

TRANSFORMING WATER TREATMENT RESIDUE (WTR) INTO CIRCULAR VALUE AT SUNGAI DUA WATER TREATMENT PLANT

CASE STUDY



Overview

Following the Package 12A upgrade (+114 MLD), the Sungai Dua Water Treatment Plant (WTP) now operates at a maximum design capacity of 1,342 MLD, fortifying Penang's total water treatment capacity to 1,726 MLD. To manage the corresponding increase in Water Treatment Residue (WTR), PBAPP facilitated the establishment of the Sungai Dua Dewatering Plant (SDDP), which became operational in February 2025.

This RM 20 million facility was built and is operated by Alam Aliran Kualiti Sdn Bhd (AAK) under a long-term contract, utilizing PBAPP land within the WTP premises. The arrangement enables a circular economy model without direct capital investment from PBAPP. The facility processes up to 500 metric tons of scheduled waste per day, converting dewatered sludge into compliant construction materials (Eco Brick) and recovering supernatant for reuse within the WTP.

Key Achievements (Mar - Nov 2025)



Water Treatment Residue

A total of 32,409.45 MT of WTR have been processed.



Cost Saving

RM 13,125,827.25 saving compared to previous off-site disposal costs.



Emissions Avoided (Penang to Selangor)

886.73 tCO₂e (loaded), or 1019.74 tCO₂e including a 15% return trip uplift.



Current Route Emissions (SDDP to AAK)

67.09 tCO₂e (loaded), calculated using DEFRA 2025 standards for the 23 km route

Background & Context

PBAPP & Sungai Dua: Why Sludge Management Is Critical

PBAPP is Penang's licensed water operator. The Sungai Dua Water Treatment Plant is the company's largest and most critical asset. Following a major capacity upgrade, the plant's increased production also results in substantial daily volumes of Water Treatment Residue (WTR) or sludge. Effective, on-site management of this by-product is essential for maintaining operational resilience, cost control, and environmental compliance.

The Malaysian Sludge Reality: A National Challenge

Water treatment sludge is a significant by-product across Malaysia, with plants nationwide generating approximately 5,500 metric tons of WTR every day. This scale transforms sludge management from a local operational task into a widespread, costly, and logically complex national challenge for the water industry.

The Unsustainability of Conventional Disposal

Traditional off-site disposal—Involving long-haul transport, landfill tipping fees, and third-party handling—became prohibitively expensive and operationally risky. For a high-throughput plant like Sungai Dua, these conventional disposal costs accumulated rapidly and diverted critical resources and focus away from core water-supply missions.

PBAPP's Pioneering Solution: A Step-Change in Sludge Management

PBAPP has pioneered a new industry model for Malaysia by implementing an integrated, on-site solution at Sungai Dua. This facility dewateres sludge at source, enabling its conversion into Eco Brick—a useful construction product containing approximately 30% WTR. This initiative is the first of its kind in the Malaysian water sector to successfully close the loop on sludge at this scale.

Strategic Impact: A Replicable Model for the Industry

PBAPP's on-site circular pathway directly tackles the national sludge challenge. It demonstrates a viable alternative that slashes costs, eliminates long-distance waste haulage, and creates value from waste, establishing a blueprint that can be replicated across the industry for sustainable utility operations.

Methodology & Assumptions

Data Sources:

- Operational Data:** Monthly and daily logs for sludge weight, trips, and supernatant quality (March – November 2025)
- Financial Baseline:** Previous off-site disposal costs (approximately RM 550/mt) versus the current contracted AAK processing rate (RM 145/mt)
- Emission Factors:** The UK Government's DEFRA 2025 conversion factors for freight transport (HGV, average-laden) were applied for transparency and international benchmarking.

Key Calculations:

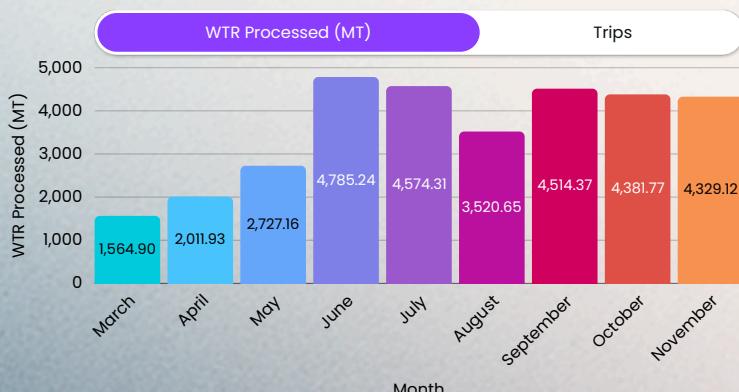
- Cost Savings:** Savings (RM) = Total Metric Tonne (mt) × RM 405/mt* (Difference between previous disposal cost and current AAK rate).
- Previous Disposal Route Emissions Avoided:** Based on the original 304 km off-site disposal route that is no longer utilized.
- Current Route Emissions:** Calculated for the 23 km SDDP-to-AAK journey using:

