



AI SUMMARY

# Geomembrane Baffle Curtains to Enhance Water and Wastewater Treatment

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## Executive Summary

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Water and wastewater treatment infrastructure depends critically on hydraulic efficiency — the ability of a treatment system to expose every molecule of water to the required disinfectant, settling time, or biological process for a sufficient duration. In real-world tanks, lagoons, reservoirs, and ponds, this ideal is frequently undermined by a phenomenon known as hydraulic short-circuiting: water finds the fastest path from inlet to outlet, bypassing the bulk of the treatment volume and leaving large stagnant dead zones untreated.

Geomembrane baffle curtains represent an elegant, cost-effective, and proven engineering solution to this problem. By physically partitioning water bodies into defined flow corridors, baffle curtains force water to travel a longer, more controlled serpentine path, dramatically increasing hydraulic detention time and improving treatment performance without requiring costly infrastructure expansion or chemical overdosing.

This document presents a comprehensive technical overview of geomembrane baffle curtain technology, drawn from an expert webinar presented by Brian Frasier (Vice President, Layfield) and Justin Gouthreau (Group Manager, Engineering Business Management, Layfield). It covers the fundamental hydraulic principles behind baffle systems, the two primary baffle configurations (fixed mechanical and floating), engineering design considerations, geomembrane material science, factory fabrication processes, installation methods and safety protocols, operations and maintenance best practices, and real-world project case studies spanning potable water, industrial wastewater, mining, and agricultural applications across North America.

### Key Takeaway for Engineers & Students

Baffle curtains are not passive dividers — they are precision-engineered hydraulic control structures. Their design requires integrated consideration of fluid dynamics, structural

engineering, material science, chemical compatibility, environmental exposure, and constructability. Mastery of this technology opens applications across nearly every sector of water infrastructure.

## 1. Hydraulic Fundamentals: Why Baffles Matter

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### 1.1 The Problem of Hydraulic Short-Circuiting

Any engineer who has studied open-channel or tank hydraulics will recognize the core problem: in an unpartitioned rectangular tank or pond, the inlet flow jet tends to travel directly toward the outlet along the path of least resistance. This short-circuit flow means that a significant fraction of influent water exits the system with a hydraulic residence time far shorter than the theoretical detention time (volume divided by flow rate). The consequences are serious and wide-ranging:

- Disinfection failure — chlorine or ozone contact time is insufficient to inactivate pathogens to regulatory standards.
- Poor solids removal — suspended solids do not have enough time to settle before the water exits.
- Inefficient biological treatment — bacteria in aeration lagoons cannot process BOD or COD before short-circuited water leaves the system.
- Dead zones — portions of the tank become stagnant, promoting anaerobic conditions, odor, and algae growth.
- Chemical overdosing — operators compensate for poor contact time by increasing chemical dosages, raising operating costs and chemical byproduct risk.

### 1.2 Serpentine Flow and the Baffle Solution

Baffle curtains solve short-circuiting by subdividing a pond or tank into a series of sequential cells connected by flow-through openings (windows) positioned alternately at opposite ends of each partition. The result is a serpentine or plug-flow hydraulic regime in which the entire water volume must traverse the full length of each cell before progressing to the next. This achieves several simultaneous benefits:

- Hydraulic detention time (HDT) approaches the theoretical value, maximizing treatment efficacy.
- Flow velocity is reduced and distributed more uniformly, promoting particle settling.
- Chemical contact is extended, allowing lower dosing rates for equivalent disinfection outcomes.
- Dead zones are eliminated or minimized, improving overall volumetric utilization of the tank.
- Existing infrastructure can be retrofitted to meet upgraded treatment standards without physical expansion.

The hydraulic improvement is quantified using the  $t_{10}/T$  ratio — the ratio of the time at which 10% of a tracer has passed through the tank ( $t_{10}$ ) to the theoretical hydraulic detention time ( $T$ ). A value approaching 1.0 indicates near plug-flow conditions. Properly designed baffle systems can raise this ratio from as low as 0.1 (in an unbaffled tank) to 0.5 or higher, a fivefold improvement in effective contact time.

