

Chatham Kent Water Resilience Strategy

Regional treatment options and a proposed municipal resilience standard

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Prepared for review by the Chatham-Kent Public Utilities Commission, municipal administration, Council, residents and provincial officials.

This paper recommends a staged resilience program that preserves multiple treatment sources while testing selected regional connections. It does not establish a final engineering design, approve construction, certify existing systems or allocate funding. Plant closures, new service boundaries and major transmission investments require a common hydraulic model, verified operating data, lifecycle costing and the applicable approvals.

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Executive Summary

Chatham-Kent should adopt a performance-based Water Resilience Standard and use it to improve the projects already being planned. The strongest provisional architecture is a network with central, northern and southern operating regions, while retaining Wheatley as an active western source. Three regions need not mean three treatment plants. A fixed three-plant consolidation policy would prematurely remove options and could concentrate risk.

The immediate policy choice is to require every major service area to demonstrate how safe supply, pressure and essential demand will be maintained after a credible critical-asset failure. Licensed capacity alone does not answer that question. A successful strategy must account for the complete supply chain from source water to the customer, including restart delays, power failures, storage accessibility, water quality and the donor system's obligations during emergency transfers.

Recommended decisions are conditional. Continue evaluating South CK supply to Ridgetown and Highgate, but verify dependable treatment output before transferring permanent demand. Retain Wheatley treatment during the next planning cycle and assess reciprocal assistance with South CK and neighbouring systems. Compare a right-sized new Wallaceburg plant, a Wallaceburg–Dresden regional plant and a Chatham connection on the same outage and lifecycle assumptions. Keep Thamesville in its existing service arrangement unless an alternate feed proves worthwhile. Evaluate Tilbury with the Wheatley system and its western connections before considering reassignment.

Chatham's raw-water chain and electrical system deserve immediate attention regardless of which regional alternative is selected. Correcting a bottleneck that restores normal production is necessary, but it does not establish an alternate path around that bottleneck. Likewise, adding storage can extend the response window without making a community independent of its treatment source.

The paper's engineering conclusions are recommendations for evaluation rather than modelled findings. The evidence supports moving toward more layers of protection, but it does not yet establish the optimum number of plants, final northern capacity, transfer-main diameters, usable emergency storage or a priced CK-wide capital program. The required information and decision tests are set out in the appendices.

The proposed sequence is to measure and test first; complete urgent corrective work; compare regional alternatives with a common model; integrate justified improvements into existing projects; and retire assets only after alternate service has been commissioned and verified. New infrastructure should proceed only where its incremental resilience benefit justifies its full operating and replacement cost.

Financial findings in Version 2

A four-source network is a credible architecture to test, but public evidence does not establish that it can be delivered mainly through inexpensive modifications to renewal projects. Shared trenching, modular expansion, electrical provisions and reciprocal controls may be economical. A long new interregional trunk, new intake or enlarged donor plant can change that conclusion. Regionalization means stronger regional nodes and effective assistance; centralization means concentrating permanent demand. They must be evaluated separately.

The fiscal baseline is substantial. The 2024 development-charge study lists \$545.8 million of gross water capital in 2024 dollars; the separate rate study forecasts \$870.2 million of water spending over 2025–2034 in inflated execution-year dollars. These overlap and cannot be added. Neither is a fully reconciled current construction commitment. [40, Table 5-1; 41, Table 2-1] An assumed 5% annual price adjustment places the first reference at \$601.7 million in 2026 purchasing-power terms, before scope changes. This is a sensitivity calculation, not a new estimate or the cost of this strategy.

The Southeast package is \$87.6 million in the published EA, including the \$24.7-million Blenheim–Ridgetown main. [14, Table 10-1] Northern replacement, Chatham storage and raw-water improvements, and western pumping already appear in capital schedules. Strategy costs must be measured against the remaining cost of an updated Current Planned Path, with planned costs replaced rather than counted twice.

Four financial findings are explicit: gross represented infrastructure has several overlapping documentary envelopes; the present baseline still needs reconciliation; avoided costs are conditional rather than bankable savings; and net incremental resilience CAPEX is presently unquantifiable at CK-wide scale. Sections 7–10 quantify documented components and conditional allowances; Section 14 supplies the ledger, lifecycle comparisons and rate sensitivities. For illustration, \$10 million of additional debt at 5% over 30 years costs approximately \$650,500 annually, or \$1.37 monthly if spread equally across 39,622 accounts. The account count is a rate-study forecast, not a verified residential billing base. Operations and renewal add to that amount. [41, Table 1-2; paper calculation]

Wheatley remains a useful active source, but restored equipment does not establish a new useful life for the entire plant. PUC records document a \$6.714-million construction budget excluding HST and partial insurance recovery; these are historical/committed recovery costs, not new network CAPEX. The corrected record also establishes temporary treatment in 2024, before the 2025 annual-report period. [38; 39]

1 Purpose and Method

1.1 Governing principle

Chatham-Kent should not evaluate water security solely according to licensed treatment capacity. Every major service area should be evaluated according to its ability to continue providing safe and adequate drinking water when a critical treatment component, transmission main, electrical supply, pump, raw-water source or other major asset becomes unavailable.

