FINAL PUBLICATION EDITION · SEPTEMBER 2026

GUYANA FRESHWATER SECURITY TO 2035

From water abundance to safe supply, functioning watersheds, productive use and climate resilience.

RAGUNAUTH RAMSAROOP
Independent research · Georgetown, Guyana
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WATER · INFRASTRUCTURE · RESILIENCE

THE RESEARCH BRIEF

From freshwater abundance to verifiable security.

Guyana's water story is not scarcity in the abstract. It is the challenge of converting abundant freshwater into verifiably safe, reliable, affordable and climate-resilient service while protecting wetlands, rivers, aquifers and public health.

98.4%
Administrative potable-water access
Government, October 2025 [3]

67.2%
Safely managed drinking water
UN SDG country profile, 2024 [21]

77%
Treated-water coverage at end-2025
Budget Speech 2026, printed p. 61 [5]

What is new in this edition

This publication edition integrates 10 original analytical exhibits, a traceable 38-source register, three reproducible economic and water-loss scenario families, source-precision notes, verification protocols and a specialist review dossier. It is independently authored document-based research, not a substitute for site investigations, engineering feasibility work or statutory approval.

> **Review disclosure:** Internal documentary and numerical review completed for this edition. Independent hydrologist, engineering, public-health and Guyana-based field reviews are explicitly pending. No institutional approval or technical sign-off is claimed.

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NAVIGATION

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Executive summary

Guyana is endowed with extensive rivers, high rainfall, forests, wetlands and groundwater. Historical international water accounts place internal renewable freshwater resources at approximately 241 cubic kilometres annually. Yet a national volume estimate does not describe what households receive, whether treatment works through the distribution network, how aquifers respond to abstraction, or whether drainage systems protect settled areas during extreme rainfall. Water security must be measured at the point of use and at the watershed scale, not inferred from total rainfall or river discharge. [1,2]

Recent public investment has materially expanded access and treatment infrastructure. In October 2025, government reported that 98.4% of Guyana's population had access to potable water, including approximately 92% of people in hinterland and riverine areas. The definitions, sampling approaches and service conditions behind administrative access figures differ from the WHO/UNICEF Joint Monitoring Programme (JMP) definition of *safely managed drinking water*: an improved source on premises, available when needed, and free from faecal and priority chemical contamination. The figures should appear side by side, never as interchangeable measures. [3,4]

The internationally comparable UN SDG country profile reports that 67.2% of Guyana's population used safely managed drinking water in 2024 and 43.4% used safely managed sanitation. It also reports 33.4% of domestic wastewater flows safely treated in 2024. These series are estimates for stated indicator definitions, not audits of each 2026 network. The 2024 UN water figure and the October 2025 national 98.4% administrative access figure must not be subtracted to produce an alleged service-quality failure rate. They have different dates, populations, data methods and service standards. [20,21]

The January 2026 national budget provides a critical verified performance baseline. Treated-water coverage increased from 52% in 2020 to 77% at the end of 2025. A 90% coverage objective publicised during 2024 and 2025 was a target rather than the documented end-2025 outcome. The budget recorded GYD 19.7 billion of 2025 water-sector spending and GYD 21.6 billion budgeted for 2026. It allocated GYD 8.2 billion during 2026 to advance works addressing water quality and service, including the Hope and Diamond surface-water plants and expansion of Shelterbelt capacity. These figures describe announced expenditures, appropriations and plans, not independently audited operational outcomes. [5,6]

Three structural issues warrant close measurement. First, historical Caribbean Development Bank (CDB) documentation reported non-revenue water (NRW) at 69.7% in 2019, while a later CDB results framework used a 79% baseline for 2023. These are dated figures with potentially different scopes. Both point to substantial water lost or unbilled between production and revenue collection, but they cannot be turned into a measured 2026 loss rate without a common methodology. Second, public descriptions of Georgetown's legacy sewerage network record an aging pumped system and historical untreated discharge. A contemporary condition audit is needed before claiming the same operating status in 2026. Third, coastal groundwater dependence leaves water supply exposed to saline intrusion, flood-borne contamination, energy interruptions and insufficient monitoring. [7,8]

The country's water decisions are spatial. Coastal settlements require integrated drinking-water supply, drainage, sanitation, groundwater and flood planning. Interior watersheds and mining districts require sediment, mercury and microbial surveillance appropriate to actual exposure. Agricultural districts need reliable seasonal allocation and drainage. Hinterland villages require maintainable pumps, appropriate water treatment, operator training, spare parts and community oversight. North Rupununi and other wetlands require hydrological protection alongside livelihood and biodiversity management. [7,9]

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The 2025 IDB financing programme is a concrete test of execution. A US$30 million conditional credit-line envelope, with a US$15.57 million first individual loan and separately identified US$36.33 million proposed JICA cofinancing, is intended to support a new Diamond plant, approximately 15 km of associated pipes, metering, leakage interventions and utility digitalisation. An estimated 151,560 people are prospective beneficiaries, not verified completed beneficiaries. The IDB project is listed as in implementation as of September 2026. Financing envelopes, individual loans and cofinancing are distinct accounting concepts and must not be added blindly. [22,23]

This paper presents a 2026-2035 decision framework rather than an unsupported national cost estimate. It distinguishes verified results, historical indicators, announced targets, proposed technical options and unresolved data. Investment options cover network loss management, wastewater, aquifer monitoring, climate-resilient treatment and drainage, village water systems, source protection and common public reporting. A staged implementation scorecard specifies what should be measured before outcomes are claimed. Its overall objective is a national freshwater system whose quality, reliability, environmental performance and maintenance capacity can be independently checked.

Executive evidence register

Indicator	Dated value or status	Interpretation
Internal renewable freshwater	About 241 km3/year, historical international estimate	Resource endowment, not service availability [1]
Administrative potable-water access	98.4%, October 2025 government report	National administrative definition, not equivalent to SDG 6.1.1 [3,4]
Safely managed drinking water	67.2%, 2024 UN SDG estimate	Improved source on premises, available when needed, free of relevant contamination [20]
Safely managed sanitation	43.4%, 2024 UN SDG estimate	Distinct from access to a toilet or basic sanitation [20]
Safely treated domestic wastewater	33.4%, 2024 UN SDG estimate	Flow-level indicator; data methods need inspection before local extrapolation [20]
Hinterland and riverine access	About 92%, October 2025 government report	Regional administrative estimate [3]
Treated-water coverage	52% in 2020; 77% at end-2025	Reported national budget performance series [5]
Earlier treated-water objective	90% by end-2025, later restated for 2026	Programme target, not verified end-2025 result [5,6]
Non-revenue water	69.7% in 2019; separate 79% baseline for 2023	Different historical CDB series needing reconciliation [7]
Budgeted water expenditure	GYD 21.6 billion in 2026	Budget allocation, not actual spending [5]
Census population	878,674 people, September 2022	Preliminary census count, not a 2026 estimate or 2035 forecast [24]

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Indicator	Dated value or status	Interpretation
IDB water programme	US$30m umbrella credit; US$15.57m first loan, approved July 2025	Separate financing layers, not the same capital line [22,23]
Coastal treatment investment	GYD 40 billion programme	Published programme envelope [6]
Major surface-water plans	Hope 24 MLD; Diamond 26 MLD	Announced 2026 project capacities [5]
Georgetown wastewater condition	Older utility description identifies untreated discharge	Current systemwide audit required [8]

Executive confidence register: how far each finding can be taken

The ratings below assess **confidence in the precise claim as worded**, not the credibility of the issuing institution. A high-confidence claim about a budget appropriation does not imply high confidence that the project is complete. Likewise, a well-documented historical water-loss baseline can be high-confidence history and low-confidence evidence of the present-day national rate. All ratings are the author's desk-based assessment; no external reviewers have certified them.

Claim stated in its correct scope	Confidence in the claim as worded	Where the claim becomes weaker	Evidentiary consequence
Guyana's historic AQUASTAT internal renewable water endowment is about 241 km^3/year [1]	Moderate	Seasonal river yield, quality or 2026 abstraction at a specific site	Use only as historical national context
Government reported 98.4% administrative potable-water access in October 2025 [3]	High that it was officially reported	Household-level safe, continuous water	Do not substitute for SDG 6.1.1
UN estimates 67.2% safely managed drinking-water service in 2024 [20]	High that it is the published UN series	Independently observed service at every 2026 household	Carry the method, date and uncertainty caveat
UN estimates 43.4% safely managed sanitation and 33.4% safely treated domestic wastewater in 2024 [20]	High for published indicator values	Current Georgetown-specific treatment performance	Keep separate household and flow denominators
The 2026 budget reports treated coverage of 77% at end-2025 [5]	High for budget reporting	Continuous compliant output for every customer in that coverage count	Request zone-level monitoring and lab QA
CDB historical NRW sources present 69.7% in 2019 and a separate 79% baseline for 2023 [7]	Moderate for historical provenance	A harmonised national 2026 loss estimate or physical-leakage volume	Reconcile measurement boundary before trend analysis
GYD 21.6bn was budgeted for water in 2026 [5,36]	High for announced allocation	Audited spending and realised household benefits	Report disbursement and commissioning separately
IDB approved a US$30m credit line and US$15.57m first individual loan in July 2025 [22,23]	High for dated approval	Money actually drawn and service results achieved	Keep financing layers nested

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Claim stated in its correct scope	Confidence in the claim as worded	Where the claim becomes weaker	Evidentiary consequence
No sufficiently validated public national 2026 total withdrawal or physical-loss series was established in this review	Moderate, limited to reviewed public sources	Unpublished utility and permit datasets	Treat as a research gap, not proof data do not exist
A precise 2035 Guyana national water-demand or capital-gap forecast can be calculated from available public data	Not supported	Any figure generated without service-area, demand and asset measurements	Publish parameter sensitivities only

The publication standard and claim boundary

This document is a **final public-release edition of independently authored, documentary research**. Publication readiness here means that its factual claims are traceable, its analytical scenarios are reproducible and its limitations are disclosed. It does **not** mean that a hydrologist, hydrogeologist, water engineer, laboratory, statutory authority or academic journal has certified its conclusions. A documented external specialist-review pathway and a blank sign-off register are provided in Appendix E. The author should not add a peer-reviewed, externally validated, engineering-approved or government-endorsed label unless the relevant review has actually occurred.

The paper distinguishes four types of evidence: A = directly observed data with stated sampling, calibration and quality assurance; B = dated institutional or internationally modelled statements with definitions; C = historical or geographically limited evidence; and D = illustrative assumptions, targets or proposed options. A citation to a reputable agency supports what that agency reported; it does not automatically establish that the reported service was independently audited. The figure grades below indicate **evidence provenance, not the quality of an institution or the desirability of a policy**.

Research scope and evidentiary method

The analysis covers natural freshwater endowment, surface water, groundwater, drinking-water provision, sanitation, ecosystem functions, food and industrial demand, climate hazards, institutional arrangements and public finance. The evidence cut-off is 26 September 2026. Public records were prioritised over unsourced estimates: Guyana's Ministry of Finance, Guyana Water Incorporated (GWI), the Government of Guyana, CDB, FAO AQUASTAT, WHO/UNICEF JMP, World Bank climate resources, the IPCC, national legislation and relevant ecological field research. Newspaper accounts provide context only where they reproduce attributable project statements.

Four evidence labels appear throughout. **Measured or reported outcome** means a dated number publicly stated by an accountable institution. **Historical baseline** means an older result still useful for identifying the nature of a problem, not proof of current conditions. **Programme target** means a future or previous intended outcome. **Proposed option** means analysis in this paper, not an approved government programme. Neither an announced construction programme nor a newly commissioned plant alone establishes delivered household water quality, continuous service or sustainable lifecycle operation.

Financial amounts use Guyana dollars unless explicitly marked otherwise. MLD means million litres per day. Water losses and investment scenarios are illustrative unless an official baseline is cited. The latest standardised UN household indicator cited here is for 2024, while the national treated-water result cited here is for

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end-2025. Financial closure, physical completion and independently measured service improvements are treated as three separate stages. No confidential operator data, unpublished mine monitoring data or employer project information are used. The paper does not claim field sampling, engineering sign-off, peer review or original hydrological modelling.

How to interpret and reproduce this paper

The strongest evidence in a public water assessment is observed performance with an identified time, geography and denominator. A national access statement and a local treatment-plant pressure record may both be accurate, but the two answer different questions. National projections are particularly vulnerable to false precision when current withdrawal, loss and asset-registry data are missing. The analytical model supplied with this edition therefore varies a defined set of assumptions rather than presenting a single unsupported 2035 demand prediction.

Evidence class	Example	Permitted use in this paper	What the class does not establish
A. Directly measured and reproducible	Accredited microbiological sample with location, method and sampling date; calibrated DMA water balance	Local operating performance for the sampled place and time	Untested national performance
B. Institutionally reported or standardised estimate	Official budget results; JMP modelled household service indicator; IDB project approval	Named indicator with publication date, methodology and caveat	Engineering certification or a different indicator
C. Historical or partial	2019/2023 NRW baselines; older sewer-condition descriptions	Identification of persistent management risks and data priorities	Present-day nationwide performance
D. Scenario, target or hypothesis	Planned plant capacity, notional demand population, illustrative cost multiple	Stress testing, project appraisal questions and monitoring criteria	Existing asset capacity or a forecast

The reproducible files accompanying this edition include a 36-row demand sensitivity CSV and a worked capital-and-operating-cost sensitivity table. Actual costs, water-loss components, project beneficiaries and disbursements must be reconciled to current records before this framework is used for procurement, permits, tariffs or public-health decisions.