$$t\text{CO}_2\text{e (loaded)} = (\text{Tonnes} \times 23 \text{ km} \times 0.09 \text{ kg CO}_2\text{e/t-km}) / 1000$$

Performance Results (Mar – Nov 2025)

Monthly Volume of WTR Processed (Metric Tons)

The chart below details the metric tons of sludge processed each month.

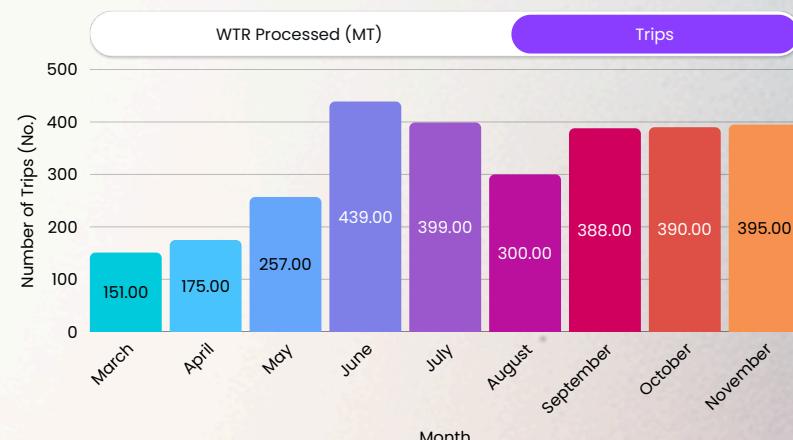


Volume Analysis:

- Ramp-Up Phase (Mar-May):** Volumes increased steadily as the facility reached operational capacity.
- Peak & Stabilization (Jun-Nov):** The system demonstrated high-volume capability, processing over 4,500 MT in four of the last six months.
- Total Processed:** 32,409.45 MT over nine months.

Monthly Transport Logistics (Number of Trips)

This table shows the number of transport trips required each month to move the processed sludge from the SDDP to AAK's brick manufacturing facility, a 23 km route.



Logistics Analysis:

- Trip Volume Correlation:** Trip counts directly correspond to processing volumes, with June requiring the most trips (439) during peak processing.
- Operational Efficiency:** The consistent trip counts from September to November (388-395 trips) despite processing over 4,300 mt monthly indicates optimized load management and scheduling.
- Total Trips:** 2,894 trips completed over the reporting period.

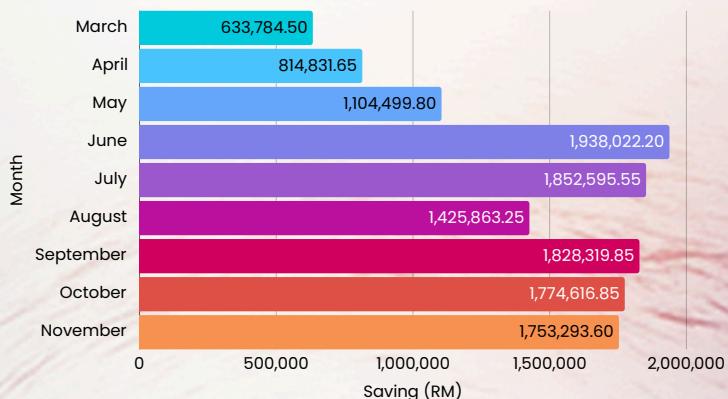
Performance Results (Mar – Nov 2025)

Financial Impact Analysis

This section quantifies the direct cost savings achieved by implementing the on-site, circular sludge management model. The savings are calculated by comparing the current contracted processing cost with Alam Aliran Kualiti (AAK) against the estimated expenses of the previous off-site disposal method.