This principle applies to public health, essential customer demand and the adopted fire-protection service level. It does not imply that every system must deliver unrestricted peak industrial consumption during every outage, or that every rural property must receive urban fire flow. Emergency service levels must be explicit, technically achievable and agreed before infrastructure is sized.

1.2 Evidence and decision status

The paper distinguishes documented facts, calculations, engineering interpretation, proposed policy and unresolved verification. Numbered references identify source documents and relevant pages or sections. Current annual reports describe operation; environmental assessments describe evaluated proposals; procurement notices describe scopes and procurement status. None of these alone certifies as-built completion or current firm capacity.

The September 2026 consultation remains an alternatives process. The study page schedules completion for March 2027 and identifies the September 23–24 PIC and October 8 comment deadline. [1] This paper should inform that process rather than establish a competing master plan.

Public records support meaningful screening, but final option selection requires the PUC's operational logs, current licences and permits, asset register, agreements, model files, capital ledger and engineering assessments. Where a requested historical or engineering value is not established, the paper identifies the evidence required instead of assigning a fabricated number.

1.3 Definitions

Term	Meaning for this strategy
Rated capacity	Permitted or stated design daily output under the relevant conditions; verify the current licence and its measurement boundary.
Demonstrated capacity	Net compliant output achieved during a documented test, with raw-water quality, duration and equipment availability recorded.
Firm treatment capacity	Proposed CK measure of sustainable compliant output after loss of the largest critical treatment component, including common dependencies.
Firm pumping capacity	Output with the required pump units unavailable, assessed with the receiving pressure zone and storage arrangement.
Emergency capacity	Sustainable compliant supply under a named outage, with an explicit duration, demand level and operating arrangement.
Available storage	Water actually withdrawable while preserving pressure, quality, disinfection requirements and the adopted fire reserve.
Genuine redundancy	An alternate arrangement that remains available after the same failure and can deliver the required service.

Ontario distinguishes treatment rated capacity from pumping firm capacity. Its design guidance considers worst predictable water quality and process losses. [2] Pumping guidance uses largest-unit-out criteria, and a more demanding two-largest-unit-out criterion for certain sole-source zones without adequate floating storage. Disinfection contact volume is excluded from available storage. [3] The CK treatment-firm-capacity definition above is a proposed additional reporting measure, not a claim that Ontario mandates that exact term or criterion for every plant.

1.4 Cost evidence hierarchy and audit boundary

Version 2 preserves the engineering screening in Version 1 and expands its capital, lifecycle and implementation analysis. Documentary figures are cited by source and scope. Arithmetic is reproducible in Appendix G. Proposed sensitivities are not presented as consultant estimates, supplier quotations or procurement prices.

Five cost types are used: current documented estimate; historical documented estimate with an explicit price adjustment; derived planning allowance using comparable CK scope; external comparable requiring adjustment; and TBD—engineering required. No external plant is used to price a CK plant without process, geography and scope adjustment. A cost class is stated only where the originating document establishes it. Other screening allowances are not promoted to engineered Class D estimates merely because they have low/base/high columns.

All economic comparisons use 2026 constant dollars where a cost base can reasonably be identified. Documented originals remain visible. Proposed annual escalation sensitivities of 3%, 5% and 7% are assumptions, not observed construction indices or inflation forecasts. A publication date is not necessarily the

estimate date. The Southeast figures are treated provisionally as 2025 amounts; confirm their base date and inclusions before financial approval. The older northern ESR does not establish an unambiguous price year in the cost-basis section reviewed, so its \$117.1 million is retained as a historical scope record rather than automatically escalated from its publication date. [13, Section 2.3; 14, Table 10-1]

Price adjustment and scope uncertainty are separate. For selected proxy components, a proposed 0.70/1.00/1.50 uncertainty multiplier illustrates concept-stage exposure after base-price adjustment. It is not a measured probability interval or a CK-approved estimating policy. Apply original contingencies once; add only missing scope identified through an estimate reconciliation. Engineering, land, commissioning, non-recoverable tax and owner costs remain additional where their inclusion cannot be confirmed.