## 1.3 Common Applications

Application Type	Purpose of Baffle System
Municipal water treatment — chlorination tanks	Ensure regulatory CT (concentration × time) compliance for pathogen inactivation
Underground potable water clear wells	Manage flow, extend disinfectant contact, prevent stagnation
Above-ground open reservoirs	Control short-circuiting in large, low-velocity storage volumes
Wastewater stabilization lagoons	Enhance BOD/COD removal in secondary biological treatment
Industrial aeration ponds	Optimize aerator placement and prevent bypassing of treatment zones
Mining sedimentation ponds	Increase particle residence time and maximize suspended solids removal
Agricultural & food processing lagoons	Separate fats, oils and greases; improve effluent quality
Equalization basins	Dampen flow and load fluctuations before downstream treatment

## 2. Baffle Curtain Types: Fixed vs. Floating

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### 2.1 Fixed (Mechanically Attached) Baffle Curtains

Fixed baffle curtains are permanently anchored to the structural elements of the tank — floors, walls, and ceilings. They constitute a rigid, non-adjustable partition system and are designed as permanent infrastructure. The mechanical attachments typically consist of stainless steel bar and gasket assemblies secured with wedge anchors drilled and grouted into the concrete substrate at intervals calculated to distribute hydraulic and wind loading.

#### *Key Structural Features*

- Attachment hardware: stainless steel flat bar, angle bar, wedge anchors, and EPDM gasket to create a compression seal preventing bypass flow.
- Open-end vertical support: where a curtain terminates mid-span (not against a wall), two angle bars are placed back-to-back, sandwiching the reinforced curtain edge and preventing pull-through.
- Ceiling suspension: in tanks with irregular overhead geometry (capitals, beams, columns), curtains can be hung from the ceiling on stainless steel cable systems — functionally resembling a heavy-duty industrial shower curtain.
- Penetration boots: where pipes, conduits, or mechanical equipment penetrate the curtain, custom-fabricated boots are welded over each penetration and seam-tested for watertightness.
- Flow-through windows: reinforced cut-out openings in the curtain, typically with a welded perimeter hem, allow controlled passage of flow from one cell to the next.

Fixed baffles are the preferred solution for underground concrete clear wells, enclosed chlorination tanks, and any application requiring precise dimensional control. They are installed in empty tanks and must be engineered to withstand hydrostatic loads as the tank is progressively filled — the filling rate must be controlled to avoid over-stressing the curtain during commissioning.

## 2.2 Floating Baffle Curtains

Floating baffle curtains are suspended vertically from a flotation element — typically encapsulated closed-cell polyethylene foam (e.g., Ethafoam) or sealed HDPE/PVC pipe floats — welded into the upper hem of the curtain. The curtain hangs by gravity and is ballasted at the bottom with heavy chain (stainless steel or galvanized), stainless steel bar, sand tubes, or percussion-driven bottom anchors to maintain vertical orientation.

### *Key Structural Features*

- Flotation sizing: the volume of foam directly governs curtain depth. Larger ponds requiring deeper curtains demand proportionally larger float sections; engineers calculate buoyancy requirements based on curtain weight, ballast weight, and hydrodynamic drag loads.
- Ballast: heavyweight chain installed along the bottom hem maintains downward tension, preventing the curtain from being lifted or billowing under wave action.
- Load lines and anchor lines: stainless steel cable assemblies located just beneath the float provide lateral tensioning and connect adjacent curtain panels into a continuous string.
- Furling lines (pearling strings): nylon ropes woven into the curtain structure allow operators to reef (roll up) the curtain for transport and controlled deployment, and to adjust effective curtain depth during operation.
- Intermediate anchors: percussion-driven or helical anchors placed at 50-foot intervals along the curtain string prevent lateral drift and maintain alignment under wind and current loading.
- Shoreline anchors: cast-in-place eyebolts, stacked lock blocks, or percussion spikes anchor the terminal ends of each curtain string to the pond embankment.

The critical advantage of floating systems is their ability to be installed and adjusted in a fully operational pond — no dewatering is required. This minimizes treatment downtime and makes them ideal for retrofit applications in large lagoons, mining ponds, and agricultural waste ponds where taking the basin offline is operationally or economically prohibitive.

### **Engineering Note: Float Size and Curtain Depth**

The relationship between flotation volume and curtain depth is non-linear when hydrodynamic drag is considered. In large open ponds subject to wind-driven waves and currents, the flotation system must overcome not only the submerged weight of the curtain and ballast but also the lateral force components transferred through the ballast chain and anchor lines. Designers should account for dynamic loading in exposed installations.

