note: This module is distinct from dedicated CO₂ mineralization engines.

Any carbonate precipitation occurring within the TRC is a secondary geochemical stabilization pathway, not the primary function of this layer.

7.1.1 Reaction Architecture

The XQ⁹SKHYDREX-MIN™ module consists of the following operational interfaces:

- **Waste Ingestion Interface:** Phase transfer module (liquid-solid) receiving sludge and precipitated residues from BIO and CHEM remediation stages.
- **Thermochemical Reaction Chamber (TRC):** Physical containment unit with atmosphere and temperature control, designed for the thermochemical stabilization of organic and inorganic waste matter.
- **Geochemical Stabilization System (GSS):** Unit responsible for the final transformation of the remaining reactive fractions into Stable Mineral Matrix (SMM).
- **SMM Extraction Interface:** Exit port for the resulting solid byproduct, consolidated as inert mineral material for reuse or environmentally safe deposition.

7.1.2 Scientific Sovereignty and Process Specification

The operational configuration of the TRC (temperature, residence time, catalytic agents, and additives) is not fixed, being defined by Local Scientific Protocols (LSP).

- **LSP Development:** The sovereign scientific research of each jurisdiction shall determine the optimal thermodynamic parameters, given the geological specificity and the composition of local waste.
- **Ontological Integration:** The XQ⁵SKOSTTM Inference Engine provides the automation framework so that LSPs, once validated and integrated into the system, are executed deterministically, ensuring the traceability of the conversion.

7.1.3 Mass and Transformation Audit

Each operational cycle of the XQ⁹SKHYDREX-MINTM module must generate an audit record linked to the Hydro Digital ObjectTM (HDO):

- **Input:** Identification and mass/volume of sludge and precipitated residues received from BIO and CHEM modules.
- **Process:** Operational parameters of the TRC (Temperature, Pressure, Duration).
- **Output:** Mass and chemical classification of the generated Stable Mineral Matrix (SMM).
- **Mass Balance:** Rigorous verification of the conversion index of environmental liability into inert byproduct.

CHAPTER 8: REFERENCE DIMENSIONING

8.1 WWTP Effluent in Critical Water Body

Premise: Treatment of wastewater treatment plant (WWTP) effluent discharging into a Class 3 or 4 water body, prior to in-situ remediation.

- **WWTP effluent flow (medium size):** 2.5 m³/s
- **Average effluent BOD₅:** 45 mg/L
- **Daily organic load:** 9,720 kg BOD/day
- **MBBR retention time:** 6 hours
- **Bioreactor volume:** 54,000 m³
- **Configuration:** 2 tanks of 27,000 m³ each, parallel operation

Note: Dimensioning scales according to effluent flow. The water body flow is not treated in its entirety. In-situ remediation (AQUA) operates through reactive barriers and induced circulation, not by total flow confinement.

8.2 Energy Balance

- **Electrocoagulation:** 0.4 - 0.8 kWh/m³
- **Advanced oxidation:** 0.3 - 1.0 kWh/m³
- **MBBR aeration:** 0.2 - 0.5 kWh/m³

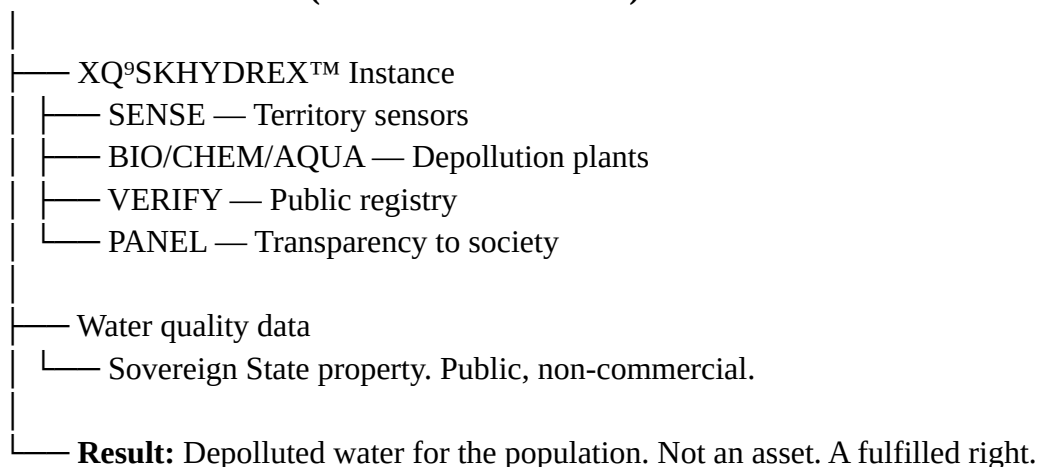
- **Photocatalysis:** 0.1 - 0.3 kWh/m³
- **Polishing:** 0.05 - 0.1 kWh/m³
- **Total:** 1.05 - 2.7 kWh/m³