2 Existing CK Water System Architecture

2.1 Present service relationships

The official drinking-water page identifies four surface-water systems, Ridgetown groundwater supply including Highgate, and Bothwell as a stand-alone distribution system. Chatham includes Dresden and Thamesville. [4]

Current system	Verified supply and distribution features	Consequence for regional planning
Chatham	Lake Erie source; North Kent extension via Eberts; Thamesville has its own standpipe and rechlorination. [5]	Reassigning northern communities changes an existing regional system.
South CK	Lake Erie source; membrane treatment; Blenheim reservoir and booster facilities. [6]	Potential southern hub, subject to production and transfer constraints.
Wallaceburg	Chenal Ecarte source; raw-water pumping approximately 1,982 m to the WTP; Wallaceburg elevated tank. [7]	Retains a different source-water pathway from the Lake Erie plants.
Wheatley	Wheatley and Tilbury, surrounding rural areas and parts of Lakeshore; elevated tanks plus Tilbury reservoir and booster facilities. [8]	A functioning western regional system, not a Wheatley-only plant.
Ridgetown and Highgate	Groundwater treatment arrangement. [4]	Assess both normal regional supply and groundwater emergency retention.
Bothwell	Southwest Middlesex supply through the Tri-County agreement. [9]	Protect the external supply agreement; do not force inclusion in a new hub.

The Chatham annual report describes roughly 600 km of distribution mains, a North Kent extension of approximately 160 km, and about 13 km within Thamesville. [5] These reported descriptions are not added here into a new total because the boundaries may overlap. The architecture must be reconstructed from GIS and operating boundaries, not inferred from community names.

2.2 Operating output and the limits of utilisation ratios

Plant or subsystem	Rated output m3 per day	2025 maximum daily treated output m3 per day	What the comparison establishes
Chatham	67,999	43,681	Historical production, not firm capacity. [5]
South CK	22,810	14,814	Historical production, not emergency export capacity. [6]
Wallaceburg	13,600	6,493	Historical production, not assurance of asset reliability. [7]
Wheatley rehabilitated plant	23,846	8,365	Short resumed-operation period; not a normal full-year utilisation baseline. [8]
Wheatley temporary plant	8,640	6,832	Temporary output under its own operating conditions. [8]

The annual aggregate report prints South CK rated capacity as 22,809 rather than 22,810. Use the current licence to settle the one-unit discrepancy. [10] None of the observed daily peaks in this table constitutes a maximum-capacity test. Nor should the peaks from different dates be added and represented as simultaneous system demand.

To establish exportable surplus, subtract the donor's coincident demand, treatment losses and required operating reserve from its dependable net production. Then constrain the result by the actual interconnection, pumps, receiving pressure and water-quality limits. A percentage below licensed capacity cannot substitute for that calculation.

3 Historical Development of the System

3.1 Integration has already occurred

The system has evolved through regional extensions, external supply agreements, local treatment renewal and selective interconnections. The premise that CK consists entirely of isolated community plants is therefore inaccurate. The historical question is how far existing integration should be strengthened and where a separate source remains valuable.

The 2014 development-charge study records the earlier W9 Blenheim–Ridgetown proposal and an Eberts–Wallaceburg connection. [11] The April 2018 addendum subsequently retained selected system interconnections and added Chatham raw-main rehabilitation and twinning alternatives. [12] These documents establish planning history; they do not establish why each annual budget decision was made.

Wallaceburg illustrates the risk of treating a historical preferred solution as permanent. Its older assessment favoured continued maintenance, but later engineering identified greater repair burdens and vulnerability. [13] A new regional concept must therefore include review points rather than assume its first design remains economically optimal for several decades.

3.2 Planning chronology and interpretation

Record	Documented milestone	Interpretation
2012 master-plan program recorded in 2014 DC study	W9 placed in the 2012–2016 window. [11]	Earliest formal program located for this paper; not proof of the first discussion ever.
April 2018 addendum	W9 moved to 2028–2032; raw-main twinning identified separately. [12]	A material change in the published planning window.
Wallaceburg 2023 EA	New northern regional supply concept through 2070. [13]	Historical demand and source assumptions require updating.
February 2024 master plan	Later reviewed and reconsidered. [9]	An input to the current process, not sufficient authority for all expenditure.
Southeast 2025 EA	Integrated southern scope and preliminary component costs. [14]	More extensive than the early W9 main alone.
September 2026 PIC	Smaller northern alternatives and capacity-restoration issues. [9]	Relevant current evidence for option screening.

A complete deferral history requires project-specific PUC minutes, budget revisions, funding applications and design instructions between these milestones. The published windows demonstrate changed timing; they do not prove political neglect, an engineering error or a particular funding refusal.