## 3. Engineering Design Considerations

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### 3.1 Hydraulic Performance Analysis

The starting point for any baffle curtain design is a hydraulic analysis of the existing or proposed tank geometry. The designer must determine the optimal number, spacing, and orientation of baffle panels to achieve the target  $t_{10}/T$  ratio while maintaining acceptable head loss across each baffle. Flow-through window sizing is particularly important: windows that are too small create excessive head loss and velocity jets; windows that are too large allow significant short-circuiting around the baffle edge.

Computational fluid dynamics (CFD) modeling is increasingly used for complex geometries, but simplified analytical methods based on plug-flow reactor theory remain valid for standard rectangular tanks. Tracer studies (using fluorescent dye or conductivity tracers) are the gold standard for validating hydraulic performance after installation.

### 3.2 Structural Load Analysis

Fixed baffle curtains impose loads on the host structure that must be carefully evaluated, particularly in aging water infrastructure where the original concrete may be deteriorated or where original design drawings are unavailable. The primary structural loads include:

- Hydrostatic differential pressure: when the water level differs on each side of the baffle (as occurs during filling or drawdown), the resulting net pressure load is transmitted through the mechanical attachments to the floor, wall, and ceiling.
- Commissioning loads: during initial filling of a previously empty baffled tank, the curtain may be exposed to its maximum hydrostatic differential load. The filling rate must be engineered to limit this transient load.
- Seismic and dynamic loads: in seismically active regions, sloshing (seiching) during earthquake events can impose large impulsive loads on internal baffle structures.
- Lateral cable loads: where open-end curtains are tensioned with lateral cables tied back to the tank walls, the wall must be checked for the resulting anchor forces.

### 3.3 Floating Baffle Environmental Loads

Floating curtain systems in open ponds are exposed to meteorological and operational loads that fixed systems in enclosed tanks are not. The designer must evaluate:

- Wind pressure: calculated per applicable building codes (e.g., ASCE 7 in North America) using site-specific design wind speed and exposure category.
- Wave action: in ponds with significant fetch, wind-generated waves create oscillating hydrodynamic pressure on the submerged curtain face.
- Water level variation: the curtain and its anchor system must accommodate the full range of operating water levels, including drought drawdown and storm surge, without grounding, lifting, or over-tensioning.
- Freeze-thaw cycling: in cold climates (e.g., Alberta, Canada, where installations have endured  $-40^{\circ}\text{F}$  winters), the flotation foam, geomembrane material, and all metallic hardware must be rated for repeated thermal cycling without embrittlement or fatigue failure.

- UV exposure: for open-top floating installations, cumulative UV radiation degrades polymer chains over the design service life; material UV stabilization must be verified for the project's latitude and expected lifespan.

### 3.4 Maintenance Access Planning

An often-overlooked aspect of baffle curtain engineering is designing for maintainability. The design team should address the following questions at the outset of the project:

- How will inspection personnel access each cell of the baffled system? Will confined space entry procedures apply?
- Are wash-down access doors or short-circuit panels required to allow personnel to move between cells without circumnavigating the entire baffle string?
- What is the anticipated frequency of inspections, and what tools and equipment will inspectors need to bring into the confined space?
- How will baffle repairs be made if a section of the geomembrane is torn or a mechanical connection fails? Can individual panels be isolated and replaced without draining the entire tank?

## 4. Geomembrane Material Science

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### 4.1 Reinforced vs. Unreinforced Geomembranes

Geomembranes used in baffle curtain applications are almost exclusively reinforced — a laminated composite consisting of a high-tenacity woven polyester scrim encapsulated between two layers of polymer coating or calendered sheeting. This construction provides a fundamentally different performance profile from unreinforced sheet geomembranes:

Property	Reinforced vs. Unreinforced
Tensile Break Strength	Reinforced: very high (scrim governs). Unreinforced: polymer-limited, significantly lower.
Tear Resistance	Reinforced: scrim arrests propagation. Unreinforced: tears propagate easily.
Elongation at Break	Reinforced: lower (5–15%). Unreinforced: high (>300% for HDPE).
Thickness Uniformity	Reinforced: excellent. Unreinforced: variable in calendered products.
Puncture Resistance	Reinforced: excellent. Unreinforced: moderate.
Fabricability (Welding)	Both weldable; thermoplastic coatings required for thermal welding.
Creep Resistance	Reinforced: very good (scrim limits creep). Unreinforced: polymer-dependent.