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09 | Evidence hierarchy and allowed interpretations

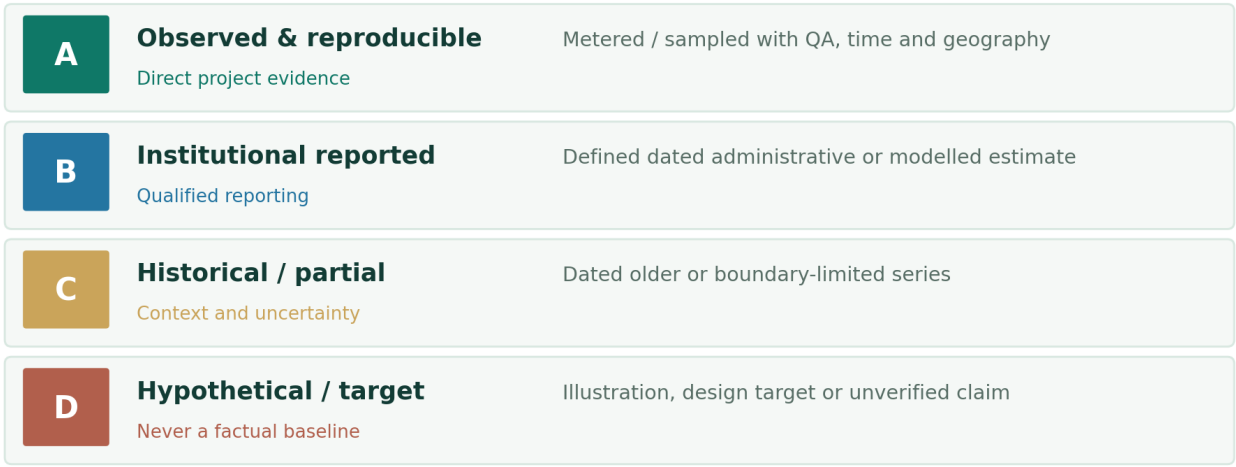


Exhibit 09. Evidence hierarchy. This paper separates direct observations, institutional reports, historical baselines and hypotheses. Designed by the author; definitions are analytical rather than an external certification scheme.

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1. Freshwater geography and the limits of national abundance

01 | Geographic orientation and four main Atlantic-draining systems

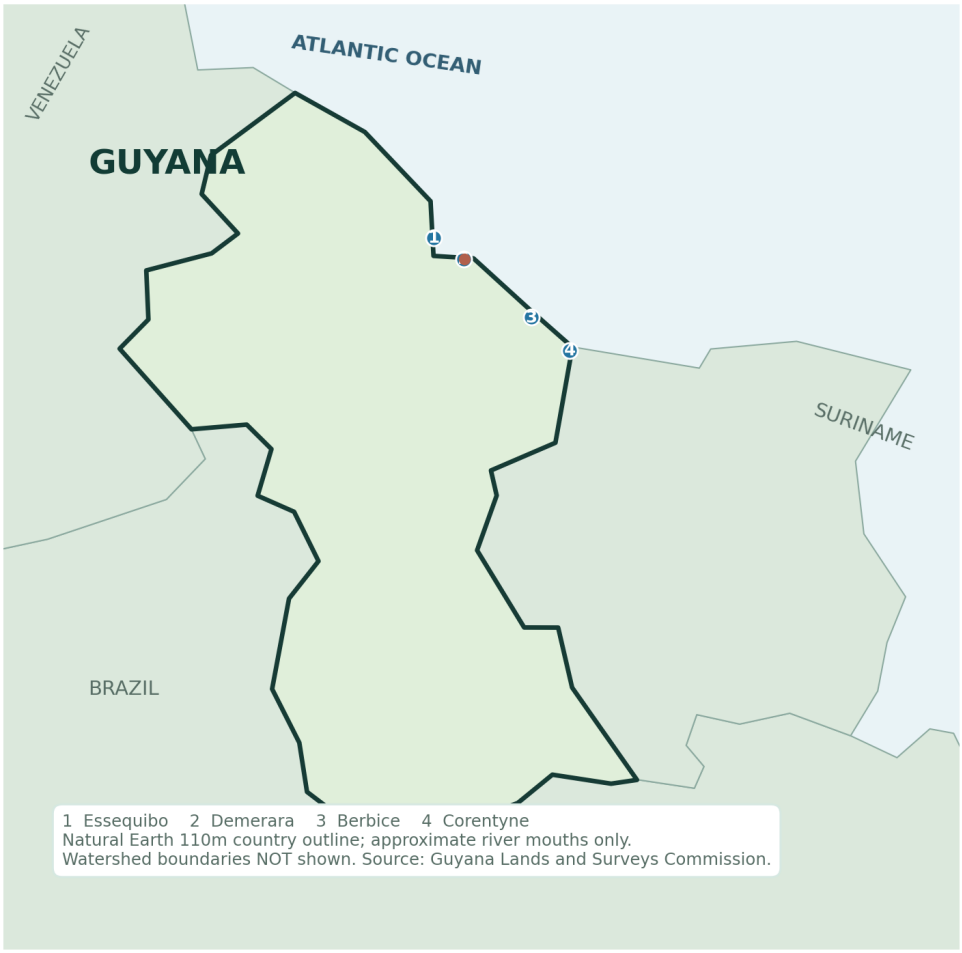


Exhibit 01. Geographic orientation. Natural Earth 1:110 million national outline (generalised), with approximate river-mouth locations based on public geographic references. No catchment boundaries or legal claims are depicted. [2,35]

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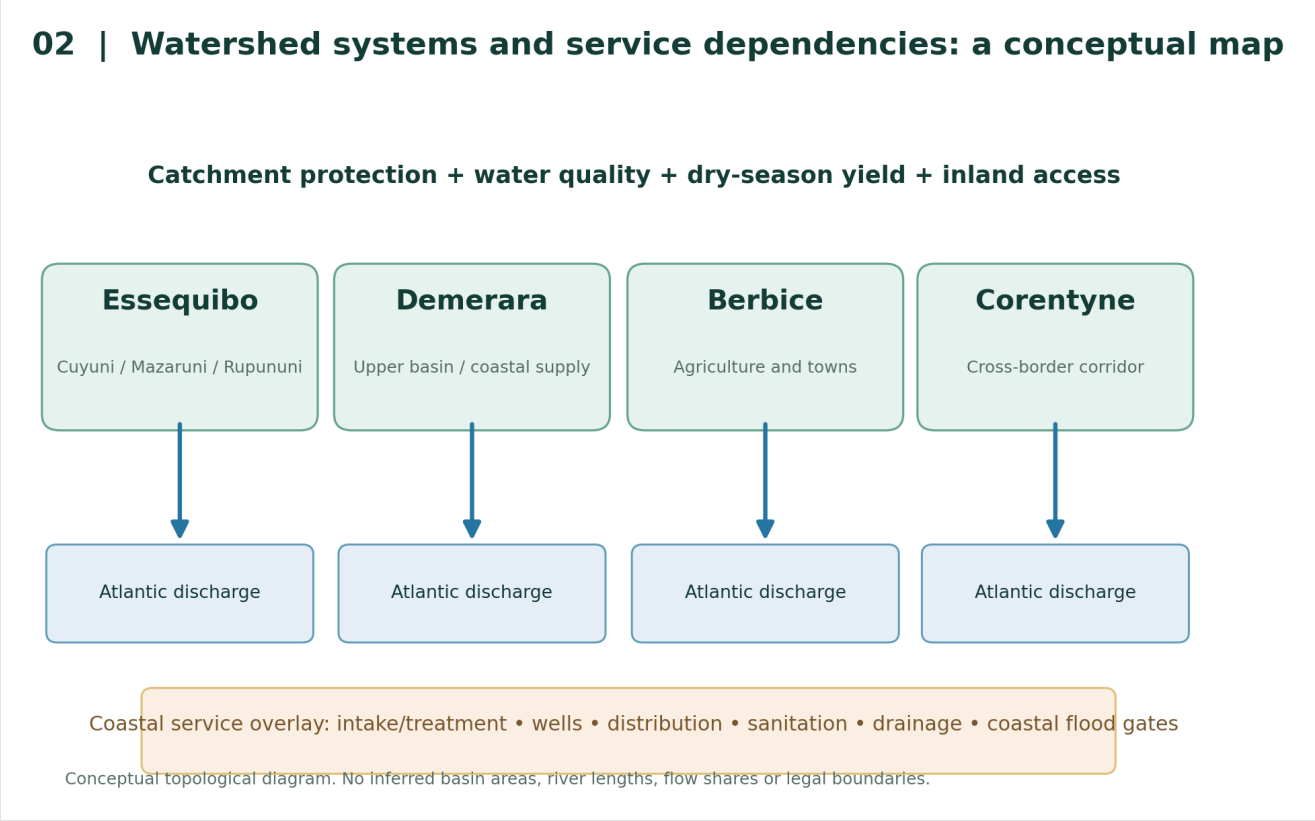


Exhibit 02. Conceptual basin-to-service map. A topological diagram of the four major Atlantic-draining systems and the coastal water-service overlay. It assigns no unverified catchment areas or annual flow shares. [2,29]

1.1 Major river systems

Guyana's four major Atlantic-draining river systems are the Essequibo, Demerara, Berbice and Corentyne. The Essequibo draws on substantial tributaries, including the Potaro, Mazaruni, Cuyuni and Rupununi. Southern boundary rivers such as the Takutu and Ireng connect Guyana hydrologically with the Amazon system through Brazil. The Corentyne is a transboundary waterway associated with Suriname. These river networks support transport, agriculture, fisheries, domestic water, forests, wetlands, settlements and commercial development. [2]

Water flows across administrative boundaries. Upstream sediment loads, wastewater discharges or changed land cover alter downstream conditions. New intakes also compete with ecological flows, navigation, flood-plains and customary water uses. For this reason, the unit for managing source protection should include the drainage basin, sub-basin and aquifer system in addition to local government boundaries.

1.2 Coastal water management

The low coastal plain contains most population centres and major areas of irrigated agriculture. Sea defences, drainage canals, kokers, pumps, conservancies and irrigation channels shape local water movement. During heavy rainfall, high tides or elevated river levels, gravity drainage becomes difficult. Saltwater intrusion becomes more consequential during low freshwater flow and prolonged dry periods. CDB identifies intense rainfall, groundwater contamination following floods, severe drought and saltwater intrusion as relevant hazards for water supply. [7]

Infrastructure decisions must therefore connect floodwater disposal and water supply. A water-treatment plant's reliability depends on road access, electrical equipment elevation, pumping power, chemical supply, staff access, wellhead protection and capacity of the drainage district. Adding treatment capacity without checking these dependencies risks creating apparent capacity which fails during emergencies.

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1.3 Interior forests and wetland systems

Interior catchments receive and retain rainfall through forests, soils, wetlands and floodplains. These ecosystems modify runoff, sediment movement, infiltration and dry-season ecological conditions. The North Rupununi wetlands are particularly important for freshwater biodiversity, community livelihoods, fish nurseries and seasonal floodplain connectivity. Published ecohydrological work reports exceptionally high fish diversity and habitats for arapaima, black caiman, giant river otters and river turtles. These biological observations do not substitute for current water-budget measurements; they establish the need to protect ecological flows and habitat connections when considering engineering changes. [9,10]

1.4 A common interpretation error

An estimate of approximately 241 km3 per year in internal renewable freshwater is a national accounting measure. It is not equivalent to daily dependable volume at Georgetown, an agricultural intake in Berbice, a village in the Pakaraimas or a particular mining catchment. Storage, treatment, river seasonality, groundwater recharge, water rights, contamination and energy availability affect local supply. The analysis therefore uses national endowment as context, not as evidence that any region is free of water risk. [1]

2. Drinking-water coverage: access, quality and continuity

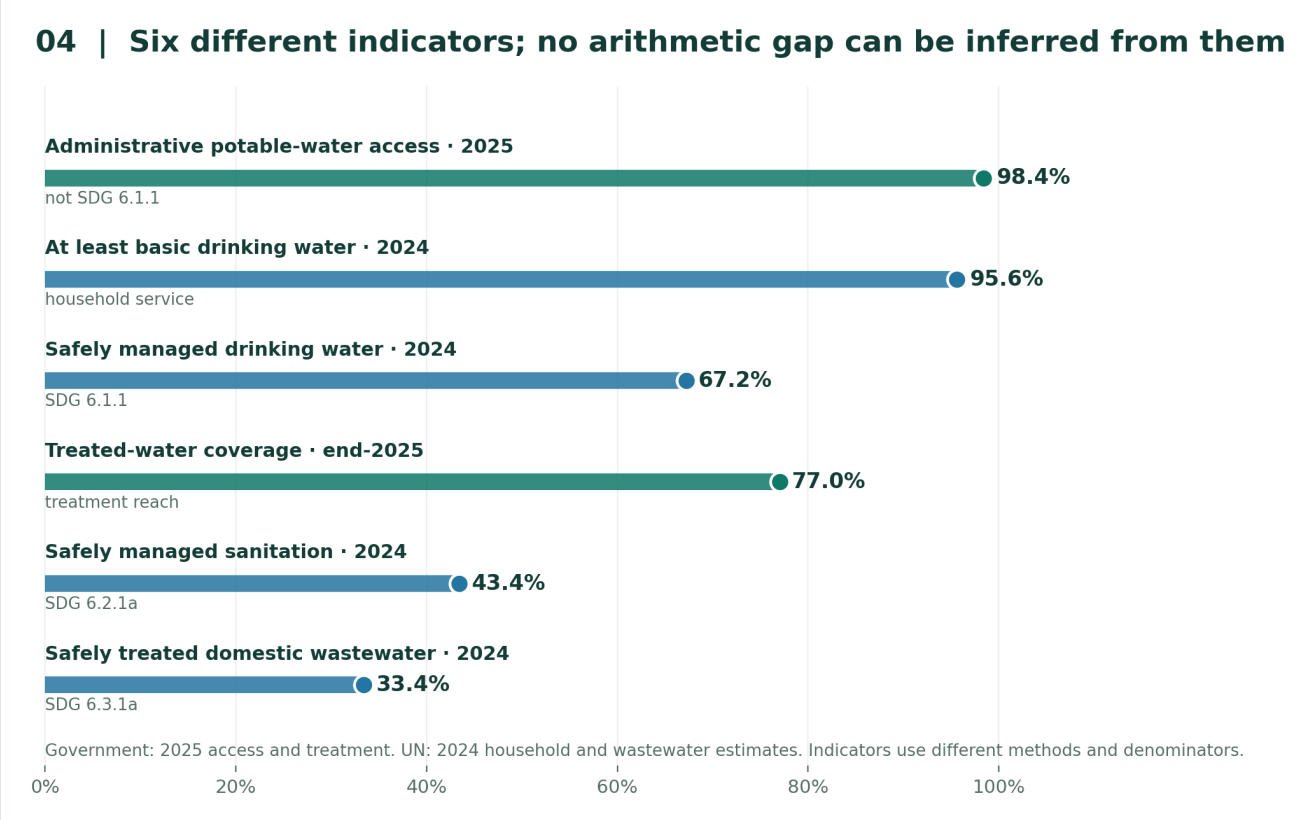


Exhibit 04. Six non-equivalent service measures. Government 2025 administrative access and treatment results, UN 2024 household and wastewater estimates. The denominators, definitions and reference years differ. [3,5,20,21]