4 Current Asset Condition

4.1 What the asset plan establishes

The water DAMP reports approximately \$2.47 billion replacement value; forecast annual lifecycle outlays of \$137.323 million; planned annual funding of \$108.534 million; and a \$28.789 million annual gap. It reports 94 watermain breaks in 2024, low confidence in age-based condition modelling, and plans formal condition ratings in 2026. Watermain age shares are 5.41% over 75 years, 13.04% aged 50–75, 17.04% aged 30–50 and 64.51% under 30. Aggregate plant condition is described as good, reservoirs fair. [15, pp. 4, 13, 18–21, 70, 77]

The funding section is internally inconsistent: its figures imply approximately 79.0% funding, consistent with its headline ratio, but one sentence states 65.73%. Its lifecycle narrative and acquisition/renewal tables also need a reconciled scope explanation. These are reasons to obtain a corrected financial bridge, not to replace the published figures with an unsupported alternative. [15, pp. 70, 73]

No verified percentage of all assets with physical condition assessments is established here. Age shares are not assessment-coverage shares. An age-derived aggregate condition does not certify a critical pipe or override a site-specific plant assessment.

4.2 Break history and evidence quality

The 2025 annual information report records 69 breaks in Chatham, 10 in Dresden, one in Thamesville and 10 in Ridgetown. [10] Raw counts must be supplemented by mains length, material, pressure, repeat-failure location and customer consequences. A short section of repeatedly failing trunk main may matter more than numerous repairable local breaks.

The strategy should require a five-year break register with failure cause, duration, isolated area, pressure loss, leakage volume where measurable, advisory status and restoration time. Separate ordinary distribution breaks from failures of critical transmission assets. Record valve failures and inability to isolate a break, because those can enlarge the affected area even when the broken pipe itself is modest.

4.3 Proposed condition program

Assess every asset whose loss could disable a major service area before relying on generic age estimates. Select inspection methods by material and failure mode. For concrete pressure pipe, the assessment must address structural and prestressing deterioration where applicable, joints and leakage; a visual inspection of accessible chambers alone is insufficient to establish pipe condition.

Create an asset-confidence field alongside the condition score. Record whether the score comes from inspection, monitoring, maintenance history, operator judgement or age. Publish assessment coverage by asset count, replacement value and criticality. Different denominators reveal different gaps and should not be combined into one reassuring percentage.

Prioritisation should combine probability and consequence, with a separate flag for uncertainty. Consequence includes residents and critical facilities affected, available alternatives, restoration lead time, fire protection, environmental impacts and the likelihood of pressure loss. Renewal should address high-consequence assets even when their failure probability is uncertain.

5 Current Capital Program

5.1 Verified projects and their status

Item	Evidence as of this paper	Treatment in the resilience strategy
Chatham reservoir expansion	Engineering procurement describes a proposed 20 ML reservoir; award status dated 17 July 2026. [16]	Existing initiative; review emergency accessibility and compartmentation.
Chatham raw-water hydraulic improvements	R26-205 issued March 2026; includes capacity study, pump testing and controls optimisation. [17]	Existing initiative; add restart and failure scenarios where contract scope permits.
Ridgetown tank and associated mains	Engineering procurement marked awarded 22 July 2026; new 2.8 ML tank, 48 m height. [18]	Existing initiative; do not count the tank again as new strategy spending.
Southeast regional works	EA preferred configuration and preliminary costs. [14]	Planned package; verify each budget and contract separately.
Wallaceburg future supply	Current master-plan alternatives under evaluation. [9]	Decision pending; compare renewal and regional options.
Local watermain renewal	Ridgetown CIPP lining procurement identifies streets for structural lining. [19]	Existing renewal work; maintain alongside regional planning.

An engineering award is not a construction award or a commissioned asset. A master-plan estimate is not an appropriated budget. The public tender displays do not establish every awarded vendor, fee or final scope, so those details should be taken from executed contracts and PUC reports.

5.2 Capital reconciliation required

Before proposing a new program total, staff should issue a project ledger containing approved budget, forecast budget, expenditures, commitments, grants, development-charge allocation, reserve contribution, debt, completion date and remaining exposure. Use unique project identifiers across the master plan, DAMP, rate study and construction contracts.

Classify resilience changes into six mutually exclusive categories: proceed under existing scope; accelerate an existing scope; redesign an existing scope; replace a planned project; add genuinely new scope; or remove a project. For a redesign, report the original remaining cost and the revised remaining cost, not the entire new project's cost as an addition.

Already-spent costs cannot fund the alternative. Avoided future spending can improve the business case, but it becomes available funding only after the responsible authority changes the capital plan. Construction cancellation costs, stranded design work and grant clawbacks belong in the comparison.

5.3 Current Planned Path comparator

The comparator is continued safe service under the best current renewal, compliance, growth and corrective program without the extra network recommendations. It includes Wallaceburg renewal or a justified replacement supply; Southeast servicing; Chatham raw-water, storage and electrical corrective work; western pumping and treatment renewal; towers, distribution renewal and studies. Its baseline cost is not zero, and it cannot assume indefinite operation of life-expired assets.