The financial model is based on a fixed per-tonne differential:

- Previous Off-site Disposal Cost:** ~RM 550 per metric ton.
- Current AAK Processing Cost:** RM 145 per metric ton.
- Savings per Tonne:** RM 405.



The financial results substantiate the business case for the circular, on-site model. The RM 13.1 million in cost avoidance over nine months validates the partnership with AAK as a fiscally prudent strategy. It transforms sludge management from a variable, high-cost operational burden into a predictable, controlled expense, contributing directly to PBAPP's long-term financial sustainability.

Environmental Impact

- Previous Disposal Route Emissions Avoided:** 886.73 tCO₂e (loaded), 1019.74 tCO₂e (+15% return trip). Emissions that would have been generated if off-site disposal continued.

- Current Route Emissions (SDDP to AAK):** 67.09 tCO₂e (loaded), 77.15 tCO₂e (+15% return trip). Actual emissions from current optimized operations.

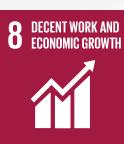
Performance Summary: Key Metrics

Performance Metric	March-Nov 2025 Actual	2026 Target	2027 Target
WTR Processed (MT)	32,409.45	105,850	112,201
Transport Trips	2,894	9,452	10,018
Cost Savings (RM) from Previous Disposal Method	13,125,827	42,869,250	45,441,405
tCO ₂ e Avoided (Previous 304km Route)	886.73	2,896.06	3,069.82
tCO ₂ e Generated (Current 23km Route)	67.09	219.31	232.46
Net Emissions Benefit (tCO ₂ e)	819.64	2676.75	3069.82



Sustainable Development Goals (SDG) Impact:

This initiative demonstrates measurable contributions across **seven key SDGs**:

	Enhanced water quality and efficiency through on-site treatment and reuse.
	Creation of local skilled jobs and economic value through circular operations.
	Infrastructure innovation through public-private partnership and industrial upgrading.
	Reduced urban environmental impact through localized waste processing.
	Responsible waste management and circular production through brick conversion.
	Significant emissions reduction via optimized logistics and climate-conscious operations.
	Effective cross-sector partnership model that can be replicated across the industry.

Governance & Operational Model

Quality Assurance & Compliance:

- Eco Brick production adheres to stringent Malaysian Standards (e.g., MS 1933: Part 1: 2007 for compressive strength)
- Routine QA/QC tests include compressive strength, water absorption, and leachability
- All operations comply with DOE scheduled waste regulations through PBAPP's supervisory oversight

Waste Conversion Process:

The transformation of WTR into usable products involves:

- **Dewatering:** Sludge is processed at the SDDP to remove excess water.
- **Material Conversion:** Treated solids are transported to AAK's facility for incorporation into brick production.
- **Water Recovery:** Supernatant is captured and reused as raw water in the WTP.
- **Product Manufacturing:** The converted material is used to produce Eco Bricks that meet construction industry standards.

Risk Management:

A proactive risk register addresses potential disruptions, with AAK responsible for operational risks (equipment downtime, QC non-conformance) and PBAPP overseeing compliance and regulatory risks. Mitigations are embedded in contractual agreements, SOPs, and continuous monitoring protocols.

CEO Statement



At PBAPP, we believe that true operational excellence is achieved when we solve our biggest challenges while delivering multiple benefits for our community and the environment. The Sungai Dua Dewatering Plant (SDDP) partnership stands as a testament to this philosophy.

Just months ago, the daily by-product of providing clean water—over 450 metric tons of water treatment residue—was a significant and costly operational burden. Today, through our innovative partnership with AAK, that same material is no longer a waste product.

Instead, it is being transformed into Eco Bricks, a valuable resource for the construction industry. We have successfully turned a perennial cost center into a catalyst for a circular economy right here on-site.

The financial impact speaks for itself. In just nine months, this initiative has generated savings of over RM 13.1 million by replacing expensive, long-haul disposal with a sustainable, fixed-cost solution. These are not just numbers on a balance sheet; they represent prudent fiscal management that protects our operational budget and ensures long-term value for Penang.

Ultimately, this project secures more than just savings. It secures our operational resilience by eliminating external disposal dependencies, and it advances our commitment to environmental stewardship by dramatically cutting transport emissions.

We are proud to pioneer this model in Malaysia—transforming sludge into sustainability, and cost into conservation. This initiative is a concrete step toward realizing Penang's Green 2030 vision, proving that responsible utility management can drive both economic vitality and ecological progress for a more sustainable future in Penang and beyond.