2.1 Separating three different measures

Administrative potable-water access records the population served under a national programme. Treated-water coverage records the reach of treatment. JMP safely managed water is a household-level service measure requiring an improved source on premises, available when needed and free from specified contamination. A

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community may appear in the first category and still lack household-level safely managed service if supply is intermittent, collection is distant, household storage is unsafe or distribution water is contaminated. Reporting should therefore publish all three measures without combining their denominators. [3,4]

The October 2025 government access report gave 98.4% nationwide access and about 92% in hinterland and riverine communities. The January 2026 budget gave end-2025 treated-water coverage of 77%, up from 52% in 2020. Both statements can be true because they describe different indicators. The gap between them is not itself a measured quality failure for every household. It reveals why service standards and independent sampling belong alongside expansion statistics. [3,5]

2.2 Coastal treatment expansion

Government described a GYD 40 billion Coastal Water Treatment Infrastructure Programme with seven large plants, smaller treatment facilities, refurbishment of existing plants and roughly 200 km of transmission mains. Project counts and target completion years have shifted across successive announcements. A February 2026 statement concerning Five Miles, Bartica, described seven large and fifteen small plants, twelve upgrades and 200 km of mains under Phase One, with 90% treated coverage aimed for 2026. Project-level commissioning should be reconciled with the Ministry of Finance's 77% end-2025 national performance figure rather than inferred from plant counts. [5,6]

The Cummings Lodge plant provides an example of rated capacity. Government reported its 2025 commissioning at approximately GYD 1.3 billion with a nominal treatment rate of 12 MLD and storage of 3.6 million litres. These values describe the facility, not its uninterrupted actual annual output. The Five Miles plant at Bartica was reported at approximately GYD 468 million and intended to serve about 6,000 residents. [11,6]

The 2026 budget provides forward-looking figures suitable for tracking. It identifies a 24 MLD Hope surface-water plant, a proposed 26 MLD Diamond surface-water plant and expansion of Shelterbelt's treatment capacity from 45 to 65 MLD. The associated GYD 8.2 billion budget line supports several water-quality and service interventions, not solely these three plants. Planned capacity should be marked 'not yet independently verified operational' until acceptance tests, water-quality data and sustained output are published. [5]

2.3 Distribution performance

Historical CDB records cite NRW at 69.7% in 2019, while a subsequent CDB result framework uses a separate 79% baseline for 2023 and sets a 45% target for 2026. The definitions, boundaries and reading periods of these figures must be reconciled before trend claims are made. NRW includes physical leakage and commercial losses such as metering and billing error. It does not mean the same percentage of water physically leaked into the ground. [7]

A technically defensible programme starts with bulk-production meters and district-metered areas. Zone boundaries and pressure control allow teams to estimate minimum night flows, identify high-loss mains and distinguish apparent from physical losses. Customer-meter audits and billing-system reconciliation address the commercial component. Each intervention should report cubic metres saved, changes in service pressure, energy use, repair cost and collection efficiency. Percentage-only progress without production and authorised-use volumes is insufficient.

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2.4 Continuous service and affordability

An improved connection does not guarantee daily continuity. A published service dashboard should disclose hours of supply, pressure, interruption frequency, water quality at the tap, response times, planned maintenance and affordability across supply zones. Utilities should separate outages at water-treatment facilities from disruptions caused by distribution failures or electricity supply.

Public-service planning also needs equity data. A remote settlement with 90% nominal access may have different operating conditions from a coastal community with 90% coverage. Relevant household measures include collection time, distance, water storage, cost, reliability for schools and clinics, disability access and whether women and children bear disproportionate collection burdens. CDB's Guyana water assessments explicitly incorporate gender and inclusion considerations. [7,12]

2.5 The UN baseline changes the performance conversation

A careful national assessment must distinguish administrative access, installed treatment coverage and household experience. The UN SDG Data Portal reports Guyana's 2024 safely managed drinking-water coverage at **67.2%**, compared with **62.7% in 2000**. This long-run series is internationally standardised and may combine surveys, administrative information and statistical estimation. The 2024 figure should be used as a recent comparison anchor, not represented as a direct sample of every distribution system in September 2026. [20,21]

The government's **98.4% potable-water access** statement from October 2025 is a later, different national administrative measure. The **77% treated-water coverage** figure for end-2025 concerns infrastructure and treatment reach. A system can improve both access and treatment while still needing stronger household-level evidence on availability, residual contamination and continuity. Neither the difference between 98.4% and 67.2% nor the difference between 77% and 67.2% is, by itself, a measured failure rate. [3,4,5,20]

Measure	Reference point	What it tells decision-makers	What it does not prove
Administrative access	98.4%, government, October 2025	Scope of reported programme reach	Safe water available continuously at every home
Treated-water coverage	77%, end-2025 budget result	Population reach of stated treatment infrastructure	End-to-end compliance in each supply zone
Safely managed water	67.2%, UN, 2024	Internationally comparable household service estimate	Exact current state of each Guyanese locality
Safely managed sanitation	43.4%, UN, 2024	Population share meeting a safe sanitation service definition	Network sewerage coverage or wastewater-treatment capacity

National reporting should therefore carry a four-part dashboard: *source access*, *treatment status*, *household safely managed service* and *continuous supply*. Local data should be joined to facility identifiers and geographical service boundaries without exposing household addresses. An annual assurance statement should explain changes in source data, missing observations and any revised historical estimates.

A verification programme in a sample of coastal and hinterland systems should combine calibrated plant-production meters, outlet and network microbial sampling, household interviews about availability, and independent review of laboratory quality. GWI and the statistical authorities can then reconcile utility operating data with JMP-style household surveys. A statistically valid approach, rather than extrapolating isolated compliant samples, is necessary before asserting that a national target has been achieved.

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3. Groundwater security and saline intrusion

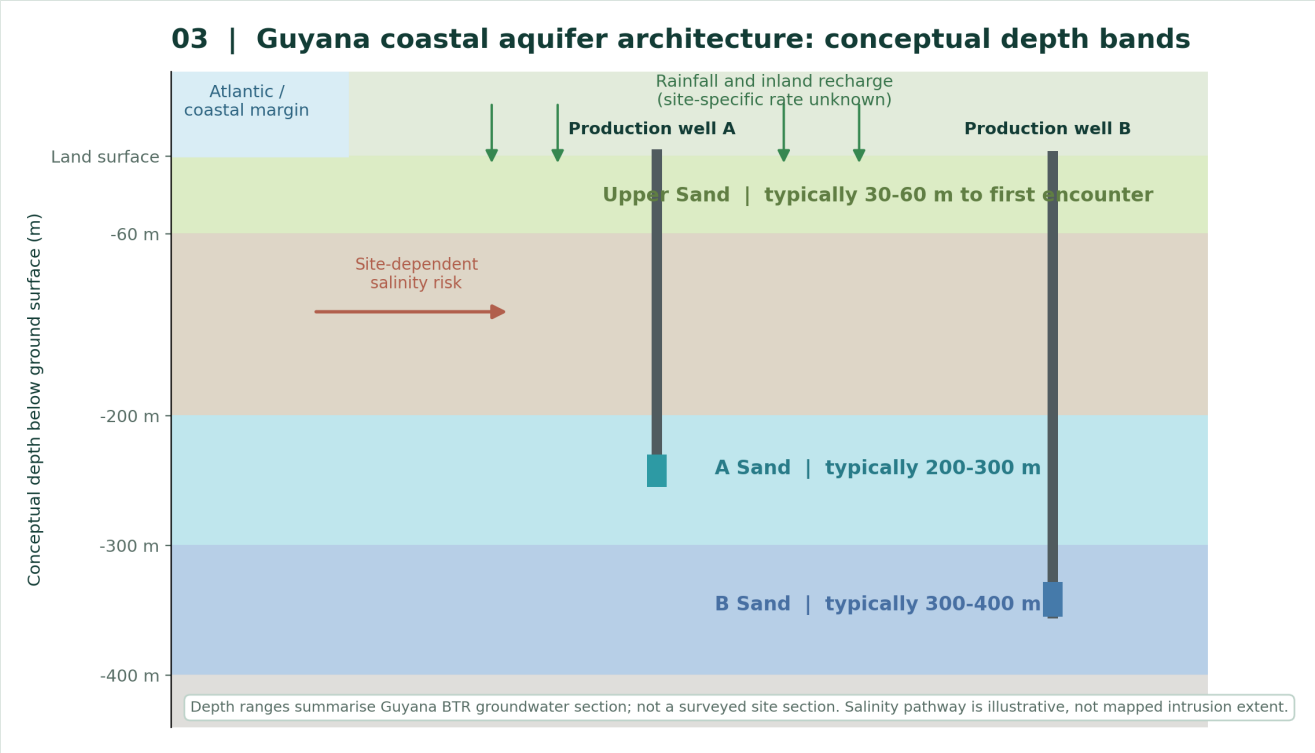


Exhibit 03. Conceptual coastal aquifer architecture. Approximate encounter-depth bands for the Upper, A and B Sands from Guyana climate reporting; not a surveyed site profile, hydraulic model or mapped salinity-intrusion front. [29]

3.1 Strategic importance

Coastal groundwater supports much of the public water network. An earlier CDB baseline documented more than 200 supply wells. Groundwater generally provides a buffer against short-term river turbidity changes, yet its protection depends on aquifer recharge, pumping rates, well construction, sanitary seals and monitoring. High iron has historically affected some coastal supplies, while long-term coastal pumping and drought raise concern about salinity. [7,13]

Groundwater governance should move beyond adding wells independently. A national digital well register should contain borehole coordinates, depth, screened intervals, pumping-test yields, pump specifications, abstraction volumes, static and pumping water levels, water chemistry, maintenance history and nearby contamination hazards. A modern database also records the uncertainty attached to historical drillers' logs.

3.2 Aquifer monitoring

Continuous observation in representative coastal zones would reveal seasonal recharge, drawdown, recovery and conductivity trends. Monitoring wells should represent different depths and aquifer units rather than only the nearest water-production asset. Groundwater-level data should be linked with rainfall, tidal observations, coastal salinity and individual well pumping records. Sentinel monitoring near major production zones permits an earlier response to rising chloride than occasional complaint-led testing.

Salinity risk requires location-specific analysis. A report of saltwater intrusion at a particular well does not establish a national salinity trend. Pumping restrictions, well rehabilitation, source blending, intake diversification and targeted groundwater recharge all involve different capital costs and environmental impacts. Decisions should rely on hydrogeological modelling and evidence from the relevant aquifer.

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3.3 Iron and broader water chemistry

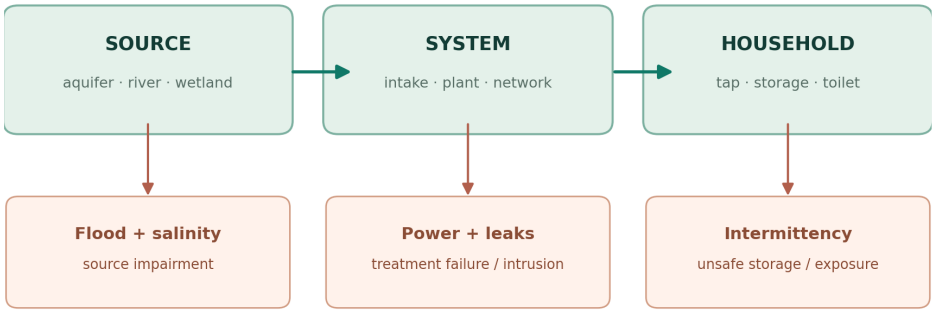
CDB documentation recorded historical iron concentrations up to about 6 mg/L in some inadequately treated supplies and used 0.3 mg/L as a programme quality threshold. GWI's March 2025 response to discoloured water in Lima Sands identified naturally high iron in the A-Sands aquifer. Reported post-treatment iron from the commissioned Cummings Lodge facility was 0.06 mg/L. Such results support treatment effectiveness at the stated point and time, not automatic network-wide compliance. [7,11,13]

Iron primarily creates aesthetic, deposition and operational concerns at ordinary drinking-water concentrations; microbial and toxic chemical parameters require separate health-based evaluation. A comprehensive well-testing programme includes iron, manganese, conductivity, chloride, pH, turbidity, relevant microbial indicators and any locally justified contaminants. Groundwater protection zones should also address fuel storage, septic systems, agriculture and industrial land use.

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4. Water quality, public health and source-to-tap management

08 | Risk pathways: why plant completion is not the same as safe household water



Cross-cutting control: independent laboratory surveillance + operator competence + asset renewal + public reporting

Exhibit 08. Source-to-household risk pathways. Source impairment, power and distribution failure, intermittent pressure and household storage can break the service chain despite successful construction. Conceptual analysis based on WHO water-safety planning. [4,34]

4.1 A risk-based surveillance model

Water quality is determined by source conditions, treatment integrity, distribution pressure, storage quality and household practices. A single compliant sample at a treatment plant does not establish safe water throughout the downstream service area. GWI's own monitoring responsibility therefore needs linked source, treatment-plant, distribution and household sampling, with accessible reporting of test frequency and exceedances. [14]

WHO water-safety planning offers a useful design discipline: identify hazards from catchment to consumer, set control points, verify performance independently and record corrective actions. In Guyana, control points differ across coastal deep-well networks, surface-water facilities, shallow village wells and creek-fed systems. Emergency sampling protocols should account for flooding, prolonged outages, pressure failure, bursts and contaminated storage.