### 4.2 Standard Polymer Systems for Baffle Curtains

Four reinforced geomembrane polymer systems dominate the baffle curtain market. Each has a distinct chemistry and performance profile suited to specific treatment environments:

#### ***Reinforced EIA (Ethylene Interpolymer Alloy)***

The most widely used material in modern baffle curtain applications. EIA is a blend of PVC with an ethylene interpolymer alloy additive that improves flexibility, low-temperature performance, and long-term plasticizer retention compared to standard PVC. EIA offers excellent resistance to chlorine and chloramine at the concentrations used in water treatment, good UV stability in exposed applications, and full NSF-61 certification for potable water contact. It is thermally weldable by hot wedge, hot air, and high-frequency (dielectric) welding.

#### ***Reinforced CSP (Chlorosulfonated Polyethylene — formerly Hypalon)***

CSP is a synthetic rubber polymer offering outstanding resistance to oxidizing chemicals, ozone, and UV radiation. It is the material of choice for ozone disinfection applications and for steel tank installations where aggressive chemical environments are anticipated. CSP is typically bonded with adhesive systems or dielectric welded; its higher cost is justified in demanding chemical service conditions.

#### ***Reinforced LLDPE (Linear Low-Density Polyethylene)***

LLDPE reinforced sheeting provides excellent chemical resistance across a broad range, including many acids, bases, and hydrocarbons. It is particularly suited to industrial wastewater and mining applications where the influent chemistry is aggressive or variable. Welding is accomplished by hot wedge or extrusion welding; high-frequency welding is not applicable to polyolefin materials.

#### ***Reinforced Polypropylene (PP)***

Polypropylene offers the highest chemical resistance of the four standard systems, with particular strength against strong acids and oxidizers. It is stiffer at low temperatures than EIA or CSP, which must be considered in cold-climate applications. Like LLDPE, it is welded by hot wedge or extrusion methods.

### **4.3 Chemical Compatibility: The Critical Importance of Chlorine Resistance**

Chlorine — whether as free chlorine (hypochlorous acid/hypochlorite), chloramine (combined chlorine), or gaseous chlorine — is a powerful oxidizer that attacks the antioxidant packages incorporated into most geomembrane polymers. Long-term immersion in chlorinated water at treatment concentrations (0.5–4 mg/L free chlorine residual) can degrade polymer chains, causing embrittlement, cracking, and loss of tensile strength over time. EIA and CSP have demonstrated the best long-term chlorine resistance among standard geomembrane materials; HDPE, while chemically inert to many substances, is vulnerable to chlorine-induced oxidative degradation at elevated temperatures.

For ozone disinfection applications (increasingly common as a chlorine alternative), CSP is the preferred choice, as EIA has limited resistance to ozone at the high concentrations used in ozone contact chambers.

### **4.4 NSF/ANSI 61 Certification for Potable Water**

Any geomembrane material that will be in direct contact with drinking water in the United States and Canada must be certified under NSF/ANSI Standard 61 — Drinking Water System Components. This standard requires rigorous testing for the extraction of potentially harmful chemicals from the

material into the water. Engineers specifying baffle curtains for potable water clear wells, treated water reservoirs, and chlorination tanks must verify that the specific product (not just the generic polymer type) holds a current NSF-61 certification for the intended application. This requirement applies equally to the geomembrane sheet, all welded seams, flotation foam, anchor hardware coatings, and gasket materials.

## 5. Factory Fabrication: Engineering Precision Before the Field

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### 5.1 The Case for Shop Fabrication

One of the most important — and frequently underappreciated — aspects of baffle curtain technology is that the vast majority of fabrication occurs in a controlled factory environment, not in the field. This distinction has profound implications for quality, safety, cost, and schedule. In a factory setting, skilled welders operate on flat, stable tables under consistent temperature and humidity, using precisely calibrated hot wedge welders, high-frequency (dielectric) welders, or extrusion welders. Quality control is systematic: every seam is destructively and non-destructively tested. Complex geometrical features — tapered bottom hems, integrated float pockets, reinforced window frames, ballast chain sheaths, cable tunnels — are fabricated with dimensional tolerances that cannot be achieved in the field.