The 2024 rate study is a financing forecast with future inflation, while the DC schedule assigns growth-related and existing-development benefits. The 2026 PIC reopens important capacity choices. [41, Tables 2-1 and 4-2; 40, Table 5-1; 9] Construct one current project schedule using unique project identifiers, remaining expenditure and approval status. Compare the resilience alternative against that same schedule, not against the old large-plant program in one column and minimal maintenance in another.

Existing renewal obligation and funding status are separate dimensions. A necessary replacement can be unfunded; an approved engineering contract does not fund the entire construction project. In particular, retaining a future replacement requirement does not authorize its historical scope, capacity or implementation date. The PUC should publish the revised baseline before asking ratepayers to approve a network premium.

6 Documented Failure and Outage Case Studies

6.1 Wheatley fire and recovery

A fire on 13 September 2023 disabled Wheatley treatment. Contemporary reporting places the fire in the generator room during maintenance, with damage to pumps, compressors and wiring; this is an attributed account rather than a reviewed forensic cause determination. [20] The extended recovery is examined in Section 8.

Engineering inference: backup power and process equipment can share a fire consequence. A generator located at the site does not protect the site against every electrical or fire event. Assess physical separation,

switchgear exposure, cable routes, smoke damage, ventilation, fire protection and access for mobile equipment.

6.2 Chatham electrical failure in September 2025

On 21 September 2025 incoming power failed. The standby generator initially operated, then failed during troubleshooting. Generator repair, interconnection activation and a 1,000-amp rental generator maintained treatment and distribution without a boil-water advisory. [10, p. 7] The municipal notice describes falling tower levels and reduced pressure. [21]

The event supports testing the complete power-transfer chain under actual load. Commissioning should demonstrate motor starts, automatic transfer, controls, chemical dosing, filtration, pumping, communications and fuel arrangements. Record essential net output during the test. A portable generator should count as a credible fallback only if its connection, compatible voltage, delivery time and commissioning procedure are verified.

Priority responses are an electrical failure-mode review, repair verification, load testing, spare and rental connection arrangements, and evaluation of physically independent power routes. Two utility feeds sharing the same upstream transformer or switchboard should not be counted as two independent supplies.

6.3 Chatham transmission and restart difficulties in August 2026

The official restriction notice links supply difficulties to repairs on the main feeding the Chatham WTP and states that water remained safe. Restrictions covered Chatham and numerous connected communities, including Dresden and Thamesville. [22]

Reporting on 1 September attributes the event to scheduled repair followed by trapped air that limited production on restart. It quotes the PUC engineering director describing inaccessible air-release points and roughly 35 ML of reservoir water, described as about 18 hours of supply. Severe restrictions began Saturday and were lifted Monday; later outdoor restrictions were reported lifted on 15 September. [23, 24] These accounts establish an operational explanation, not a complete engineering root-cause report.

The paper cannot establish the exact repaired component, air locations, production curve, valve sequence or final corrective design from those notices. Obtain the work order, isolation plan, pressure and flow traces, reservoir levels, air-valve records and post-incident review. Do not mislabel a planned repair and difficult restart as a proven spontaneous failure of the full raw-water main.

Proposed improvements include surveyed high-point and air-valve coverage, maintainable air-release facilities, controlled refill and transient analysis, staged recommissioning, reservoir refill criteria and preplanned donor assistance. Test whether a second transmission path would maintain adequate supply while repair and restart proceed. The benefit depends on its independent valves, hydraulics and common structures.

6.4 Lessons across the cases

The cases justify four distinct capabilities: surviving an equipment failure, operating without utility power, bridging a treatment outage, and restarting safely after maintenance. A single capacity figure cannot represent all four.

Emergency assistance was useful, but emergency success should not be interpreted as full unrestricted redundancy. Restrictions may have prevented a more serious service loss. The target is to make the next response less dependent on improvised equipment and voluntary demand reductions, while preserving proportionate emergency curtailment procedures.

7 Ridgetown and Blenheim Analysis

7.1 Historical scope and cost comparison

Record	Main or package scope	Estimate and timing
2014 DC study reflecting 2012 program	W9 Ridge Line main, 17.7 km	\$5.21088 million in 2011 dollars; \$5.496313 million in 2014 dollars; 2012–2016 window. Separate Highgate pumping, pipe and tower projects also listed. [11, p. 45]
April 2018 addendum	W9 17.7 km, 300 mm interconnect	\$5.487 million; 2028–2032 window. [12, Appendix A]
2025 Southeast EA	Blenheim–Ridgetown main	16 km, 300 mm; \$24.667875 million preliminary estimate. [14, Table 10-1]
2025 Southeast EA	Full east-side package	\$87.601960 million, including treatment, pumping, storage and additional mains. [14, Table 10-1]
2026 tank procurement	Detailed engineering for new elevated tank and associated mains	Award status verifies procurement progress, not a total construction price. [18]

The early and later main estimates differ in route, estimating basis and construction period. The total package has an even broader boundary. There is no defensible calculation that attributes the full difference to inflation, or calls the entire later package the price of the early pipe.