4.2 Regional risk matrix

Setting	Exposure pathways to examine	Minimum surveillance design
Coastal production wells	Iron, manganese, saline intrusion, flooding around wellheads	Aquifer head, chloride, conductivity, treatment performance and sanitary inspection
Dense urban distribution	Pressure loss, bursts, storage, wastewater intrusion	E. coli, residual disinfectant, pressure telemetry and incident logs
Georgetown drains and sewer outfalls	Sewage, stormwater, industrial discharges	Fecal indicators, nutrients, oxygen demand and receiving-water monitoring

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Setting	Exposure pathways to examine	Minimum surveillance design
Mining catchments	Suspended sediment, turbidity, site-specific mercury and metals	Upstream/downstream sampling, hydrological context and independent laboratories
Irrigated agricultural districts	Nutrients, pesticides, saline drainage, pathogens	Seasonal sampling tied to cultivation and flood cycles
Hinterland creek or shallow-well systems	Wet-season turbidity, animal waste, septic contamination	Microbiology, turbidity, sanitary surveys and safe-storage inspections

4.3 Mining and mercury

Inland mining has a geographically concentrated relationship with freshwater. Land clearing, sediment release, road drainage, fuel handling, tailings, domestic wastewater and possible mercury use require site-specific controls. Baseline and downstream samples should reflect flow conditions because contaminant concentration alone may not describe load during floods. High turbidity is not proof of mercury contamination, and mercury detection in one waterway is not proof of exposure across a whole region.

A credible mining-water programme records intake, recycling, discharge, sediment-management works, upstream reference stations, downstream compliance points and laboratory chain of custody. Where mercury risks are present, surveillance should include fish-tissue exposure pathways alongside sediment and water monitoring. Public results require detection limits, sampling dates, units, analytical methods and context on flow rates.

4.4 Community health

The CDB's Nappi field assessment described a failed drilled-water system, a contaminated hand-dug well, seasonal drying, flood contamination and long collection distances, alongside community-reported waterborne illness. The case shows why new hardware without recurrent maintenance cannot guarantee durable service. Recorded illness in a community assessment should not be interpreted as a nationwide disease rate. [12]

Village water programmes should budget local operators, replacement pumps, spare chlorination equipment, simple water-safety plans and laboratory access. Health clinics and schools require explicit priority arrangements during system failure. Community councils should hold inspection records and know how to escalate contamination events.

5. Wastewater, sanitation and urban drainage

5.1 Georgetown's inherited infrastructure

GWI's publicly available description of Georgetown's central sewerage system records an original network dating from 1929, 24 sewer basins and associated pumping stations. The description also records historical untreated discharge and past operational problems at the Tucville treatment works. Because the published description is older, present-day operating conditions require an independent asset and discharge audit. A new investment plan should not assume every historical defect remains unresolved. [8]

The audit should cover pump condition, electrical resilience, pipe integrity, infiltration, illicit connections, blockages, customer coverage, actual wastewater flow, outfall water quality, industrial connections, septic systems and emergency bypass frequency. Pump rehabilitation without downstream treatment and receiving-water controls would address only part of the environmental exposure.

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5.2 Choosing sanitation systems by settlement type

Dense parts of Georgetown suit sewerage and central or modular treatment where hydraulic gradients, service density and land availability justify the cost. Secondary towns might combine clustered sewer networks, package treatment and decentralised management. Low-density communities may achieve greater reliability through regulated onsite sanitation and scheduled fecal-sludge collection rather than long conventional sewers. The choice needs independent assessment of soil, flood exposure, groundwater depth, land tenure, power, receiving waters and O&M capacity.

Potential environmental performance measures include the percentage of collected wastewater receiving effective treatment, effluent compliance at each outfall, operating uptime, fecal-sludge volumes safely transported, illegal discharge reports and receiving-water trends. Reported access to toilets cannot substitute for safe management of the waste after collection.

5.3 Drainage and sanitation are linked

Pluvial flooding can overwhelm urban drainage and contaminate wells or household storage when sewer or septic systems surcharge. Where drinking-water pressure is intermittent, pipe defects elevate the risk of intrusion during pressure loss. Coastal drainage design should account for rainfall duration, coincident high tide, river stage, pump outages and future relative sea level. Engineering studies should quantify these compound conditions rather than apply a generic national climate uplift.

5.4 A measurable wastewater and sanitation baseline

The UN's 2024 Guyana series estimates **43.4%** of the population using safely managed sanitation and **33.4%** of domestic wastewater flows safely treated. The first is a household service indicator; the second addresses waste flows. It would be an accounting error to assume that the two percentages should match or that either is Georgetown's current network-treatment rate. National estimates should be verified against plant inflows, actual treatment, safe on-site containment and licensed sludge-disposal records. [20]

A transparent wastewater investment case should start by measuring the sewered and unsewered populations within each proposed project boundary. Flow-monitoring should capture dry-weather flows, wet-weather infiltration and possible bypasses. Where gravity sewerage is not practical, a safely managed fecal-sludge chain must include household containment, licensed emptying, transport, treatment and permitted end use or disposal. The performance metric is effectively treated waste, not the number of toilets constructed or kilometres of new sewers.

The IDB's 2024 technical-cooperation project **GY-T1200** covers preparation of climate-resilient water infrastructure and potential future wastewater investment in unserved Georgetown areas. It is a preparation activity, not proof that proposed sewerage or treatment works have been commissioned. The later first individual loan under **GY-L1087** targets potable-water quality, non-revenue water and GWI digitalisation. These programmes are complementary but should retain separate benefit registers and avoid counting the same households twice. [23,27]

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6. Agricultural water security and food-system resilience

Agriculture requires dependable water at the right time, in the right location and at suitable salinity. Rice, sugar, livestock and diversified crops face different seasonal demand patterns and water-quality limits. Coastal conservancies and drainage channels often perform dual functions: retaining freshwater for agriculture while disposing of excess rainfall. Conflicting operating objectives must be identified explicitly in water-management rules.

In an extended dry period, allocation should consider drinking water, ecological minimums, livestock and crops, industrial continuity and available storage. During extreme rainfall, pumping may protect one agricultural block while transferring peak flows downstream. A basin and drainage-district approach should therefore record intakes, flow control, conveyance losses, crop calendars and receiving-water impacts.

Options include calibrated irrigation scheduling, field moisture monitoring, improved canal control, storage rehabilitation, water-user reporting and salinity alerts. Farmers need decisions based on local water levels and water-quality data rather than broad annual rainfall projections. Economics should include pumping energy, crop yield, lost days from waterlogging, salinity recovery and maintenance of canals and structures.

Agricultural pollutants also require proportionate surveillance. Nutrient or pesticide sampling should reflect actual farming systems and application calendars. Risk controls may involve buffer strips, drainage timing, storage of agrochemicals, integrated pest management and targeted extension support. Such controls should be assessed against measured contamination and farmer adoption costs instead of blanket assumptions.

7. Industry, mining, energy and commercial water demand

Guyana's urban development, construction, agro-processing and extractive activity will add new water users and change local demand patterns. National water abundance should not be treated as unlimited operational entitlement. An industrial site needs reliable source quantity, intake permits, pretreatment or discharge approvals, protected community access, seasonal storage and defined responses to drought or floods.

Mining-water balances require separation of fresh makeup water, recycled process water, mine dewatering, rainwater, contact water and environmental releases. A project with high recycling may still affect downstream flows or quality depending on the season. Commercial disclosure should therefore identify litres or cubic metres withdrawn, recycled, consumed and discharged, with monitoring at defined compliance stations. The same transparent mass-balance discipline is useful for food processing, cooling systems, construction and future manufacturing.

Water-related energy costs form another investment variable. Pumping deep wells, operating treatment plants, producing chemicals and running drainage pumps can place a persistent burden on utility finances. Solar pumping and backup storage can improve some hinterland systems, but they introduce equipment, control and maintenance requirements. A lifecycle comparison should include replacement parts and technical support rather than treating renewable-power infrastructure as maintenance-free.

Corporate participation may support source protection, shared laboratories, community infrastructure and hydrometric data, subject to regulatory oversight. Public institutions should retain authority over resource allocation and compliance. Voluntary company disclosure supplements, rather than replaces, independent environmental monitoring and public-service accountability.

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8. Freshwater ecosystems and Indigenous stewardship

Guyana's forests, rivers and wetlands deliver functions often omitted from engineering balance sheets. Riparian forests limit erosion and moderate localized sediment transfer. Wetlands store water, attenuate flood peaks under appropriate conditions and support fisheries and wildlife. Mangroves support coastal protection and biodiversity but do not eliminate the need for engineered sea defences or drainage management. Their actual hydrological contributions should be assessed site by site. [9,10]

North Rupununi illustrates the connection among water, Indigenous livelihood systems and conservation. Seasonal inundation supports fisheries and habitat connectivity. Infrastructure projects must consider village knowledge, customary use, migration routes, fish breeding sites and the timing of floods. Community organisations need meaningful participation in defining monitoring locations and interpreting local changes. [9]

A conservation programme should report ecological condition in addition to area protected. Suitable indicators include wetland connectivity, water levels, seasonality, turbidity, habitat condition, fish assemblages where feasible and agreed livelihood outcomes. Restoration should avoid planting or engineered interventions that disrupt natural flood regimes. Funding models include government budgets, grant finance, ecosystem restoration projects and responsibly governed conservation programmes. Revenue estimates should not be presented as bankable without a defined methodology and market pathway.

9. Climate change, flood exposure and drought planning

9.1 Compound hazards

Guyana's coastal water infrastructure faces interacting hazards: intense rainfall, high tides, elevated river water, local drainage obstruction, electricity failures and sanitary contamination. Drought presents a different combination of risks: low shallow-water availability, irrigation stress, greater deep-well demand and saline intrusion near vulnerable coastal zones. CDB has identified flooding, contamination and drought-related salinity as sector risks. [7]

Risk assessments should study plausible sequences. One example is a short-duration extreme rainfall event coinciding with high coastal levels and power interruption. Another is a dry period during which pumping concentrates in the most reliable wellfields, reducing heads in particular aquifers. Neither scenario is a prediction of event frequency. Both are valid engineering stress tests requiring site-specific input data.

9.2 Sea-level and rainfall scenarios

The IPCC Sixth Assessment Report provides global sea-level scenarios through 2100. Local relative sea level along Guyana's coast differs because regional ocean variability and local land motion affect the experienced water level. Coastal infrastructure should use local tide-gauge and elevation data alongside climate projections. Simply applying one global projected rise to every coastal district risks both underdesign and unjustified expense. [15,16]

Country-level climate projections from the World Bank Climate Change Knowledge Portal support screening, but annual average rainfall is not sufficient for pump, outfall or reservoir design. Design requires intensity-duration-frequency relationships, antecedent moisture, drainage-area response, sea-level boundary conditions, erosion and available pumping redundancy. Where long records are incomplete, sensitivity tests should show how uncertainty affects infrastructure choices.

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9.3 Adaptation options and tradeoffs

Flood-resilient water facilities may require raising electrical equipment, protecting access roads, sealing wellheads, diversifying power, storing chemicals securely and protecting emergency water reserves. Drainage adaptations include calibrated pump operation, sluice rehabilitation, vegetation and solid-waste management, targeted storage and clear flood-response responsibilities. Nature-based options may complement engineered systems where their benefits can be measured.

Drought options include monitoring triggers, public demand management, storage, protection of shallow sources, alternative intakes, seasonal abstraction limits and contingency water transport. Desalination is a possible technology under some localized salinity scenarios, but capital cost, energy needs, brine management and available alternatives require appraisal. No single intervention suits all Guyanese coastal and interior settings.

9.4 How to use climate scenarios without inventing local forecasts

The World Bank's June 2024 coastal-resilience project describes a planned intervention expected to benefit approximately **320,000 people** through better adaptation and lower coastal flood risk. It provides independent evidence that coastal flood management is nationally material, but the beneficiary estimate is not a measured 2026 reduction in flood losses. [25]

The World Bank Climate Change Knowledge Portal presents CMIP6 multi-model scenario data for Guyana at roughly **0.25-degree spatial resolution** and explicitly cautions that precipitation is variable and local-scale projections have uncertainty. Consequently, this paper does not assume that national rainfall will fall by an arbitrary 5%, 10% or 15% by 2035, or that every Guyanese district faces the same dry-season change. For individual investments, design teams should use the relevant coastal or hinterland grid cells, historical gauge data, site drainage surveys and a range of plausible rainfall and sea-level conditions. [26]

A compound-hazard engineering check should examine heavy rainfall concurrent with high tide and power outage; a prolonged dry period concurrent with low river discharge and elevated salinity; and flood damage concurrent with interrupted chemical deliveries. Resilience should be measured through time to service restoration, verified safe storage, emergency power autonomy and the share of vulnerable users maintaining minimum supply, rather than by a generic national climate-stress score.

10. Governance, law and institutional coordination

The Water and Sewerage Act establishes the sector's primary statutory framework and makes provision for national water-resource coordination, including a National Water Council. GWI is the public water and sewerage operator. Drainage and irrigation, hydrometeorology, environmental permits, public health, disaster risk, regional administration and Indigenous governance sit across other bodies. By 2026, GWI operated under the Ministry of Public Utilities and Aviation. [14,17]

Integrated planning does not require collapsing every institution into one agency. It requires common information, clear authority, compatible standards and enforceable escalation when one sector's actions affect another. A national water information arrangement should join basin data, production and customer demand, groundwater levels, water quality, drainage operations, climate hazards and investments under common geographic identifiers.

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A functional coordination mechanism requires publicly identified representatives and defined outputs: updated basin plans, water-budget methods, groundwater licensing, shared transboundary data protocols, drought triggers, wastewater discharge standards and priority capital projects. Legal advice is necessary before specifying new statutory powers or asserting the current legal status of individual permits.