### 5.2 Standard Factory Fabrication Operations

- Panel joining: individual geomembrane rolls (typically 6–12 feet wide) are seamed together to produce panels of the required baffle width. Both wedge welding and high-frequency welding are used, depending on polymer type.
- Bottom taper: the bottom hem of the curtain is cut and welded to follow the slope contour of the pond embankment, ensuring uniform bottom-of-curtain clearance along the full span.
- Float pocket fabrication: longitudinal pockets are welded at the upper hem to receive the closed-cell foam billet, which is then inserted, compressed, and sealed to create the integrated float.
- Ballast chain integration: heavyweight galvanized or stainless steel chain is threaded through the lower hem and secured at each end with custom-fabricated anchor lugs.
- Cable tunnel installation: stainless steel tensioning cables are routed through welded cable tunnels at mid-height and at the load line elevation, terminating in swaged cable fittings.
- Flow-through window fabrication: rectangular or custom-shaped cutouts are made at the specified elevation, and the perimeter of each window is reinforced with a welded geomembrane hem or a stainless steel batten strip to prevent tearing under flow-induced vibration.
- Furling line integration: nylon or polypropylene ropes are sewn or welded into the curtain body at regular intervals to enable accordion-folding for transport and deployment.
- Perimeter edge reinforcement: all free edges of the curtain — top, bottom, and vertical sides — are folded and welded to create a reinforced rope edge or bar pocket that distributes mechanical attachment loads and resists tearing.

### 5.3 Welding Methods

Method	Description and Applications
Hot Wedge (Thermal Fusion)	A heated wedge is drawn between two overlapping geomembrane sheets, simultaneously melting both contact surfaces. The melted surfaces are then pressed together under roller pressure. Produces a dual-track seam with a central air channel for non-destructive pressure testing. Applicable to EIA, PP, LLDPE, and CSP with compatible coatings.
Hot Air Welding	A focused stream of hot air melts the geomembrane surface ahead of a pressure roller. Used for detail work, patches, and smaller-scale seaming where a wedge welder cannot access. Applicable to EIA, PP, LLDPE.
High-Frequency (Dielectric) Welding	An electromagnetic field in the radio-frequency range (typically 27 MHz) is applied across the overlapping material, generating heat within the polar polymer molecules (PVC/EIA) and producing a fusion bond. Produces very clean, wide seams ideal for panel joining. Applicable to PVC/EIA and CSP only — not applicable to polyolefins (LLDPE, PP, HDPE).
Extrusion Welding	A ribbon of molten polymer is extruded onto the seam area while a hot air shoe pre-heats the substrate. Used primarily for thick HDPE and LLDPE geomembranes and for field repairs. Not commonly used in factory baffle fabrication except for patching.
Adhesive Bonding	Solvent-based or contact cements are used for CSP and certain specialty polymers. Seam quality is highly dependent on surface preparation and environmental conditions; used where thermal welding is not practicable.

## 6. Installation and Construction

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### 6.1 Fixed Baffle Installation

Installation of fixed baffle curtains in underground or enclosed tanks involves some of the most challenging construction conditions in the geosynthetics industry. The following sequence describes a typical fixed baffle installation:

- Tank dewatering and cleaning: the tank is fully drained, cleaned of sediment and biological growth, and ventilated. Confined space entry protocols — atmospheric monitoring, ventilation, communication systems, and rescue standby — are activated.
- Anchor layout and drilling: stainless steel wedge anchors are drilled and set in the concrete floor, walls, and ceiling at design spacings. In aging tanks, each anchor location may require hammer-sounding and visual inspection to identify and avoid delaminated or deteriorated concrete.
- Bar and gasket installation: stainless steel attachment bars and EPDM gaskets are positioned over the anchor bolts; the curtain is placed between the gasket and the bar; nuts are torqued to the specified preload.
- Scaffold and lifting systems: given that some curtains reach 20–30 feet in height, a combination of scissor lifts, scaffolding towers, and custom pulley systems are used to maneuver and hold panels in position during attachment.
- Field seaming: where panels cannot be pre-joined in the factory (typically at corners, penetrations, and irregular geometry), on-site wedge welding or hot air welding completes the seam. All field seams are tested.
- Penetration booting: all pipe, conduit, and mechanical equipment penetrations are custom-booted with fabricated geomembrane sleeves, welded in place and vacuum-box or air-pressure tested.
- Final inspection and testing: completed installation is inspected for mechanical attachment integrity, seam continuity, and penetration seal quality prior to tank refilling.

