Communications Technology Validation

Water Meter Monitoring — City Life, 477 Anton Lembede Street, Durban

Prepared by: Jason van Wyk, Precept Systems

Prepared for: Mosaic Group — Tanya Dowley

Supporting document for: Business Case (MGW-PRO-202602-002)

1. Purpose

This document validates the selection of **private LoRaWAN (868 MHz)** as the wireless communications technology for the City Life water meter monitoring system. It evaluates the site-specific challenges at 477 Anton Lembede Street, compares available technology options, and demonstrates that LoRaWAN is the only practical choice that satisfies all project requirements: reliable signal penetration through reinforced concrete, battery life measured in years, zero recurring subscription fees, and proven scalability to 588+ devices.

588	12	4	R0/mo	6–15 yr
Wireless Devices	Concrete Floors	LoRa Gateways	Subscription Fees	Battery Life

2. Site Environment

2.1 Building Characteristics

Factor	Detail	RF Impact
Building age	~60 years	Denser concrete = higher attenuation per floor
Construction	Reinforced concrete, brick, steel	23 dB signal loss per floor (conservative)
Floors in scope	12 (of 27 total)	No single access point can cover all 12 floors
Units per floor	48 (588 total)	High device density requires capacity planning
Meter location	Passage ceiling above front door	Corridor line-of-sight, concrete between floors
Main riser	75mm steel pipe	+5–10 dB additional loss near riser

2.2 Existing IT & Durban CBD

Factor	Detail
WiFi APs	13–15 per floor — 2.4 GHz heavily congested
Network	Ubiquiti UniFi, Cat6, dedicated VLAN available
UPS	Comms room and switches protected
Location	Durban CBD — dense urban RF environment
868 MHz band	Less congested than 2.4 GHz in CBD
Regulatory	ICASA EU863-870 channel plan, licence-exempt
Load shedding	Battery-powered nodes unaffected
Wired runs	Rejected by client (cost, disruption)

3. Technologies Evaluated

Criterion	LoRaWAN (868 MHz)	WiFi (2.4 GHz)	Wired Ethernet	Sigfox / NB-IoT
Concrete penetration	**23 dB/floor (manageable)**	35–40 dB/floor (severe)	N/A	Moderate
Battery life	**6–15 years**	6–18 months	N/A (mains)	2–5 years
Infrastructure cost	**R28–36K (4 gateways)**	~R0 (existing APs)	R145–200K (cabling)	R0 (carrier)
Subscription (annual)	**R0**	R0	R0	R103K–R311K
10-year subscription	**R0**	R0	R0	R1.03M–R3.11M
WiFi band congestion	**Not affected (sub-GHz)**	Competes with 13–15 APs/floor	Not affected	Not affected
10-year battery cost	**R0–R90K**	~R864K	R0	~R200K
Data ownership	**Full (self-hosted)**	Full	Full	Carrier-dependent
Client rejection	—	—	Rejected (cost)	—
Verdict	Selected	Not viable	Rejected	Not viable

Why Not WiFi?

WiFi at 2.4 GHz suffers 35–40 dB attenuation per concrete floor (vs 23 dB at 868 MHz). The 2.4 GHz band is already heavily congested with 13–15 APs per floor. WiFi nodes need rechargeable batteries lasting 6–18 months — replacement across 576 units costs ~R172,800 per cycle. **10-year battery cost alone: ~R864,000.**

Why Not Sigfox / NB-IoT?

Public IoT networks charge R15–45 per device per month. At 588 devices, that is R105,840–R317,520 per year — **over R1M across 10 years.** Sigfox allows only 4 downlinks per day. No data ownership guarantee. Dependent on carrier's continued operation and pricing.