7.2 Current scope and implementation

The EA's package includes a 4.55 ML Blenheim reservoir, a booster station, Ridgetown elevated storage, Scane/Mitton and Talbot Trail mains, and South CK treatment and high-lift upgrades. Its conclusion anticipates property acquisition in fall/winter 2025 and design in winter/spring 2025–2026. [14, Table 10-1 and Section 13] The latest PIC envisages connection by 2031. [9]

These are planning milestones rather than a verified critical-path construction schedule. Staff should identify which contracts, land acquisitions, permits, plant works and commissioning steps control the connection date. The record does not establish a complete annual deferral history or its causes.

7.3 Why regional supply may be worthwhile

A regional connection can reduce dependence on local groundwater treatment and allow shared operations. It may also provide more flexible supply for Highgate and growth. However, closure of all local treatment turns the connecting main and donor plant into critical dependencies. The business case must show what remains available when that main, its booster or South CK treatment is out of service.

A new reservoir and elevated tank can stabilise the receiving system and cover peak demand while the transmission main delivers a steadier flow. Storage must be located and controlled so that Ridgetown can use it under the failure being tested. Water upstream of the failed connection cannot be counted as receiving-system emergency storage.

7.4 Required design tests

Compare the EA configuration against a staged arrangement that retains selected wells, and against a second limited emergency path where practical. Do not assume a second full-size permanent main is justified. The model should determine whether a modest route-diverse connection, targeted local looping or retained treatment supplies the required contingency at lower lifecycle cost.

Run normal average-day, maximum-day, peak-hour and adopted fire-flow cases, followed by connection-main failure, largest booster failure, plant treatment-train failure, donor-system outage, power loss and low-storage restart. Include future demands without allowing speculative industrial consumption to determine the base design automatically.

Model minimum flows and extended outages for water age, chlorine residual, disinfection by-products and mixing. Regional transport should not solve quantity problems while creating water-quality problems. Check surge pressures under pump trips, valve closure, change of supply direction and restoration of power.

7.5 Retaining groundwater emergency capability

The annual information report records commissioning of Colby No. 2 in June 2025 and retention of Hitch No. 2 as a standby well. [10, p. 8] That existing standby designation does not establish suitability for an expanded regional emergency role.

Assess each candidate well independently for sustainable yield, licence and taking-water conditions, water chemistry, treatment barriers, source protection, equipment condition, backup power, sampling and restart requirements. Preserve a well only if it can provide a useful quantity of compliant water within the receiving system's response window.

A dormant well without a funded exercise and maintenance program has little resilience value. Retention requires defined operation intervals, verified treatment, replacement reserves and operators able to bring it online. A well that needs extensive new treatment or provides little dependable output may cost more than strengthening the regional connection and storage.

Recommended position: retain the option of groundwater contingency through connection commissioning, then compare the best candidate well against alternative protection on a 30- and 50-year basis. Decommission unsuitable wells after the approved alternate arrangement is proven. Do not promise permanent retention of all wells.

7.6 Reasons for changed timing that need verification

The record supports scope evolution and changed planning windows. It also identifies current production constraints and a broader master-plan reassessment. It does not quantify how much delay resulted from funding, regulatory changes, growth assumptions, land acquisition or prioritisation.

Request a dated decision log separating deferral, redesign and prerequisite work. Reconcile original dollars to a common construction-price year, then separate route length, diameter, restoration, crossings, contingencies, engineering, storage, treatment and tax treatment. Review whether the environmental-assessment classification changed because the scope changed; do not assume that a different classification itself caused the entire delay.

7.7 Southern capital baseline and scope bridge

Table 7A disaggregates the preferred east-side package. The source amounts sum to \$87,601,960. They are published preliminary estimates, not tender awards; a current construction estimate class and complete inclusion schedule are not established here. [14, Table 10-1]

Component	Published estimate \$m	Provisional 2026 equivalent \$m	Fiscal treatment
Blenheim–Ridgetown 16 km 300 mm transmission	24.668	25.90	C: planned connection; resilience increment is additional independence beyond the baseline.
Charing Cross 2.4 km 600 mm transmission	7.371	7.74	C: donor conveyance; reconcile with earlier 2.6 km scope.
Blenheim 4.55 ML reservoir	6.386	6.70	A/C: renewal and service provision; D only for extra demonstrated contingency features.
Blenheim booster	2.801	2.94	C: transmission duty; identify standby and reversible-duty changes separately.
Ridgetown 2.8 ML elevated tank	8.343	8.76	A/B/C: renewal/design underway; construction commitment requires the current ledger.
Scane/Mitton 4 km 250 mm works	7.493	7.87	C: local/conveyance scope; assess renewal, growth and resilience allocation.
Talbot Trail 3.7 km 250 mm works	6.548	6.87	C: local/conveyance scope; do not automatically count as a second independent regional feed.
South CK treatment expansion 28 L/s	21.682	22.77	C: donor output; verify whether bottleneck recovery or new capacity is required.
South CK high-lift expansion 42 L/s	2.311	2.43	C: donor pumping; component-out duty controls resilience.
Package total	87.602	91.98	One package; no addition of its component rows to its total.