### 6.2 Floating Baffle Installation

Floating baffle installation involves a fundamentally different sequence — one that takes advantage of the pond's existing water as the installation medium:

- Shoreline layout: the pre-fabricated, furled curtain is transported to the pond edge and laid out flat on a prepared staging area. The accordion fold is checked for proper furling line placement.
- Shoreline anchor establishment: the terminal anchor point is established at the first shoreline, using cast-in-place eyelets, lock-block assemblies, or percussion-driven spikes as designed.
- Curtain launch and deployment: the leading end of the curtain is attached to the shoreline anchor. The furled curtain is progressively walked into the water — using boats, pontoons, or wading in shallow areas — while workers on shore pay out the furling lines to control the release of each accordion fold. Cranes or winches are used for heavy or long curtain strings.
- Intermediate anchor placement: as each curtain section is deployed, intermediate anchors are positioned and connected to the load lines at the design intervals. In deep ponds, a support boat positions anchors based on GPS coordinates.
- Opposite shoreline connection: the trailing end of the curtain is tensioned and secured to the opposite shoreline anchor.

- Alignment verification and adjustment: the deployed curtain is inspected from the water surface and, where possible, from below, to verify correct vertical orientation, consistent bottom clearance, and absence of twist or fouling.

### **6.3 Confined Space Safety**

Underground water infrastructure — clear wells, buried reservoirs, chlorination tanks — is universally classified as permit-required confined space under OSHA 29 CFR 1910.146 (USA) and equivalent Canadian and international regulations. The following safety requirements are non-negotiable on every such project:

- Atmospheric monitoring: continuous or pre-entry testing for oxygen content (minimum 19.5%), flammable gases (LEL <10%), and toxic gases (H<sub>2</sub>S, CO, chlorine) before and during all confined space work.
- Ventilation: forced-air mechanical ventilation is required throughout the work shift to maintain breathable air quality.
- Entry permit system: a written confined space entry permit must be completed, approved, and posted for every entry. The permit documents atmospheric conditions, hazard controls, entrants, attendants, and rescue arrangements.
- Rescue standby: a trained rescue team with appropriate equipment must be available during all confined space entry. Non-entry rescue systems (retrieval lines, tripods) are preferred wherever practicable.
- Fall protection: work at elevation within confined spaces — often unavoidable given the height of baffle curtains — requires full personal fall arrest systems or fall restraint systems anchored to engineered points.
- Supplementary lighting: underground tanks are dark; temporary high-output lighting systems must be deployed to illuminate all work areas to safe illuminance levels.

## 7. Operations, Maintenance, and Service Life

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### 7.1 Establishing an O&M Program

The service life of a geomembrane baffle curtain system — which can extend to 20 years or more with proper care — is directly dependent on the quality of the operations and maintenance program. The FGI has published an Operations Guideline for Geosynthetic-Lined Water Reservoirs that provides a comprehensive framework for O&M planning, documentation, and reporting. Key elements of a robust O&M program include:

- **Baseline documentation:** as-built drawings, material certifications, seam test records, and photographic documentation at the time of installation provide the baseline against which future inspection findings are assessed.
- **Scheduled inspection frequency:** annual inspections are the industry standard minimum. More frequent inspections may be required by the regulator or by the plant's own quality management system. Post-event inspections should be conducted after major storm events, seismic activity, or any operational upset that may have imposed unusual loads on the baffle system.
- **Inspection methodology:** visual inspection by qualified personnel is the primary tool. For submerged baffles in tanks that cannot be dewatered, trained commercial divers perform the inspection and report on condition using standardized checklists and underwater photography.
- **Defect classification and prioritization:** discovered defects (tears, wear points, loosened mechanical connections, corrosion of hardware) are classified by severity and assigned repair priority. Minor abrasion is monitored; seam separation or significant tearing requires prompt remediation.
- **Repair documentation:** all repairs are documented with photographs, location records, and material traceability to maintain a complete history of the installation.