Transboundary information sharing with Suriname and Brazil matters for the Corentyne and southern border waters. Existing bilateral cooperation on infrastructure offers a technical channel for exchange of river-stage data, water-quality alerts, construction impacts and emergency spill information. This paper does not assume a comprehensive allocation treaty exists without a current legal inventory. [2,18]

10.4 Regulatory crosswalk: responsibilities and evidence needed

The **Water and Sewerage Act, Cap. 30:01** establishes a legal framework relevant to water and sewerage, including hydrometeorological and abstraction functions described in its text. The **Environmental Protection (Water Quality) Regulations, 2000**, and other applicable environmental authorisations regulate relevant discharge activities. The **GGMC Code of Practice** library includes mining-water-related guidance on mercury, mine effluents, tailings and environmental-effects monitoring. These are different functions: a permit, a drinking-water service standard, a wastewater effluent condition and a mining environmental-monitoring obligation are not interchangeable. The latest consolidated text, current permit conditions and agency mandates should be checked for every regulated activity before a legal compliance conclusion is made. [30,31,32]

Institutional interface	Relevant public responsibility or function	Evidence the public system should preserve	Boundary
GWI	Drinking-water and sewerage service provision	Production/billing balance, disaggregated service reliability, tap-quality monitoring and maintenance records	Utility operating data are not a substitute for independent household service surveys
Hydrometeorological Service	Weather, river and groundwater-related data and drought bulletins	Station metadata, quality-controlled trends, drought triggers, abstraction and borehole records where held	Drought bulletins are seasonal assessments, not well-specific pumping permits [33]
Environmental Protection Agency	Water quality and environmental authorisations	Permit conditions, source and discharge samples, audit and enforcement records	Permit conditions may differ by project and receiving-water characteristics [31]
GGMC	Mining sector technical and environmental oversight	Mine discharge, sediment, mercury-management and rehabilitation evidence	Sector codes must be read alongside applicable permits and legislation [32]
NDIA / Ministry of Agriculture	Drainage and irrigation assets and service	Canal/sluice/pump register, event-based drainage performance, salinity and irrigation demand	Flood-control output is not drinking-water output [25]
Bureau of Statistics and health institutions	Population denominators, household data and public-health surveillance	Survey methodology, disaggregation and safe health-data governance	Modelled service estimates should not be represented as universal household tests [24,28]

The public-interest test is to reconcile identifiers across these data systems, not to centralise every regulatory mandate. A common well ID, treatment-plant ID, source basin ID and discharge location can support transparent cross-agency analysis without releasing sensitive household or community information.

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10.5 Climate services, drought intelligence and local resilience design

Guyana's Hydrometeorological Service publishes seasonal drought bulletins, including March-May 2026 and other 2026 outlooks. These constitute decision inputs for irrigation managers, village water operators and utilities. Their meaning is probabilistic and seasonal; a national outlook cannot establish the yield of one well or the exact rainfall at a specific future construction site. [33]

For a high-impact coastal project, stress-test the compound conditions of rainfall plus high tide plus power interruption plus restricted drainage outlet. For a hinterland system, test a prolonged dry-season source reduction together with delayed delivery of fuel, chlorine or pump spares. For a wellfield, test high abstraction, lower recharge and individual well failure while independently observing hydraulic head and conductivity. Each design file should state the event, model version, gauge period, land elevation datum, pump reliability and recovery-time objective. [15,16,25]

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11. Public investment, financing and lifecycle economics

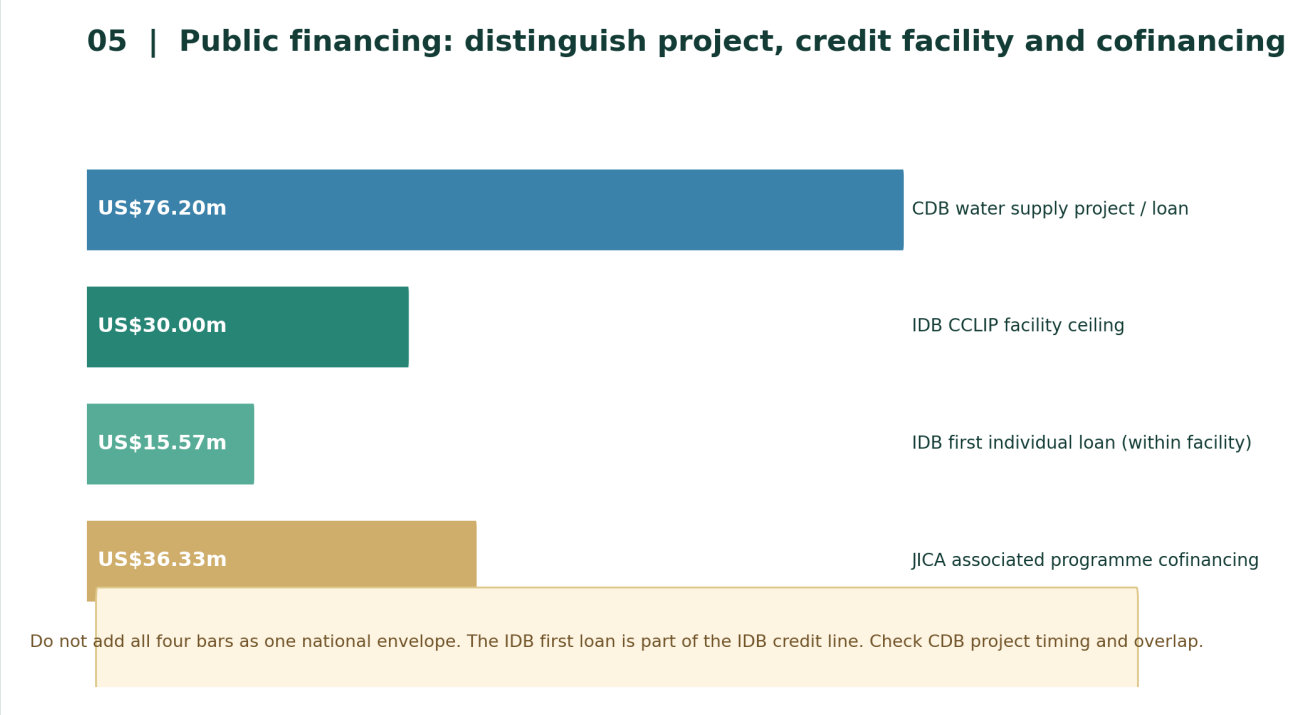


Exhibit 05. Non-additive financing layers. The IDB first individual loan is inside its conditional credit-line ceiling; associated JICA cofinancing and a separate 2023 CDB operation require independent accounting. The graphic is not a consolidated capital-budget estimate. [19,22,23]

11.1 What the official figures establish

The 2026 budget reports GYD 19.7 billion of water-sector expenditure in 2025 and allocates GYD 21.6 billion for 2026. GYD 8.2 billion of the 2026 sum is associated with water-quality and service interventions. The budget also identifies hinterland water investments, including solar pumping, new wells and community distribution systems. Ministry-wide appropriations covering other public utilities and aviation must never be represented as dedicated water spending. [5]

The GYD 40 billion coastal treatment programme and CDB's July 2023 approval of a USD 76.2 million water-supply improvement loan illustrate the investment mix. CDB's financed works cover several coastal areas, water treatment, storage, transmission mains and meters. Amounts from separate announcements should not be added into an asserted national total unless their funding and programme overlaps are reconciled. [6,19]

11.2 Planning options

A national investment pipeline can be organised by service outcome rather than institution alone. Drinking-water projects should publish produced volume, treated volume, household service, pressure, water quality and energy cost. NRW programmes should publish measurable recovered volume and reductions in apparent loss. Wastewater projects should report actual treatment and effluent compliance. Drainage projects should report the level of service achieved under specified design events. Nature projects should disclose ecological and community monitoring evidence.

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Financing sources differ by asset and beneficiary. National budget finance may cover public-health protections and strategic flood assets. Development-bank lending may support large treatment, sewerage and network investments with independent safeguards. Grants may support low-density remote systems and community capacity. Tariff revenue may cover recurring utility operations if affordability measures and transparent service standards are maintained. Climate and biodiversity finance may support eligible resilience or ecosystem projects, subject to financing rules and measured outcomes.

11.3 Lifecycle affordability

The least expensive construction tender is not necessarily the least expensive water service. The relevant measure combines acquisition, land, treatment consumables, pumping electricity, operators, laboratory testing, repairs, spare parts, renewal, waste residuals and end-of-life liabilities. For major plants, a publicly disclosed 20-year present-value comparison should test different energy prices, maintenance levels and demand assumptions. Remote solar systems deserve the same replacement-cycle assessment for panels, control units, pumps and batteries where applicable.

No validated consolidated 2026-2035 national water-investment gap was located in the public sources reviewed for this paper. A precise national cost estimate would therefore overstate available evidence. The practical first step is an audited asset inventory, consistent service standard and climate-adjusted capital and O&M costing methodology.

11.4 IDB and JICA: a financing and delivery test case

On **16 July 2025**, the IDB approved conditional credit line **GY-O0013**, with a **US$30 million** envelope for water and sanitation improvement, and the first individual loan **GY-L1087**, worth **US$15.57 million**. The IDB's public account also describes **US$36.33 million** of JICA cofinancing to support the programme. The credit-line envelope is not the first-loan amount and should not be presented as though all financing lines were fully disbursed or separately additive. IDB's current project page lists GY-L1087 as under implementation and includes a public monitoring report published in July 2026 referring to the 2025 period. [22,23]

The public programme expects **approximately 151,560 people** to benefit from safe, reliable service improvements. Its described assets include the proposed Diamond water treatment plant and about **15 kilometres** of transmission mains and interconnections. Its operating reforms include advanced leak detection, meter improvements, information systems, and commercial management across East Bank Demerara, East Coast Demerara and Cummings Lodge. These are planned scope and expected benefits. A credible results report should separate procurement, physical completion, commissioning, verified service-hours and verified household water quality. [22,23]

Project-control question	Public starting point	Required verification before claiming benefit
Was capital committed?	Approved CCLIP and first individual loan	Executed financing documents and actual disbursement
Were assets installed?	Diamond plant and associated mains in programme scope	Contract award, progress certificate and asset acceptance
Did billed and physical losses fall?	NRW work explicitly included	Pre/post calibrated water balance by metered district
Did households gain reliable safe water?	151,560 expected beneficiaries	Valid household surveys, supply logs and independent test data

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Project-control question	Public starting point	Required verification before claiming benefit
Will gains last?	Metering and digitalisation in programme	Trained operators, funded O&M and verified maintenance records

The financing case for further expansion should be recalibrated when the initial project's operating data arrive. It is inappropriate to infer that a new treatment plant's rated output translates into equivalent increases in delivered water when existing distribution losses, intermittent supply and power constraints have not been resolved.

11.5 Capital evidence register: keep the financing ledgers separate

Public documents disclose several investments that illustrate the scale and diversity of Guyana's water and flood infrastructure. Their headline values cannot be aggregated into a national capital requirement: budget allocations may finance multiple works, some project costs overlap with development-bank financing, and 2024-2026 projects have different purposes, schedules and beneficiary definitions. The table deliberately places the instrument and verification boundary beside each amount.

Investment or instrument	Public amount	Reference period / type	Accounting interpretation	Source and verification boundary
Water-sector spending	GYD 19.7bn	2025 reported expenditure	Dated sector spending, not capital-only	Ministry of Finance 2026 Budget Speech, printed p. 61 [5]
Water-sector spending plan	GYD 21.6bn	2026 budget	Allocation, not audited spending	Ministry of Finance 2026 Budget Speech, printed p. 61 [5]
Water quality and service works	GYD 8.2bn	2026 allocation within water plan	Subset; must not be added to GYD 21.6bn as separate national spending	Budget-at-a-glance 2026, p. 19 [36]
Coastal Water Treatment Infrastructure Programme	Around GYD 40bn	Announced multi-project programme	Programme envelope, project composition requires reconciliation	Government programme announcement [6,37]
Cummings Lodge treatment plant	GYD 1.3bn	Plant commissioned October 2025; nominal 12 MLD	Facility-specific reported construction cost, not full network lifecycle cost	DPI commissioning account [11]
Five Miles, Bartica treatment plant	GYD 468m	Plant commissioned February 2026	Facility-specific reported construction cost, not a national unit-cost benchmark	DPI commissioning account [6]
CDB water supply project	US$76.2m	Approved 2023 financing	Project-level loan; overlap with subsequent subprojects must be checked	CDB approval announcement [19]
IDB water/sanitation conditional credit line	US$30m	Approved July 2025	Facility ceiling, not equivalent to amount drawn	IDB GY-O0013 [23]

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Investment or instrument	Public amount	Reference period / type	Accounting interpretation	Source and verification boundary
IDB first individual loan	US$15.57m	Approved July 2025	First loan within the conditional credit line	IDB GY-L1087 [23]
Associated JICA programme cofinancing	US$36.33m	Publicly described July 2025	Separate lender source, not proof of disbursement	IDB announcement [22]
Coastal Adaptation and Resilience project	US$45m	GRIF-financed World Bank project approved June 2024	Drainage/flood-resilience project, not additional GWI potable-water capital	World Bank press release [25]

The Cummings Lodge plant's reported **GYD 1.3bn / 12 MLD** yields **GYD 108.3m per installed MLD** as a descriptive arithmetic quotient. This is not a tender price for another plant. Site works, chemical processes, storage, distribution, power, transport, escalation and contractor risk allocation may vary materially. Its 12 MLD rating is also not equivalent to verified average compliant output. No feasible national investment gap can be computed by multiplying that quotient by a countrywide guessed treatment deficit. [11]

11.6 A transparent worked lifecycle-cost sensitivity

For scale only, consider an **entirely hypothetical 10 MLD plant** whose capital cost is set at 0.5x, 1.0x or 2.0x the observed Cummings Lodge capital-per-nameplate-MLD quotient. These multiples are sensitivity assumptions, not market quotations, contractor estimates or a proposal for a specific site. Annual O&M is illustrated at 3%, 5% and 8% of initial capital expenditure, with a 20-year operating horizon and 6% real discount rate. The annuity present-value factor at these assumptions is 11.4699. All cases exclude land, expansion of distribution, residual-value assumptions, major rehabilitation, debt service, working capital and any differentiated treatment chemistry.

Hypothetical case	Initial capex GYD bn	Annual O&M share	Annual O&M GYD m	Discounted 20-year O&M GYD bn	Discounted capital + O&M GYD bn
Half-baseline capex, low O&M	0.542	3%	16.3	0.186	0.728
Baseline-analogue, middle O&M	1.083	5%	54.2	0.621	1.704
Double-baseline capex, high O&M	2.167	8%	173.3	1.988	4.155

The worked example demonstrates how lifecycle commitments can vary by more than the initial headline capital cost, not what Guyana should spend. Actual procurement needs local geotechnical studies, finished-water design criteria, intake/well yield tests, detailed bills of quantities, utility financial accounts, a distribution hydraulic model and reviewed escalation scenarios. A reproducible CSV is included in the companion technical packet.

11.7 Appraisal architecture for capital investment

Every major supply, sanitation or flood project should state a baseline that can be audited: people and supply zones served, achieved pressure, compliant water delivered, hours of supply, measured physical and apparent losses, design-season source yield and assets at risk. At least four options can then be evaluated on the *same*

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service denominator: renewal and NRW management only; source/treatment expansion only; combined supply and network works; and a diversified supply-plus-contingency option. For wastewater, compare central sewerage with clustered and safely managed onsite alternatives using equivalent verified pollutant-removal or safe-containment outcomes. For drainage, compare civil works, pumping, nature-based storage and maintenance recovery using stated rainfall/tide events.