The 2026 equivalents are arithmetic at the proposed 5% one-year adjustment; at 3% and 7%, the unchanged package becomes \$90.23 million and \$93.73 million. This narrow variation covers assumed price movement only, not construction uncertainty. Applying the separate proposed proxy multiplier to the \$91.98-million base

gives \$64.39–\$137.97 million for an unchanged-scope stress test. The low case is not a promised saving and the high case is not a procurement budget.

The booster design description identifies 30 L/s toward South CK and 35 L/s toward Ridgetown/Highgate. [14, Table 10-1] Those proposed duties demonstrate why a pump-station price cannot be equated with field-tested emergency delivery. The hydraulic model must resolve the receiving network, simultaneous use and failure of the common station.

The 2024 DC schedule assigns 90% of the Ridgetown/Highgate main and tank gross estimates to existing-development benefit. [40, Table 5-1] That supports an existing-service rationale in that study; it does not prove that 90% of every later EA item is renewal or that the same allocation remains legally correct. The wider package combines replacement, connection, production and growth functions. Allocation requires a demand and asset-by-asset bridge, not a single municipal percentage.

7.8 Incremental alternatives for groundwater and a second path

Groundwater alternative G1 retains no production source after successful regional commissioning. Its forward cost is decommissioning plus the agreed regional contingency. G2 retains one suitable licensed well, treating facility and power connection. Its cost is rehabilitation, modifications, regulatory compliance, exercises, sampling, staffing and eventual replacement minus decommissioning that is actually avoided. G3 supplies contingency with a route-diverse main and regional storage. Compare all three for the same essential demand and activation deadline.

No defensible whole-well retention CAPEX or annual operating estimate is established from the public well data. Use TBD—engineering required until yield, water chemistry, treatment train, licence conditions and equipment condition are known. Do not infer a nominal emergency supply from a well's standby designation. A well requiring major new treatment could be more expensive than a limited transfer; a compliant well requiring modest work could be a valuable independent source.

A conditional extra 5 km of 300 mm pipe would carry a derived civil allowance of approximately \$5.5/\$8.0/\$12.5 million at low/base/high, using the local proxies in Appendix G. Add terminals, pumping, crossings, land, quality controls and missing owner costs. This is a quantity sensitivity, not a recommended route or a quoted second-feed project. A main terminating upstream of the same Blenheim booster failure has less protection than the same expenditure connecting an independent source.

For well O&M sensitivity, each additional \$25,000/\$50,000/\$100,000 annually has a 40-year present cost of approximately \$0.53/\$1.07/\$2.14 million at 3.5% real discount. These are proposed scenarios, not Ridgetown operator budgets. Report them together with the quantity of compliant emergency water achieved.

8 Wheatley Analysis

8.1 Recovery chronology

Period	Established evidence
September 2023	Fire disabled the plant. [20]
By August 1 2024	PUC minutes report operating temporary trailers and South CK assistance; Leamington links then closed. [39]

Period	Established evidence
November 2024 onward	Wheatley annual report identifies Union-supplied water through Leamington. [8]
Early 2025	CK records describe South CK and Leamington interconnection assistance. [10]
May 10 2025	The Wheatley annual report says temporary treatment returned to service; the aggregate report says it came online. Earlier 2024 operation is separately documented. [8, 10, 39]
November 21 to December 15 2025	Records differ on the temporary plant's end date; reconcile logs. [8, 10]
December 15 2025	Rehabilitated permanent plant resumed supply. [8]

From the dated fire account to permanent restart was approximately 27 months. This is plant downtime, not proof that customers were without water for that duration. The August 2024 minutes establish earlier temporary operation; the exact initial startup date and later commissioning changes still need operating records. [39]

Union's board minutes confirm installed Leamington–Wheatley interconnection flowmeters and assistance in November 2024, with accounting of transferred flows. [25, p. 8] A municipal restriction notice records critically low reservoir and tower levels under extra demand while temporary treatment was being prepared. [26] Those primary records demonstrate useful assistance and limits on service under the emergency arrangements.

8.2 What the event proves and does not prove

The recovery demonstrates that neighbouring supply and temporary treatment can bridge a prolonged plant outage. It does not establish that every existing interconnection can meet unrestricted emergency demand, or that another plant had unlimited dependable surplus.