Reference: Seawater reverse osmosis consumes 3-7 kWh/m³. Direct competitor technology for effluents (activated carbon + UV): 0.5-1.5 kWh/m³. HYDREX is competitive in the upper application range for complex effluents.

CHAPTER 9: SOVEREIGN DEPLOYMENT ARCHITECTURE

9.1 Deployment Model per Sovereign State

SOVEREIGN STATE (ANY JURISDICTION)



Sovereign states operate independent instances. The ontology federation (XQ⁵) enables interoperability without transferring sovereignty over raw data.

9.2 Data Sovereignty

- **Raw sensor data:** Sovereign State — Public environmental management
 - **Remediation records:** Sovereign State — Transparency and audit
 - **Verification evidence:** Public — Societal oversight
 - **Shared ontologies:** Federation (XQ⁵) — Interoperability between sovereign states and jurisdictions
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CHAPTER 10: TERRITORIAL APPLICATION MODELS

10.1 Water Body Typologies and Approach

TYPOLGY A — Multi-Jurisdictional River: Water body crossing multiple municipalities, states, or countries.

Approach: SENSE instances distributed by segment. Each jurisdiction operates its remediation node. VERIFY unifies the evidence chain. Protocol selected per segment according to predominant pollutant source.

TPOLOGY B — Local Water Body: River or lake supplying a single municipality or jurisdiction.

Approach: Concentrated SENSE instance. Centralized remediation. A single jurisdiction operates the entire depollution cycle.

TPOLOGY C — Shared Aquifer: Groundwater under multiple jurisdictions.

Approach: AQUA operates with reactive barriers and pump-and-treat. Federated coordination via XQ⁵ among states sharing the aquifer.

TPOLOGY D — Transboundary Basin: River crossing national borders.

Approach: Each sovereign state operates its HYDREX instance. XQ⁵ ontology shares anonymized metadata. VERIFY records each country's interventions with sovereignty over its data.

10.2 Reference Proof of Concept

- **Water body:** Multi-jurisdictional river segment Class 3/4
- **Pilot segment length:** 10 km
- **SENSE points:** 5 points with 12 parameters each
- **Remediation:** 1 CHEM node + 1 BIO node
- **Validation duration:** 3 months
- **Goal:** Elevate WQI by 2 levels

10.3 Degradation Scenarios and Response

- **Multiple quality levels along the length:** SENSE monitors each segment individually
- **Need for automated diagnosis:** DIAGNOSE queries XQ⁵ ontology and selects protocol per segment
- **Soil contamination by polluted water:** AQUA interrupts the water-soil cycle in the liquid phase
- **Treatment must be differentiated by source:** BIO + CHEM + AQUA in cascade with specific protocols
- **Need for continuous public evidence:** VERIFY generates public record for each intervention

CHAPTER 11: FAILSAFE PROTOCOL

11.1 Failure Behavior

- **SENSE — Sensor failure:** 3 sensors per point with majority voting. Alert if 2/3 disagree.
- **SENSE — Communication loss:** Local buffer with retransmission. Data not lost.
- **DIAGNOSE — XQ⁵ ontology unavailable:** Fallback to pre-approved conservative protocol.
- **BIO/CHEM/AQUA — Critical parameters absent:** Safe shutdown with bypass. No action without data.