### 7.2 Common Failure Modes and Prevention

Failure Mode	Prevention Strategy
Galvanic corrosion of mixed-metal hardware	Use all-stainless-steel hardware. Where stainless contacts dissimilar metal (e.g., steel tank), install non-metallic plastic insulators on all bolts, washers, and brackets.
Mechanical attachment loosening	Specify correct anchor embedment depth and torque values. Inspect and re-torque annually. Use nylon-insert locking nuts on vibrating connections.
Geomembrane UV degradation (exposed systems)	Specify material with documented UV stabilization package. Inspect for surface chalking, cracking, and embrittlement annually. Replace panels showing significant degradation before failure.
Chlorine-induced oxidative degradation	Select EIA or CSP for chlorinated applications. Avoid HDPE. Verify chemical resistance with manufacturer technical data.
Ballast chain corrosion (floating systems)	Use stainless steel or HDPE-coated galvanized chain. Inspect chain links for pitting and section loss during annual inspections.

Failure Mode	Prevention Strategy
Flow window edge tearing	Reinforce all window perimeters with welded geomembrane hem or stainless steel batten. Avoid sharp corners — radius all window openings.
Flotation foam degradation	Specify closed-cell PE foam with documented resistance to chlorine, UV, and freeze-thaw. Replace foam inserts showing permanent compression or disintegration.

## 8. Project Case Studies

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### 8.1 London, Ontario — Underground Potable Water Clear Well

This project involved the installation of 22 fixed baffle curtains in a large underground concrete clear well serving a municipal drinking water system. The curtains, each 28 feet tall, were cable-suspended from the ceiling and mechanically attached to the floor, producing a serpentine flow path through the full volume of the reservoir to extend chlorine contact time and achieve CT compliance. The confined space environment presented the primary construction challenge: scissor lifts, custom scaffolding, and pulley systems were required to maneuver and secure the 28-foot panels, all under strict fall protection protocols. The EIA geomembrane was selected for its NSF-61 certification and proven chlorine resistance.

### 8.2 Lloydminster, Alberta — Industrial Aeration Lagoon

A food processing facility required significant improvement in its wastewater lagoon treatment performance, specifically targeting the separation and removal of fats, oils, and greases (FOG). Layfield installed approximately 1,300 linear feet of floating EIA baffle curtains, dividing the lagoon into five separate treatment cells. The extreme climate of this region — seasonal temperatures ranging from -40°F in winter to over 90°F in summer — was a primary material selection driver. Concrete anchors spaced at 50-foot intervals managed the exceptional lateral loads on the long curtain spans. After more than 10 years in service, the curtains have performed reliably through multiple seasonal cycles, demonstrating the durability of reinforced EIA in harsh environmental conditions.

### 8.3 Quebec, Canada — Mine Water Sedimentation Pond

A mining operation needed to improve the treatment of mine-impacted water before reuse in operations, with a goal of maximizing solids settlement within a constrained footprint. Floating EIA baffle curtains divided the pond into three sequential sedimentation cells, substantially increasing particle residence time and reducing total suspended solids in the treated effluent. Key design drivers were low-pH mine water contact (requiring robust chemical resistance), long-term UV exposure (requiring demonstrated UV stabilization), and the need for installation without taking the pond out of service. The curtains — each 200 feet in length — were assembled on the shoreline and floated into position as a continuous string.

### 8.4 Bakersfield (Kern County), California — Municipal Potable Water Steel Tank

Two reinforced CSP baffle curtains (28 feet × 156 feet each) were installed in a 6.7 million gallon potable water storage tank. The unique engineering challenge of this project was galvanic corrosion management: the stainless steel attachment hardware and the carbon steel tank shell form a galvanic couple capable of producing rapid localized corrosion. The solution required comprehensive electrical isolation of all stainless steel hardware using non-metallic plastic insulators on every bolt, washer, bar, and bracket, supplemented by spray-applied dielectric adhesive on all contact surfaces. CSP was selected for its superior resistance to chlorine and ozone compared to EIA, and the product held current NSF-61 certification.