Why LoRaWAN Works

Advantage	Detail
Sub-GHz penetration	868 MHz penetrates reinforced concrete at 23 dB/floor — manageable with 4-gateway design
Below noise floor	CSS modulation decodes signals up to 20 dB below noise floor — resilient to CBD interference
Adaptive Data Rate	Nodes auto-adjust spreading factor per floor position — self-optimising network
Zero subscription	Private ChirpStack server — no per-device fees, no carrier dependency
Multi-year battery	Li-SOCl2 D-cell: 6–15 years depending on interval — no replacement cycle
Multi-gateway redundancy	4 gateways, overlapping coverage — auto-failover via ADR shift
Proven locally	RAK3172 proven in production water monitoring deployments

4. RF Propagation and Coverage Design

4.1 Link Budget

Parameter	Value
Node transmit power	+14 dBm (25 mW, ICASA max)
Node antenna gain	+2 dBi
Gateway antenna gain	+3 dBi
Gateway sensitivity (SF7)	−138 dBm
Gateway sensitivity (SF12)	−148 dBm
Max path loss (SF7)	**138 dB**
Max path loss (SF12)	**151 dB**

4.2 Per-Floor Attenuation

Component	Loss
RC floor slab (1960s-era)	23 dB per floor
Horizontal path (corridor → gateway)	35 dB
Fading margin (multipath, metal)	10 dB
Formula	**(N × 23) + 35 + 10 dB**

4.3 Floor Penetration Feasibility

Floors	Path Loss	SF7	SF10	SF12
1	68 dB	70 dB margin	Yes	Yes
2	91 dB	47 dB margin	Yes	Yes
3	114 dB	24 dB margin	Yes	Yes
4	137 dB	1 dB margin	11 dB	Yes
5	160 dB	No	No	No

> **Each gateway reliably covers 3 floors at SF7** (most battery-efficient) and 4 floors at SF10 fallback. No node needs to penetrate more than 3 floors.

4.4 Four-Gateway Placement

```
Floor 12  ── GW4 ──  Covers 10-12 (primary), 9 (backup)
Floor 11  ── ●
Floor 10  ── ●
Floor  9  ── GW3 ──  Covers 7-9 (primary), 10 (backup)
Floor  8  ── ●
Floor  7  ── ●
Floor  6  ── GW2 ──  Covers 4-6 (primary), 7 (backup)
Floor  5  ── ●
Floor  4  ── ●
Floor  3  ── GW1 ──  Covers 1-3 (primary), 4 (backup)
Floor  2  ── ●
Floor  1  ── ●
```

Coverage Metric	Value
Primary coverage	12 of 12 floors (100%)
Dual-gateway coverage	8 of 12 floors (67%)
Max floors to nearest GW	3 (at SF7)
Single GW failure	All floors still covered (ADR shift)

Gateway Specification

Model	RAK7268V2 (or equivalent)
Channels	8 simultaneous LoRaWAN
Power	PoE (UPS-backed switches)
Backhaul	Ethernet via Cat6 to IoT VLAN
Cost	R7–9K per unit × 4 = R28–36K

> **Self-healing:** If a gateway fails, nodes auto-shift to SF10 on adjacent gateways via ADR — no manual intervention, no data loss.

5. Network Capacity

5.1 Uplink Traffic Analysis (588 nodes, 4 gateways)

Interval	Uplinks/Hour	Per Gateway	Channel Use	Success Rate
5 minutes	7,056	1,764	1.5%	>97%
10 minutes	**3,528**	**882**	**0.75%**	**>98.5%**
15 minutes	2,352	588	0.5%	>99%

Even at the most aggressive 5-minute interval, channel utilisation is 1.5% — well within the capacity of 4 eight-channel gateways. The recommended 10–15 minute interval provides adequate resolution for billing and leak detection.

5.2 Multi-Gateway Deduplication

With 4 gateways and overlapping coverage, most uplinks are received by 2+ gateways simultaneously. ChirpStack automatically:

- Deduplicates packets (selects best SNR copy)
- Provides >99% effective packet delivery rate
- Catches missed packets at one gateway via another
- Generates signal quality metrics for diagnostics

No capacity concern at any proposed interval. 588 devices across 4 gateways operates at <2% of available capacity.

6. Battery Life

6.1 Battery Specification

Parameter	Value
Chemistry	Lithium Thionyl Chloride (Li-SOCl2)
Cell	ER34615 (D-cell)
Nominal capacity	19,000 mAh (19 Ah)
Configuration	Dual cells in parallel (30.4 Ah practical)
Self-discharge	<1% per year
Temperature range	−55°C to +85°C

6.2 Life Projections

Interval	Daily Use	Single Cell	Dual Cell
5 minutes	0.315 mAh	~6 years	~8+ years
10 minutes	**0.176 mAh**	**~10 years**	**~15 years**
15 minutes	0.129 mAh	~14 years	~20+ years

6.3 LoRaWAN vs WiFi Battery Economics

Metric	LoRaWAN	WiFi
Battery life per cycle	**6–15 years**	6–18 months
Replacement cycles (10 yr)	**0–1**	5–7
Cost per replacement (576)	~R90,000	~R172,800
10-year battery cost	**R0–R90,000**	**~R864,000**

LoRaWAN battery advantage saves R774K–R864K over 10 years compared to WiFi.