- **VERIFY — Registration failure:** Offline storage with synchronization upon restoration.
 - **General — Power failure:** Local UPS + generator. Safe state maintained.
-

CHAPTER 12: XQ⁹AS-AC⁹XHIDREX™ — Advanced Structural & Aquatic Core

12.0 Information Security Classification

The engineering documentation associated with **XQ⁹AS-AC⁹XHIDREX™** shall be classified according to the Intellectual Property Protection Policy of the **MaindXQ12™** ecosystem.

Classification Levels:

- **Public:** General system architecture and operational concepts.
- **Controlled:** Functional specifications and integration interfaces.
- **Restricted Intellectual Property:** Physical architecture, reaction chambers, hydraulic configurations, electromechanical assemblies, constructive parameters, engineering materials, embedded algorithms, manufacturing specifications, and proprietary operational processes.

Access Control: Documentation classified as Restricted Intellectual Property shall be accessible only to authorized engineering personnel under applicable confidentiality and intellectual property protection agreements. Unauthorized disclosure, reproduction, reverse engineering, or redistribution of restricted technical information is outside the scope of this public technical specification.

12.1 Classification: Physical Remediation Core Architecture™

12.2 Nature: Proprietary physical infrastructure designed for the execution of hydro-environmental remediation processes of **XQ⁹SKHYDREX™**.

12.3 Purpose: This section describes the existence of the physical architecture responsible for system operation. The constructive parameters, geometries, materials, reaction chambers, motors, electromechanical components, hydraulic arrangements, circulation systems, internal processing mechanisms, and other engineering specifications constitute Confidential Intellectual Property (IP) and are not disclosed in this document.

12.4 General Components

- **Modular physical structure:** Physical base of the remediation engine
- **Technical compartments:** Segregated areas for each treatment stage
- **Environmental sensor interface:** Connection to **XQ⁹SKHYDREX-SENSE™**
- **Electromechanical systems interface:** Pumps, valves, actuators, controllers
- **Reaction module interface:** BIO, CHEM, AQUA, MIN
- **Hydraulic units interface:** Flow, pressure, flow rate, recirculation
- **XQ⁵SKOS™ Kernel communication interface:** Ontological instructions → physical actions
- **WatchLion™ integration interface:** Observability and command

- **Physical audit interface:** VERIFY — material evidence of remediation

12.5 Intellectual Property Protection

The internal architecture of the **XQ⁹AS-AC⁹XHIDREX™** module integrates the protected technological asset portfolio of the **MaindXQ12™ EOS** platform. Specifications regarding reaction chambers, motors, actuators, internal geometries, hydraulic flow, physicochemical processes, biological processes, mineralization systems, structural components, engineering materials, embedded control algorithms, and electromechanical architecture remain classified as Confidential Technical Information (Confidential Intellectual Property – IP), made available only in restricted technical documentation.

12.6 Systemic Integration

XQ⁹AS-AC⁹XHIDREX™ operates as the physical operational core of **XQ⁹SKHYDREX™**, executing the processes determined by the intelligence, monitoring, audit, and control layers of **MaindXQ12 EOS Ecosystem™**.

XQ⁹SKHYDREX™ (Water Intelligence)

|
| Remediation instructions



XQ⁹AS-AC⁹XHIDREX™ (Physical Core)

|
| Physical execution of processes



POTABLE WATER / SAFE REUSE WATER

DOCUMENT SIGNATURE

Document: XQ⁹SKHYDREX™ Technical Architecture Specification

Version: 12.0 — Consolidated Foundational Technical Specification

Date: 2026-06-27

Status: Final reference version

Systemic Category: Hydro-Environmental Intelligence & Remediation Engine™

Position: Water Submodule of XQ⁹ (Critical Utilities Infrastructure, MaindXQ12™ EOS) — Water Intelligence Layer between WatchLion™ and MaindXQ12™ EOS

Dependencies: WatchLion™ (observability), XQ⁵SKOS™ (ontological kernel), MaindXQ12™ (EOS)

Physical Core: XQ⁹AS-AC⁹XHIDREX™ — Advanced Structural & Aquatic Core

Official Registry: XQ⁹SKHYDREX-REGISTRY™ — Hydro Intervention Registry™ (HIR)

Domains: Physical Engineering + Chemical Engineering + Systems Engineering

Purpose: Public policy for water remediation and restoration. Sovereign government function.