### **8.5 Parker, Colorado — Municipal Wastewater Treatment**

Parker Water and Sanitation District installed eight hybrid baffle curtains (36 feet wide × 20 feet tall) in a wastewater treatment facility. The design combined the structural stability of mechanically-attached bottom anchors with integrated foam flotation along the upper curtain portion — a hybrid approach that provided buoyancy-assisted alignment across the wide horizontal span while maintaining precise bottom-edge sealing. The installation, performed by Colorado Lining International, was conducted from scaffolding and ladders within an active treatment facility, requiring careful coordination with operations staff.

### **8.6 Toronto Region, Ontario — Lessons Learned: Hardware Material Failure**

This case study is particularly instructive for young engineers. A series of fixed baffle curtains in an underground water treatment reservoir failed structurally due to a single material substitution error: galvanized steel bar was inadvertently used in place of specified stainless steel for the mechanical attachments. The galvanized hardware corroded rapidly in the chlorinated water environment, disintegrating the mechanical connection and allowing the baffle curtains to collapse. The lesson is unambiguous: in water treatment environments with chlorine contact, stainless steel (minimum Type 304, preferably Type 316 in aggressive applications) must be used exclusively for all mechanical hardware. The replacement installation used EIA curtains with rope-reinforced edges, integrated flow-through windows, and correctly specified stainless steel hardware throughout, returning the facility to service rapidly.

## **9. Conclusions and Key Takeaways for Engineers**

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### **9.1 Summary of Core Principles**

Geomembrane baffle curtains are a mature, versatile, and cost-effective technology for improving hydraulic efficiency across a wide spectrum of water and wastewater treatment applications. The following core principles should guide any engineer or engineering student approaching this technology for the first time:

- Hydraulic performance first: every design decision — number of baffles, window sizing, curtain depth, flow-through opening placement — must be validated against the hydraulic performance target ( $t_{10}/T$  ratio or CT compliance value).
- Material selection is not a commodity decision: the choice of polymer (EIA, CSP, LLDPE, PP) and the verification of chemical compatibility, UV resistance, low-temperature performance, and potable water certification must be tailored to the specific conditions of each project.

Never assume that a material that worked on a previous project is automatically appropriate for the next.

- Hardware is as important as the geomembrane: mechanical attachment failures (particularly galvanic corrosion from mixed metals) are a leading cause of baffle system failure. Specify all-stainless hardware and electrical isolation where dissimilar metals are unavoidable.
- Factory fabrication is a quality system: the shift of complex fabrication operations to controlled factory environments is not merely a convenience — it is a systematic approach to quality assurance that produces better seams, more consistent geometry, and lower field rework rates than in-situ fabrication.
- Safety is non-negotiable: confined space work in underground water infrastructure requires complete, uncompromising implementation of permit-required confined space entry procedures. Fall protection, atmospheric monitoring, ventilation, and rescue standby are mandatory, not optional.
- Operations and maintenance extends service life: a baffle curtain system that is never inspected or maintained will fail prematurely. A well-managed O&M program, including annual inspections and prompt repair of minor defects, can extend service life to 20 years or beyond.

## 9.2 Emerging Applications and Future Directions

The mining sector is a rapidly growing market for baffle curtain technology, driven by increasingly stringent environmental regulations governing the quality of water discharged from mine sites and the growing use of water recycling in mining operations. Similarly, the expansion of distributed water treatment — small community water systems, industrial pretreatment, agricultural water reuse — creates a growing need for cost-effective, easily deployable treatment enhancement technologies that baffle curtains are uniquely positioned to serve.

Advances in geomembrane material science — including improved antioxidant packages for chlorine-resistant EIA, enhanced UV stabilizers for long-duration outdoor exposure, and the development of bio-based geomembrane coatings — will further extend the chemical compatibility and service life of baffle systems. CFD modeling tools are making it increasingly practical to optimize baffle configurations for complex, non-rectangular pond geometries. And the growing use of remotely operated underwater vehicles (ROVs) for inspection of submerged baffles promises to reduce the cost and safety risk of inspection in large, deep treatment lagoons.

### For Further Study

The Fabricated Geomembrane Institute (FGI) publishes technical articles, research papers, and operational guidelines covering all aspects of geomembrane technology, including reinforced vs. unreinforced geomembranes, operations guidelines for geosynthetic-lined reservoirs, and material-specific chemical resistance data. FGI also maintains an online learning center with courses in geomembrane welding basics and construction quality assurance (CQA). Visit [fginet.org](http://fginet.org) for access to these resources.

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