The appraisal should publish net-present lifecycle cost, environmental and social safeguards, affordability distribution, power intensity, resilience under outage, operator staffing, procurement maturity and service-outcome uncertainty. No option is labelled universally superior here: which option performs acceptably depends on project-specific measurements and the chosen public-service standard.

12. Case studies with verification boundaries

12.1 Cummings Lodge: treatment capacity and source-to-tap delivery

The Cummings Lodge water-treatment plant, commissioned in October 2025, provides a concrete reference for modern treatment infrastructure. Government reported approximately GYD 1.3 billion of investment, nominal 12 MLD treatment capacity and 3.6 million litres of storage. A reported post-treatment iron result of 0.06 mg/L indicates effective removal at the sampled location. Verification of the broader benefit requires monthly operational output, treated-water quality, zone-level pressure, downtime and customer feedback over a complete seasonal cycle. [11]

12.2 Bartica: modular capacity and secondary-town growth

The Five Miles facility illustrates investment outside the dense coastal corridor. Government reported a GYD 468 million plant serving around 6,000 residents and described modular design to facilitate expansion. Long-term performance should be assessed against population growth, nearby development, staffing, spare parts, energy resilience and actual water-quality trends. A commissioning ceremony is evidence of a project milestone, not a lifecycle evaluation. [6]

12.3 Nappi: remote systems and maintainability

CDB's Nappi case documents a failed installed system, reliance on contaminated or seasonally unreliable water, collection burden and reported illness. The most relevant transferable lesson is that design acceptance should include operator training, funding for repairs, safe storage, microbiological monitoring and reliable access to spare parts. Community knowledge and control of the maintenance response are central project design inputs. [12]

12.4 Hope Canal: surface-water diversification

Government has identified the Hope Canal area for a new surface-water treatment plant with a proposed 24 MLD capacity. Such diversification can reduce exclusive dependence on particular groundwater sources, but surface-water facilities require a distinct treatment, intake protection and flood-contamination assessment. Feasibility appraisal must address seasonal raw-water quality, drought reliability, ecological effects, sediment, chemical and sludge handling, and full power requirements. The proposal remains a planned project until actual operating data are available. [5]

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12.5 Georgetown: wastewater verification before design

GWI's historical description makes Georgetown's sewer system a case for condition-based investment. A verified 2026-2027 audit should inspect current assets and outfalls rather than copy older assumptions into a new master plan. The investment choice between sewer repair, centralized treatment and decentralized systems depends on real measured flow and receiving-water conditions. [8]

13. Strategic pathways through 2035

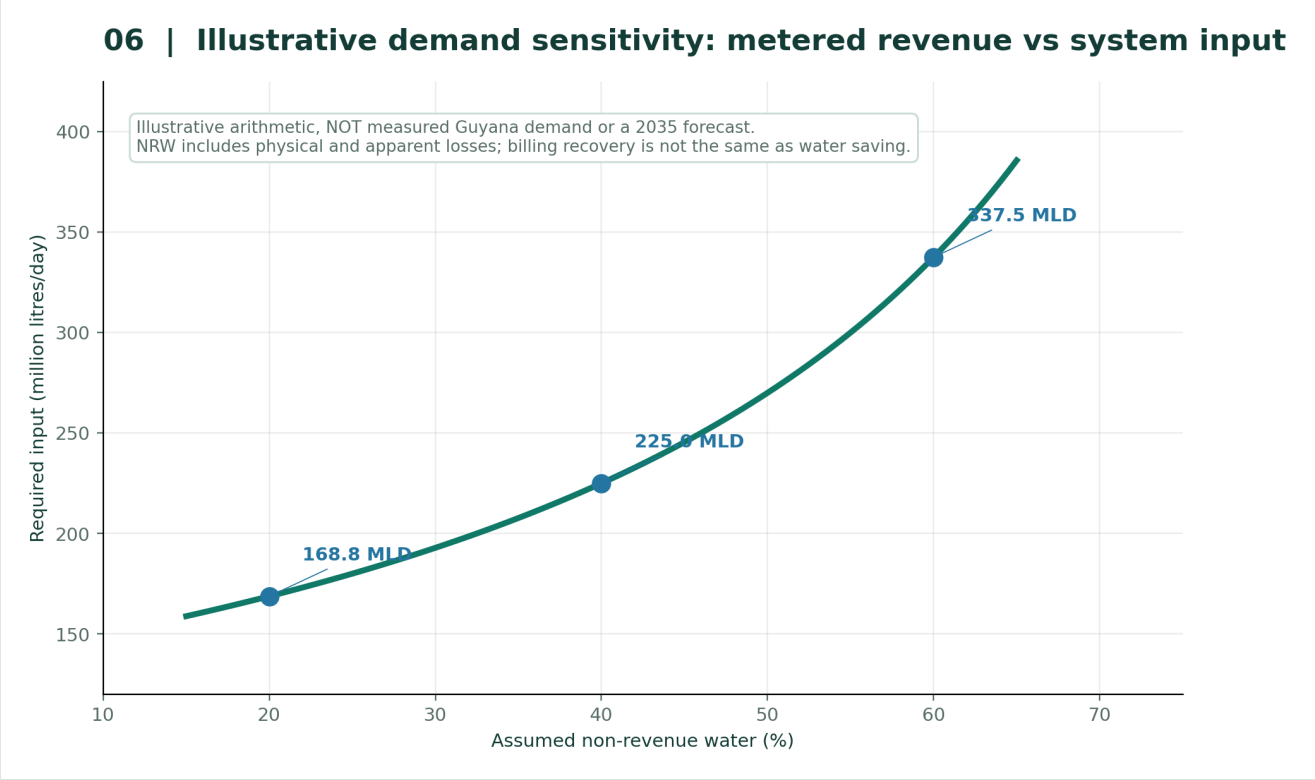


Exhibit 06. Reproducible demand sensitivity. Fixed hypothetical billed use of 135 MLD for 0.9 million notional consumers at 150 L per capita per day; increasing assumed NRW increases required input. This is arithmetic, not measured demand or a 2035 forecast.

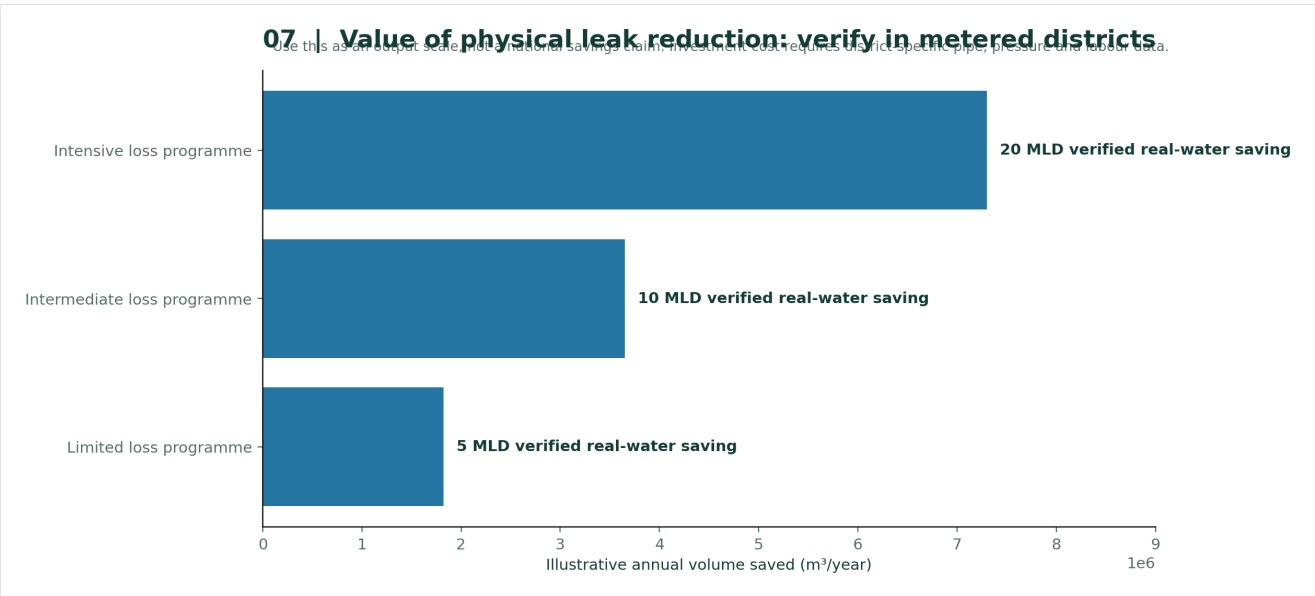


Exhibit 07. Physical loss output scale. Illustrative real-water savings of 5, 10 or 20 MLD correspond to 1.825, 3.65 or 7.30 million m³/year if independently demonstrated for a full year. They are not Guyana performance claims.

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This paper presents three illustrative investment pathways for stress testing. These are structured alternatives, not forecasts and not recommended political programmes. Each pathway faces a different combination of delivery risk, near-term affordability and asset-management requirements.

Illustrative pathway	Principal emphasis	Potential benefit	Principal tradeoff
Expansion-led	New treatment plants, mains and wells	Faster extension of nominal supply capacity	Leaves operating losses and sanitation gaps unless separately funded
Performance-led	NRW, water quality, maintenance, current asset rehabilitation	Greater usable output and reliability from existing facilities	Benefits depend on credible baseline data, metering and skilled operators
Integrated resilience	Drinking water, wastewater, drainage, aquifers and watershed protection	Addresses interacting climate, health and ecosystem exposure	Higher coordination and project-preparation requirements

A transparent comparison needs consistent measures. The alternatives should be tested against service-hours gained, people receiving safely managed water, life-cycle cost, emissions, water losses, public-health risk, flood exposure, ecological impacts and institutional execution capacity. Reporting only tonnes of concrete, kilometres of pipe or headline budget allocation will not capture these differences.

Scenario analysis must also test adverse conditions: slower revenue growth, higher power costs, delayed construction, extreme rainfall during commissioning, a multi-month drought, higher-than-expected O&M, low meter functionality and uneven village maintenance. The output should identify robust options under several conditions rather than assign unsupported probabilities to a preferred outcome.

13.1 A transparent demand-and-loss sensitivity test

Public water-withdrawal series do not provide a defensible 2026, all-sector volumetric baseline that can be projected mechanically to 2035. The **2022 census population of 878,674** is a verified population count at that date, not evidence for a precise 2035 population. The following table is therefore a **deliberately hypothetical arithmetic sensitivity**, not a prediction, project design, approved target or statement about actual Guyanese withdrawals. It illustrates how demand and water accounting interact if planners test different service populations, per-capita authorized water use and non-revenue-water assumptions. [24]

Illustrative service case	Assumed served population	Assumed authorized use	Assumed NRW	Authorized use (MLD)	Approx. system input (MLD)	Approx. annual input (million m3)
More efficient	900,000	120 L/person/day	25%	108	144	52.6
Middle case	1,000,000	150 L/person/day	45%	150	273	99.5
High-loss stress test	1,100,000	180 L/person/day	65%	198	566	206.5

Formula: authorized-use MLD = assumed population x daily litres per person / 1,000,000; approximate system-input MLD = authorized-use MLD / (1 - assumed NRW share); annual million m3 = system-input MLD x 0.365. Values are rounded. The simplified denominator treats authorized use as if it were the relevant billed-demand

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equivalent. Actual NRW also contains authorized unbilled use and apparent losses, and system boundaries may exclude self-supplied households. A real national model must reconcile those categories before applying the formula.

The spread is not evidence that Guyana will need 52.6, 99.5 or 206.5 million cubic metres a year for public supply. It demonstrates that unverified losses can dominate an investment model. A smaller capacity increment paired with measured NRW reduction may deliver different value from expanding raw abstraction alone. The test intentionally **excludes** agricultural and industrial withdrawals, which require separate, basin-specific accounting rather than being invented as a percentage of this table.

13.2 From sensitivity to investment appraisal

For any proposed intake, wellfield, plant or transmission main, require a metered current-day demand baseline, explicitly modelled future connections, fire and emergency provision, seasonal peak factors, verified physical-loss and commercial-loss assumptions, actual days of treatment-plant uptime, and climate-related source derating. Compare an expansion-only case with targeted leak control, demand management, source diversification and a combined option. Report the discounted lifecycle cost and service-quality result for each option. No comparative cost ranking should be asserted without the project's real cost and output data.

Public appraisal must also evaluate electricity and chemical intensity, maintenance capacity, land acquisition, receiving-water effects, Indigenous and local community consultation, resilience during flood or drought events, and the affordability of tariffs or subsidies. A project with an attractive capital unit cost can have high long-run cost if its power supply or repair chain fails.

13.3 Reproducible demand sensitivity: 36 cases, not a point forecast

Let P be the hypothetical served population in millions, q the hypothetical billed authorised use in L/person/day and n the assumed NRW share. Then billed demand in MLD is P x q, and required system input is (P x q) / (1-n). This intentionally simplifies away unbilled authorised consumption, storage changes and seasonal peak factors. The accompanying 36-row CSV varies P = 0.8, 0.9, 1.0 and 1.1 million; q = 100, 150 and 200 L/person/day; and n = 20%, 40% and 60%. No scenario row is labelled a forecast for Guyana. The 2022 preliminary census reported **878,674** residents; a later government statement estimated **956,044** at end-2024, but neither can be equated to future utility customers without settlement and service-area modelling. [24,38]

For a transparent central arithmetic example, P = 0.9 million and q = 150 L/person/day imply 135 MLD billed demand. With an assumed 20% NRW, system input is 168.75 MLD. At 40%, it is 225.00 MLD. At 60%, it is 337.50 MLD. The span is an input requirement under assumptions, not actual utility output. Even if a utility's reported NRW share falls sharply, the volume physically recovered must be established separately because correcting billing errors and meters can reduce NRW without saving the same volume of real water.