7. Regulatory Compliance

7.1 ICASA and 868 MHz

Frequency band	868 MHz (EU863-870, adopted by SA)
Regulatory body	ICASA
Power limit	25 mW ERP (+14 dBm)
Duty cycle limit	1% (868.0–868.6 MHz)
Actual duty cycle (10-min)	~0.01% — 100× headroom
Type approval	Required for radio modules — to be verified
Licence fee	None (ISM band, licence-exempt)

7.2 POPIA Compliance

All data remains on-premises (or SA-hosted cloud). No consumption data leaves South Africa. The system collects unit-level water consumption linked to a unit number (not a person). CLTM ERP handles the tenant-to-unit mapping within Mosaic Group's existing systems.

8. Total Cost of Ownership (10-Year)

Cost Component	LoRaWAN (Private)	WiFi	Wired Ethernet	Sigfox / NB-IoT
Infrastructure (once-off)	**R28–36K**	~R0 (existing)	R145–200K	R0
Subscription (10 years)	**R0**	R0	R0	R1.03–3.11M
Battery replacement (10 yr)	**R0–90K**	R864K	R0	R200K
Maintenance labour (10 yr)	~R50K	~R250K	~R100K	~R50K
10-Year Total	**~R78K–R176K**	**~R1.11M+**	**~R245–300K**	**~R1.28–3.36M**

LoRaWAN has the lowest 10-year TCO by a significant margin — up to 19× cheaper than public IoT networks and 6× cheaper than WiFi.

9. Risk and Mitigation

Risk	Likelihood	Impact	Mitigation
Floor attenuation exceeds 23 dB model	Low–Med	Medium	Pilot validates actual propagation; 4-GW design limits to 3 floors; additional GWs can be added
Metal riser degrades antenna	Medium	Medium	Antenna testing during pilot; placement offset from riser; external antenna option
ICASA type approval gap	Medium	High	Verify RAK3172 and RAK7268V2 approval before procurement; alternative modules available
CBD RF interference	Low	Low	CSS modulation operates below noise floor; 868 MHz less congested than 2.4/5 GHz
Gateway hardware failure	Low	Low	4-GW redundancy with auto ADR shift; replacement within 24 hours; no data lost
Battery early depletion	Low	Low	Dashboard monitors voltage; dual-cell design; Li-SOCl2 has <1% self-discharge

> **The pilot phase is designed specifically to validate RF propagation and coverage** before committing to the full 12-floor rollout. All pilot hardware is reused in the full system.

10. Conclusion

Requirement	LoRaWAN Delivers
Penetrate 60-year-old reinforced concrete	Sub-GHz (868 MHz) with 23 dB/floor — covered by 4-gateway design
Support 588 devices reliably	<1.5% channel utilisation at 5-min intervals; >99% packet delivery
Battery life measured in years	6–15+ years on Li-SOCl2; no recurring battery replacement
No recurring subscription fees	Private ChirpStack — R0/month, R0/year, R0/decade
Survive load shedding	Battery-powered nodes; gateways on UPS-backed PoE
Data stays on-premises	Self-hosted network server; POPIA compliant by design
Self-healing and redundant	4 gateways with ADR; automatic failover; no SPOF
Proven technology	RAK3172 proven in production water monitoring deployments
CBD-resilient	CSS below noise floor; 868 MHz less congested than 2.4 GHz
Lowest 10-year TCO	R78–176K vs R245K–R3.36M for alternatives

> **LoRaWAN at 868 MHz is not a preference — it is the only technology that meets all project requirements simultaneously.** WiFi fails on penetration and battery life. Wired Ethernet was rejected on cost and disruption. Public IoT networks impose unsustainable subscription costs. LoRaWAN addresses every constraint while delivering the lowest total cost of ownership.