Destination: Potable water or safe reuse water

Data ownership: Sovereign State. Public records for transparency.

IP Protection: Constructive specifications of the physical core are Confidential IP
Security Classification: Public · Controlled · Restricted Intellectual Property

XQ⁹SKHYDREX™ is a licensed governmental technology framework designed to execute, verify, and record water body remediation and restoration processes. It operates on Physical Engineering, Chemical Engineering, and Systems Engineering. Recovered water supports public environmental and water security outcomes.

LEGAL ANNEX: OWNERSHIP, AUTHORSHIP AND INTELLECTUAL PROPERTY

1. Ownership and Copyright Declaration

The XQ⁹SKHYDREX™ (Hybrid Hydro Remediation & Environmental Recovery Engine™) system, including its systemic architecture, ontological intelligence, remediation mechanisms, Hydro Intervention Registry™ (HIR), and the proprietary physical infrastructure core **XQ⁹AS-AC⁹XHIDREX™**, constitutes a proprietary technological architecture and associated technological asset portfolio under the exclusive ownership of Maind International™, encompassing its physical, logical, scientific, documentary, and operational components.

Such ownership applies exclusively to the technological architecture and associated intellectual assets and does not extend to sovereign operational data generated by licensed jurisdictions, which shall remain subject to the ownership rules defined within the **XQ⁹SKHYDREX™** governance framework.

Foundational Intellectual, Scientific and Architectural Author: Anderson José Colaço de Freitas

Holder of Economic Rights and Commercial Exploitation Rights: Maind International™

Economic rights associated with commercial exploitation, institutional implementation, derivative development, licensing, distribution, operational deployment, and all other forms of utilization of the present technology are exclusively assigned to or vested in Maind International™, in accordance with applicable legal instruments.

2. Research, Development and Technological Validation

The complete scientific research foundation, development of physicochemical processes, mineralization algorithms, electroactive biofilm structures, and hybrid remediation mechanisms associated with **XQ⁹SKHYDREX™** have been conceived, developed, and subjected to internal modeling, testing, and technical-scientific validation procedures conducted by the **Maind Neural Carbon Mineralization Laboratory™**.

The laboratory acts as the technical-scientific entity responsible for maintaining architectural functional integrity, defining engineering operational parameters, and supporting the methodological validation established within Version 12.0 of this Consolidated Foundational Technical Specification.

3. Trade Secret Protection and Restricted Intellectual Property

As established in Chapter 12 of this Consolidated Foundational Technical Specification, construction specifications, hydraulic arrangements, reaction chamber geometries, embedded algorithms, execution methodologies, systemic interactions, and associated operational mechanisms related to the **MaindXQ12™ EOS and XQ5SKOS™** ecosystem constitute Confidential Intellectual Property and Protected Trade Secrets of Maind International™.

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4. Documentary Integrity and Foundational Binding

This legal annex shall integrate the **XQ9SKHYDREX™** Consolidated Foundational Technical Specification and all subsequent revisions thereof, preserving historical traceability and documentary continuity. This annex constitutes a formal record of authorship, technological origin, and institutional association related to the technology described herein. Anderson José Colaço de Freitas, **Maind International™**, and **Maind Neural Carbon Mineralization Laboratory™** are recognized as originating entities and holders of rights associated with the conception, development, and technological exploitation of the present system.

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7. Technological Continuity and Derivative Architecture Protection

Any future evolution, modular expansion, functional adaptation, architectural revision, technological enhancement, or development of additional components associated with the **XQ⁹SKHYDREX™** ecosystem, including future modules, computational engines, physicochemical processes, ontological systems, semantic structures, inference mechanisms, artificial intelligence models, machine learning systems, semantic inference engines, computational decision frameworks, and integrated operational layers, shall be considered derivative or associated technological developments whenever substantial architectural, methodological, ontological, computational, or operational continuity with the original system can be demonstrated, and shall remain associated with the intellectual property rights established by the present foundational structure.

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