Scenario	Hypothetical population served	Hypothetical billed L/capita/day	NRW assumption	Billed authorised demand	Required system input
A: Low input sensitivity	0.9m	150	20%	135 MLD	168.75 MLD
B: Middle input sensitivity	0.9m	150	40%	135 MLD	225.00 MLD
C: High input sensitivity	0.9m	150	60%	135 MLD	337.50 MLD

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Scenario	Hypothetical population served	Hypothetical billed L/capita/day	NRW assumption	Billed authorised demand	Required system input
D: Lower-use / smaller service area	0.8m	100	40%	80 MLD	133.33 MLD
E: Higher-use / larger service area	1.1m	200	40%	220 MLD	366.67 MLD

A utility engineering forecast would need to replace every illustrative assumption with verified customer counts, approved demand planning standards, industry off-take, real/apparent loss splits, service hours, seasonal coincidence factors, pressure zones, environmental source-flow constraints and capital commissioning dates.

13.4 Test the physical-loss component separately

When a metered district demonstrates a sustained **real** saving of 5, 10 or 20 MLD, the annual source-volume reduction at an equal level of service would be 1.825, 3.650 or 7.300 million m^3, respectively. The equation is saved MLD x 365,000 m^3/year per MLD. Real savings also require enough pressure and demand to deliver equivalent service; savings inferred only from low night-flow estimates require independent spot checks and seasonal normalisation. These values are an output scale for project appraisal, not an assertion that such water is currently available or being lost nationwide.

A financial benefits model needs avoided energy, chemicals, emergency water transport, distribution failure and, where relevant, source-development costs. Additional billed revenue from commercial-loss reduction is a separate financial stream. Combining the two benefits without a measured water balance risks overstating economic returns.

13.5 Integrated scenario matrix: five independent stressors

Stressor and documented source	Illustrative planning case	Measured variable needed	Actionable decision test
Population and settlement change [24,38]	Accelerated connections in selected coastal growth zones	Georeferenced household and connection count	Capacity only where actual demand and source rights justify it
Non-revenue water [7]	20%-60% arithmetic range	Metered system input and verified apparent/real losses	Compare leak control and metering with new-plant expansion
Coastal hazard [15,16,25]	Rainfall coincident with high tide and power interruption	IDF curves, tide gauge, asset elevation, pump uptime	Identify design combinations and recovery time, not a universal national uplift
Drought [33]	Low source yield during an extended dry season	Aquifer head, river flow, salinity and forecast uncertainty	Plan alternate supply and operating restrictions by source
Project delivery [22,23]	Delayed procurement and staggered commissioning	Signed contracts, disbursement, plant tests and verified beneficiaries	Avoid counting approved finance or nameplate capacity as delivered results

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The matrix is deliberately not assigned a national probability distribution because countrywide hydrometric, consumption, leakage and asset-condition datasets were not sufficient to calibrate one in the public record reviewed.

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14. A staged national delivery framework, 2026-2035

10 | Stage-gated national delivery pathway, 2026-2035



Each gate requires a released evidence pack. Published capital spending is necessary, not proof of delivered service.

Exhibit 10. Stage-gated implementation. Baseline, validate, scale and assure: each stage requires evidence of service and maintenance, not only a construction payment or announcement.

Stage 1: establish the verified baseline, 2026-2027

The principal task is a common source of truth. Reconcile coverage and treatment definitions, independently verify CWTIP commissioning and output, create a digital register of wells and treatment assets, establish NRW district baselines, inspect Georgetown sewerage and major outfalls, map the most exposed water-supply facilities and publish a minimum national water-quality dataset. The work requires agreed reporting conventions before new progress percentages are publicised.

Stage 2: prove operating improvements, 2027-2030

Implement metered pressure zones, leakage repair and commercial-loss controls where audits support the business case. Commission selected wastewater interventions after detailed design and environmental review. Expand groundwater head and salinity monitoring. Establish funded O&M agreements for remote-community systems. Introduce location-specific climate design checks for new coastal assets and protection of priority river intakes and wetlands.

Stage 3: extend integrated resilience, 2030-2035

Evaluate the effectiveness of earlier investments against a consistent service record. Expand treatment and distribution where verified population and industrial demand justify capacity. Renew assets according to risk and remaining life. Scale appropriate wastewater approaches beyond Georgetown. Maintain watershed and wetland monitoring, cross-border data exchange and annual public reporting of service, costs and environmental outcomes.

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The sequencing is illustrative. Exact construction schedules should reflect project readiness, finance, procurement, consultation, environmental safeguards and operator capacity. The framework avoids assuming completion dates for projects whose implementation documents were not independently audited.

Stage 4: accountable delivery gates and a public 2030 checkpoint

Each institution should own a measurable contribution without presuming new statutory authorities. A GWI-led utility workstream can report treated output, non-revenue water, daily hours of supply, tap-water microbial compliance, meter functionality and the maintenance backlog. Hydrometeorological and appropriate scientific institutions can lead rainfall, river-flow and aquifer observations. NDIA can own drainage and irrigation asset-performance indicators within its mandate. EPA and sector regulators can report relevant permit monitoring, environmental incidents and remediation status. The statistical authorities should coordinate publicly explained household survey definitions with GWI operating data, while the ministries responsible for water, agriculture, the environment and finance coordinate priority investment decisions.

A practical **2030 checkpoint** should ask whether the 2026-2027 baseline was independently reconciled; whether new plants have completed sustained operating trials; whether named priority supply districts publish continuous water-quality and service-hour records; whether Georgetown has a measured wastewater flow and condition register; whether representative coastal aquifer observation wells have multiyear head and conductivity records; and whether remote village schemes have funded repair plans. Numeric targets can then be approved against audited baseline series. Publishing attractive but unverified targets before defining service and data coverage would undermine comparability.

Delivery gate	Minimum evidence package	Responsible function	Independent check
Baseline accepted, 2026-2027	Consistent meter periods, survey definitions, mapped asset IDs	Utility, statistical and hydrological teams	Cross-agency data-quality review
Infrastructure commissioned	Water-safety plan, test certificates, as-built network and standby-power test	Asset owner and contractor	Technical acceptance and regulator as applicable
Reliable service demonstrated	90-day operating record, representative tap tests, pressure and uptime	Utility operations	Independent laboratory and household sample
Source resilient	Aquifer/river monitoring, salinity triggers and emergency operating plan	Source owner, science agencies	Periodic external technical review
Benefits maintained, 2030-2035	O&M finance, spares, repeat service survey and asset condition	Owner, ministry and finance functions	Published assurance statement

The 90-day trial in this table is a proposed illustrative minimum, not an existing national contract requirement; actual acceptance criteria must be tailored to asset risk and regulatory obligations.

15. National indicator and assurance architecture

A national performance dashboard should publish indicators at least annually, with more frequent operational measures where feasible. All series should state definitions, geography, units, data collection method, coverage, quality-control process and version date.

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Indicator	Denominator or unit	Suggested reporting frequency	Quality check
Drinking-water access	Share of population under the stated national definition	Annual	Regional population reconciliation
Safely managed drinking water	JMP compliant household share	Survey cycle and annual updates when valid	Sampling and household criteria disclosure
Treated-water coverage	Share of relevant served population	Quarterly and annual	Plant output and network-zone reconciliation
Continuous supply	Median hours/day by supply zone	Monthly	Pressure/flow logs and customer surveys
Non-revenue water	(System input - billed authorized consumption) / system input	Quarterly	Calibrated bulk and customer meters
Physical leakage	Volume/day by pressure district	Monthly	Water balance and night-flow validation
Microbial compliance	Compliant samples / valid samples	Monthly	Accredited laboratory and chain of custody
Groundwater head	Metres relative to a stated datum	Daily telemetry, annual trends	Calibrated observation-well record
Coastal salinity	Chloride and specific conductance by well	Monthly or continuous at sentinels	Reference standards and laboratory confirmation
Wastewater effectively treated	Treated volume meeting standard / collected volume	Quarterly	Effluent sampling and flow meters
Flood service	Hours to drain after stated rainfall/tide event	Event-based and annual	Rainfall, tide and pump record
Remote-system functionality	Systems meeting defined service thresholds / audited systems	Quarterly	Independent site checks
Wetland status	Area, hydrology and agreed ecological indicators	Annual/seasonal	Remote sensing and field validation
Capital delivery	Approved budget, commitment, actual expenditure and operating readiness	Quarterly	Audited programme reporting
O&M adequacy	Funded recurrent costs / independently assessed requirement	Annual	Asset-class lifecycle estimates

These indicators should be disaggregated by coastal/hinterland status and, where legally and ethically appropriate, by region and community type. Public dashboards must protect household and Indigenous-community privacy, avoid releasing sensitive well-security details and provide access to underlying definitions and correction histories.

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16. Implementation risk and institutional capacity

Major delivery risks are not confined to construction. They include poor source data, unmetered assets, unsuitable technology selection, unreliable power, lack of skilled operators, delayed spare parts, inadequate laboratory coverage, overlapping institutional mandates and insufficient recurrent funding. Land, environmental and community-consent processes may also alter schedules. These risks should be visible in public project appraisal rather than hidden within contingency percentages.

Water projects need clear acceptance gates. Engineering completion should lead to commissioning tests, then a defined reliability trial, then ordinary operating performance reporting. Financial closeout should be tied to the availability of as-built drawings, operating manuals, parts lists, asset-register updates, water-safety plans and trained operators. Independent verification is especially valuable for large facilities whose output will affect multiple downstream communities.

For remote infrastructure, a maintenance agreement should name the entity accountable for pump failures, the maximum replacement lead time and the budget source. For large utilities, a common asset-management system should connect work orders, failures, metering, energy use and costs. For environmental monitoring, independent laboratories and consistent chain-of-custody arrangements improve confidence without displacing regulator authority.

17. Decision points and research gaps

Several gaps limit a comprehensive national water-risk model in 2026. A current independently reconciled national NRW figure was not established from the reviewed public record. A complete current national inventory of treatment, distribution, sewerage, drainage, irrigation and groundwater assets was not located. A recent national JMP-compatible safely managed drinking-water estimate is available for 2024 (67.2%), but geographically disaggregated current monitoring with independent tap-water validation still needs strengthening. Publicly accessible time-series data on abstraction, groundwater head, conductivity, microbial compliance, wastewater treatment and flood service remain fragmented.

These gaps should not be filled with modelled figures without disclosing assumptions. Instead, project appraisals should state the consequence of uncertainty. For example, different true NRW levels produce different value from leak repair compared with a new water source. Alternative aquifer-recharge assumptions change long-term pumping limits. Different rates of urban growth change treatment and wastewater needs. Public decisions become more transparent when these sensitivities are shown explicitly.

The central test for national freshwater security is not the presence of more infrastructure alone. It is whether the system supplies water of verified quality when needed, maintains essential public health and ecological conditions, supports productive uses, withstands climate shocks and pays for maintenance over the asset life. Guyana's extensive natural water resources create a substantial starting endowment. Their lasting value depends on measurable service and environmental outcomes.

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18. Evidence audit: claims this paper deliberately does not make

The Deep Research review identified useful official project information but also surfaced numerical claims that are **not adequately supported** by cited Guyana-specific measurements. They have been excluded from the paper's factual baseline. No current national water-withdrawal total, 2026 NRW rate, 2035 public-supply demand figure, or nationwide aquifer-salinity trend was established from the public sources reviewed. Sector shares sometimes repeated from generic international literature are not transferable to Guyana without matching the country's definition and measurement period.

The paper also declines to assert that Guyana will experience a fixed 5-15% reduction in rainfall by 2035; that national freshwater supply will face a defined numerical deficit; that all coastal aquifers have uniform chloride risk; or that inland water bodies are unaffected by transboundary governance. Climate and abstraction outcomes depend on site-level evidence, ensemble uncertainty and policy responses. Similarly, a financing approval is not proof of disbursement, construction completion or safe-water benefits. [22,23,26]

Claim type	Evidence status as of this edition	Safe use
Historic national renewable water	Contextual international water-account estimate	Describe endowment, with date and methodology caveat
2024 JMP drinking water and sanitation	Internationally comparable estimates	Service-level discussion with definitions [20,21]
2025 national treated-water coverage	Government-reported outcome	Track national programme series [5]
2026 water-sector capital	Enacted budget statement and commitments	Budget discussion; never infer output [5]
July 2025 IDB project	Approved project and expected beneficiaries	State planned scope and implementation status [22,23]
Current physical leakage	No reconciled current public nationwide baseline verified	Require calibrated district-level measurement
2035 household water demand	Scenarios depend on future population and actual losses	Illustrative sensitivity only
Regional climate hazard	Strong general basis but variable local projections	Require site data and multiple scenarios [25,26]

Independent research boundary. This study is a document-based synthesis and an explicit decision framework. It is not peer-reviewed, is not a statutory environmental assessment, is not a qualified hydrogeological study, and does not certify local source-water safety. It does not claim original fieldwork, public-sector approval or employer endorsement. The value of the paper is the ability to trace each major assertion to its real evidentiary status and to specify the records needed to make a defensible capital or regulatory decision.

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Appendix A. Illustrative water-system audit checklist

Supply assets. For every well, intake and plant, record coordinates, owner, commissioning date, actual operating capacity, design capacity, energy source, equipment elevation, residual life, operators, critical spares, laboratory plan and emergency power. Include project commitments, warranty status, acceptance tests and historical outages.

Network assets. Map transmission and distribution mains by diameter, age, material, condition, break history and pressure district. Calibrate production meters and customer meters. Record known illegal or unbilled consumption separately from measured physical losses. Check pressure under peak-demand and emergency conditions.

Sanitation assets. Map sewer pipes, pump stations, septic concentration, discharge points, treatment units and sludge transport. Record wastewater flows, effluent quality, bypass events and proximity to sensitive domestic or ecological waters.

Natural resources. Maintain rain and river gauges, seasonal flow measurements, aquifer observations, source-water quality and drainage district boundaries. Log land-use change in priority drinking-water catchments and ecological condition for sensitive wetlands.

Community evidence. Measure hours of access, household collection burden, school and clinic functionality, customer water-quality complaints, local repair arrangements and the way flood or drought incidents change access. Record Indigenous village consent, data-sharing agreements and cultural water uses where applicable.

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Appendix B. Core calculation definitions

Non-revenue water: NRW (%) = (system input volume - billed authorized consumption) / system input volume x 100. The calculation should account transparently for authorised unbilled consumption and differences between bulk-meter and customer-meter periods. The percentage alone does not identify physical leakage.

Treatment capacity factor: Actual annual treated volume / (rated MLD x actual calendar operating days). The denominator must distinguish design nameplate capacity from permitted or seasonally derated capacity. Report water meeting standards separately from gross throughput.

Water balance at an industrial site: Opening storage + freshwater intake + rainfall capture + recycled inflow - evaporation - product incorporation - discharge - other losses = closing storage, within documented measurement error. Water recycled internally must not be double-counted as new withdrawal.

Groundwater response: Track static and pumping heads in representative observation wells with clear elevation datum, rainfall and pumping context. A one-time falling head cannot establish an irreversible aquifer decline or saltwater intrusion.

Wastewater effectiveness: Report the volume entering treatment, volume leaving treatment, proportion meeting permit standards and bypass volume. Treatment-plant capacity is not a proxy for pollutant removal or environmental compliance.

Climate resilience: State the hazard combination, return-period or scenario assumptions where applicable, local land elevation datum, critical equipment protection level, power redundancy and post-event recovery objective.

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Appendix C. Selected source register

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Appendix D. Verification-ready operating protocols and data dictionary

The following minimum schema converts the paper into an auditable programme of future evidence collection. It is a proposal for data completeness, not a statement that each institution has already implemented the fields. Each record needs a unique asset or sampling point, a date, a responsible organisation, a calibration or laboratory method where relevant and a controlled revision history.

Data stream	Minimum required fields	Required quality check	Representative frequency
Surface-water hydrology	Site ID, latitude/longitude, stage, rating curve, measured discharge, rainfall, season, equipment	Gauge calibration and rating-curve revision record	Continuous where possible, quarterly review
Groundwater quantity	Well ID, screened interval, pumping and resting heads, reference datum, rate/volume of abstraction	Verified borehole completion log and calibrated measurement	Daily/weekly telemetry; annual analysis
Groundwater quality	Well ID, pH, electrical conductivity, chloride, iron, microbiology and site-relevant constituents	Accredited laboratory, chain of custody, analytical method and limits	Risk-based monthly/quarterly
Drinking-water treatment	Plant ID, raw-water quality, treated flow, disinfectant residual, turbidity, operating hours, power outages	Calibrated instruments, operational QA and independent sample checks	Daily process logs; monthly public roll-up
Distribution/service	Supply-zone ID, pressure, supply hours, system input, billed volume, customer population, breakages	Customer-meter reconciliation and defined DMA boundaries	Daily telemetry; quarterly audited water balance
Wastewater/sanitation	Catchment, served population, collection flow, treatment flow, removal effectiveness, bypass and sludge disposal	Validated influent/effluent sampling and legally compliant disposal manifest	Monthly operating data; annual public report
Irrigation/drainage	District and asset ID, water level, salinity, structure operating hours, rainfall, high tide, flood duration	Event logs linked to local hydrological records	Continuous operations; event reporting
Mining catchments	Reference/downstream stations, flow, turbidity/TSS, mercury where risk-based, sediment and fish tissue where indicated	Chain of custody, matched upstream/downstream samples, appropriate method detection limits	Baseline, seasonally and incident-triggered
Hinterland village supply	System ID, households, minutes to collect, uptime, water-safety inspections, repair and spare-part lead times	Independent community confirmation and sample QA	Monthly operator log; quarterly spot audit

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D.1 National sampling logic

Sampling must distinguish dry and wet periods, upstream reference locations and downstream compliance stations, household taps and treatment outlets, and shallow versus confined aquifer horizons. A statistically designed household survey should stratify coastal/hinterland areas and service types, then weight results to an explicitly dated population frame. Testing only plants that voluntarily supply data or communities reached easily by road would not establish national service quality.

For mine-related mercury, turbidity or metal concerns, establish site-specific potential pathways before selecting samples. A single high suspended-sediment reading does not establish elevated methylmercury in fish. Fish-tissue surveillance requires species and size controls, consumption information, laboratory quality assurance and human exposure interpretation by qualified practitioners. Avoid extrapolating any single mining district's results across all inland water bodies.

D.2 Publication-ready audit controls

Each factual table and figure should have a versioned source and extraction note, a definition of its population or denominator, a quality category and a reviewer field. Every quantitative forecast should be reproducible from parameter values, formulae and scenario labels. Where official sources conflict, publish both statements, identify why they may differ, and record the follow-up request rather than selecting the larger or more politically convenient number. Citation URLs should be checked before each new digital edition. The source-audit CSV supplied with this package is a starter ledger, not an institutional audit certificate.

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Appendix E. External expert-review dossier and sign-off register

A documentary review cannot substitute for technical validation by people with access to current field observations and institutional records. For a water paper intended for governments, utilities, development banks and technical audiences, the following independent reviews remain necessary for a *technically externally validated* edition. No reviewer has been listed as having endorsed or signed off on this publication. The template below is a workflow, not a fabricated peer-review result.

Reviewer discipline	Sections to test	Specific challenge questions	Expected evidence before sign-off
Guyana-based hydrologist / basin specialist	1, 6, 8, 9	Are river systems, wetland connections, source-yield constraints and flood/drought pathways correctly described?	Basin maps, gauge records and field interpretation
Licensed or experienced hydrogeologist	3, 9, 13	Are the conceptual Upper/A/B Sand representations and site-specific salinity uncertainties defensible?	Borehole logs, formation correlations, water levels, water chemistry and abstraction history
Drinking-water and network engineer	2, 4, 11, 13	Are plant capacities, pressure continuity, NRW and lifecycle examples sound?	GWI process and network drawings, meter logs, performance tests and QA datasets
Wastewater and environmental engineer	5, 10, 11	Are sanitary risk, sewage treatment, septic management and discharge controls accurately framed?	Sewer and septic surveys, permit text, treatment measurements and receiving-water monitoring
Environmental toxicologist / public-health scientist	4, 7, 8	Are microbial, iron, mercury and exposure pathways appropriately distinguished?	Validated lab data, exposure pathways and sampling design
Guyana-based hinterland practitioner	2, 4, 8, 14	Do village operation assumptions match transport, seasonality, local authority and maintenance realities?	Field visits, operator records and community feedback with consent
Water utility finance / public-investment analyst	11, 13, 14	Are financing instruments counted correctly and sensitivity models transparent?	Audited project accounts, contract scope, current procurement data and lifecycle costing

E.1 Independent review workflow

Round 1: factual redline. Send the relevant source extract, figure and text to each reviewer. Ask them to mark inaccurate, overstated, outdated or missing statements, and separate errors from professional disagreements. **Round 2: data reconciliation.** Obtain dated documentation for any changed figure, and update charts and model parameters simultaneously. **Round 3: methodological challenge.** Request at least two counterexamples for each major conclusion, such as an aquifer where salinity has not changed despite pumping or a pressure zone where

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metering, rather than physical leak repair, was responsible for NRW improvement. **Round 4: author response and release.** Publish a change log that records accepted and unresolved issues and clearly says which sections were actually reviewed.

Suggested institutional recruitment channels: University of Guyana's appropriate science/engineering departments; relevant professional engineering societies; independent consulting hydrologists and hydrogeologists; water and sanitation specialists familiar with the Guyana utility; and affected regional/community representatives. Recruitment should disclose conflicts of interest, professional qualifications, employer restrictions and any honorarium. An agency's public documents may be cited without implying its personnel reviewed this work.

Reviewer name and qualifications	Affiliation	Sections	Conflict declaration	Review received	Author disposition	Release status
Pending	*Pending*	*Pending*	*Pending*	No	No external review claimed	Not externally validated

E.2 Technical release checklist

A later externally validated edition should not carry the review label until the author has the signed comments, review dates, a version-controlled response document and permission to identify reviewers publicly. GWI, a government ministry or a development bank should not be described as endorsing the paper solely because it supplied source documents or responded to questions.

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Appendix F. Calculation audit and reproducibility

F.1 Demand model: Billed authorised demand (MLD) = assumed served population (millions) x assumed billed L/person/day. Required system input (MLD) = billed authorised demand / (1 - NRW). This simplified model excludes authorised unbilled use, storage changes, fire demand, industrial demand and seasonal peaking. The companion CSV contains 36 scenario combinations. The population series are assumptions, not the 2022 census or an approved 2035 population forecast.

F.2 Loss scenarios: Annual volume of independently measured real water saved (m^3) = sustained real savings in MLD x 1,000 x 365. Commercial loss improvement creates accounting and revenue benefits, but is not automatically physically recovered water.

F.3 Plant-capital analogue: GYD 1.3bn / 12 MLD = GYD 108.33m per installed MLD for a particular announced 2025 plant. Ten notional MLD at half, one and twice this quotient gives GYD 0.542bn, 1.083bn and 2.167bn initial capex. These are scenario outputs, not local tenders or site designs.

F.4 Discounted operating exposure: At 6% real discount, 20 equal year-end payments have factor (1 - 1.06^-20)/0.06 = 11.4699. Annual O&M scenario = initial capital x 3%, 5% or 8%; discounted operating present value = annual O&M x annuity factor. Environmental mitigation, periodic overhaul, distribution mains, financing charges and residual values are excluded from this deliberately narrow illustration.

F.5 Traceability: Every calculated table is reproducible from the files in the publication packet. Numerical outputs should be recalculated if an input source is corrected. The model is intended to demonstrate how missing local data alter public-investment choices, not to substitute for a feasibility study.

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Appendix G. Claim-by-claim source audit and reconciliation log

The purpose of this register is to make the paper independently checkable. The locator for a live dashboard is its dated series and indicator definition, not an invented page number. The locator for a PDF is its printed page or section. A primary-source link establishes what that institution reported, not automatically that the result has been independently audited in the field. Each row gives the proposition that can be repeated and the unsupported inference that must be avoided.

High-impact claim	Precise source locator	Evidence class	Safe published interpretation	Outstanding verification
Internal renewable resources ≈241 km³/year	FAO AQUASTAT Guyana 2015 country profile and historical series [1]	C	Historical national resource-endowment estimate	Seasonal yield and source quality by basin
Potable-water access 98.4%	President's Office release, 18 Oct 2025 [3]	B	Government-reported administrative access	Independent household quality and service continuity
Hinterland/riverine access ≈92%	Same release, hinterland passage [3]	B	Official regional administrative estimate	Settlement-by-settlement uptime and quality
Basic drinking water 95.6%	UN SDG Guyana profile, 2024 [20]	B	Internationally comparable household basic-service estimate	Difference from national access methodology
Safely managed drinking water 67.2%	UN SDG Guyana profile, 2024 SDG 6.1.1 [20]	B	Internationally comparable safe-service estimate	Local network-zone quality and availability measurements for 2026
Safely managed sanitation 43.4%	UN SDG Guyana profile, 2024 SDG 6.2.1a [20]	B	Standardised sanitation service estimate	Drainage-basin and onsite-system audit
Safely treated domestic wastewater 33.4%	UN SDG Guyana profile, 2024 SDG 6.3.1a [20]	B	Domestic flow-treatment estimate	Plant-by-plant treated flow and effluent quality
Treated coverage 52% to 77%	Budget Speech 2026, printed p.61, water section [5]	B	Budget-reported 2020 to end-2025 trend	Independent service-zone verification
GYD 19.7bn 2025; GYD 21.6bn 2026	Budget Speech 2026, printed p.61 [5]	B	Reported expenditure vs budget allocation	Final audited programme outturn
GYD 8.2bn for water quality/service	Budget 2026 at a Glance, p.19 [36]	B	Component of GYD 21.6bn envelope	Verified project spending and results
Hope 24 MLD; Diamond 26 MLD; Shelterbelt 45 to 65 MLD	Budget 2026 at a Glance, p.19 [36]	D, official plan	Proposed treatment design/expansion capacity	Commissioning and sustained compliant output

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High-impact claim	Precise source locator	Evidence class	Safe published interpretation	Outstanding verification
NRW 69.7% (2019); separate 79% (2023)	CDB country-engagement documentation [7]	C	Separate historical baselines	Current reconciled common-boundary loss balance
Cummings Lodge GYD 1.3bn; 12 MLD	DPI commissioning release, 18 Oct 2025 [11]	B	Facility-specific reported capital/rating	Scope, outturn and full-year safe service
IDB US$30m line; US$15.57m first loan	IDB GY-O0013/GY-L1087, approvals 16 Jul 2025 [23]	B	Approved nested financing layers	Disbursement and verified service outputs
JICA US$36.33m associated financing	IDB programme release, July 2025 [22]	B	Separately described cofinancing	Current agreements and disbursement
Separate coastal resilience US$45m	World Bank CARes approval, 10 Jun 2024 [25]	B	GRIF-financed flood/drainage project	Drainage assets commissioned and event performance
Preliminary 2022 population 878,674	Bureau of Statistics census portal [24]	B	Historical census count	Geographically consistent service-area counts
End-2024 population est. 956,044	DPI/Finance census release, Jan 2026 [38]	B	Later government estimate	Method and growth distribution
Current nationwide withdrawal, physical leakage and groundwater trend	No verified comprehensive 2026 series located	Data gap	No national point claim	Source/asset registry and calibrated observation programme
National 2035 demand and financing gap	No validated integrated baseline located	D if illustrated	Transparent assumption sensitivities only	Feasibility demand model, measured losses and BOQs

G.1 Reconciliation tests before public quotation

The 98.4% administrative access figure must not be subtracted from the 67.2% safely managed figure and represented as a measured service failure rate. The 77% treated-water coverage is a third measure. A 90% or 95% treatment objective remains a target until evidence of a dated result exists. The IDB credit-line ceiling and its first individual loan are nested rather than additive. NRW includes physical and apparent components; an improving billing ratio does not necessarily mean an equivalent volume of physical water saved. Likewise, financing approval is not disbursement; physical commissioning is not a full year of compliant service; and a historical groundwater estimate is not a monitored national trend.

Publication and independence statement

This is independently authored desk research by Ragunauth Ramsaroop, prepared without external or employer research funding. This final publication edition maintains an auditable separation among dated official observations, administrative reports, international estimates and illustrative scenarios. It includes original analytical figures, a reproducible sensitivity model and an external-review dossier; no unperformed expert sign-off is claimed. No external hydrologist, engineer, Guyana-based field practitioner or university reviewer has certified this edition. The external-review protocol remains pending; readers should not infer specialist sign-off

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from the publication label. The paper is not an official statement of the Government of Guyana, Guyana Water Incorporated, any employer, regulator or referenced institution. Institutional figures retain their original definitions and dates. Technical pathways are analytical options rather than approved projects. The author retains publication rights over the original analysis; underlying third-party reports and their data remain subject to their respective rights and licences.

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