Actual transfer capacity cannot be established here as a verified L/s value for each path. Obtain meter traces, pressures, donor output, receiving demand, valve configuration and hours of operation. Separate instantaneous maximum flow from sustainable daily volume. A transfer observed with low donor demand may not be available on a hot maximum-demand day.

The March 2026 PUC minutes establish a construction budget and partial insurance recovery, discussed in Section 8.5. They do not establish the complete emergency operating cost. Reconcile temporary-treatment rental, pumping, purchased water, staffing, grants and commissioning separately. [38]

8.3 Comparison of long term operating arrangements

Arrangement	Potential merit	Principal problem	Position
Permanent independent Wheatley treatment with stronger assistance links	Uses restored assets and preserves local treatment availability.	Still vulnerable to shared plant dependencies unless addressed.	Preferred near-term baseline.

Arrangement	Potential merit	Principal problem	Position
Wheatley retained as an active secondary regional source	Adds reciprocal support and can share normal production.	Requires compatible pressure, controls and water quality.	Strong candidate for modelling.
South CK primary with Wheatley reserve treatment	Could concentrate routine operation at the donor.	Reserve readiness costs, restart time and donor capacity may eliminate savings.	Do not adopt without a complete business case.
Wheatley primary with stronger South CK connection	Builds on the existing western architecture.	Adequate donor surplus and path independence must be proven.	Strong candidate for incremental improvement.
Eventual consolidation and closure	May avoid a later major replacement if economics justify it.	Removes a source and requires substitute emergency capability.	Defer until renewal decision and verified analysis.

The recommended baseline retains normal Wheatley treatment. This is a forward-cost recommendation, not a requirement to recover sunk rehabilitation expenditure. The restored asset should be evaluated on its remaining condition, replacement needs and ongoing cost. If a future lifecycle comparison demonstrates that another configuration is both less costly and at least as resilient, consolidation can remain an option.

8.4 Tilbury placement

Tilbury's existing treatment supply and storage arrangements place it within the Wheatley comparison. [8] Geographic labels should not determine a new boundary. Analyse Wheatley–Tilbury as the baseline, stronger western assistance, a South CK contingency and any Chatham alternative identified by the hydraulic model.

Compare hydraulic grade, tower filling, booster duty, receiving and donor demand, ownership boundaries, water quality and capital already planned. Retaining storage or pumping may still be necessary after reassignment. Do not count those operating costs as avoided merely because the normal source changes.

A split arrangement could be useful: normal supply from Wheatley with an independently routed emergency feed to Tilbury. But an emergency route terminating in the same vulnerable pipe segment may not protect the intended customers. Map the actual isolation boundaries before selecting the connection point.

8.5 Documented restoration cost and remaining condition

March 19 2026 PUC minutes approve additional rebuild work. The report records previously approved Oscar purchase orders of \$5,910,335.58, a further \$804,152.38 excluding HST, and a resulting \$6,714,487.96 construction budget excluding HST. The additional reserve-funded amount after the HST rebate is \$818,305.45. Insurance receipts were \$4,120,973.25 as of February 23 2026, with further recovery pursued. Building restoration, equipment reinstatement and uninsured betterments are distinguished. [38, rebuild report and carried motion]

These figures are budget/approval and receipt evidence, not certified final expenditure or complete outage cost. Do not subtract the recorded insurance receipt from an ex-HST construction budget and call the result final ratepayer cost: expenditure dates, recoverable tax, other emergency costs and outstanding claims need reconciliation. Restoration is A/B, not a new network investment. Unpaid approved commitments remain in the baseline cash forecast, but already spent money is excluded from forward alternative selection.

The report identifies additional decontamination, damaged filter components, valve replacements, temporary-plant dismantling, restoration of modified facilities and pump rebuilding. [38] This reinforces the need for a subsystem condition register. New electrical/process equipment can coexist with older civil structures, mains and reservoir components. The public record does not support a single remaining-life figure for the whole restored plant or prove independent generator/switchgear survivability.

The August 2024 minutes approved an additional \$351,242 PUC insurance contribution in each of 2025, 2026 and 2027. [39, pp. 8–9] This is a documented fiscal consequence of the event, not a permanent insurance saving available for financing new pipes. Avoid attributing all restoration expense to predictable annual renewal.

8.6 Western capital options

Wheatley starts with an operating plant, existing territory and assistance links. Its new resilience project is the difference between adequate current readiness and the adopted contingency target. W2, W3 and W4 below are alternatives or overlapping scopes; they must not be summed as independent projects.

Option	Capital scope	Supportable monetary evidence	Incremental-cost condition
W1 active source with minimum upgrades	Integrated power test; isolation, restart, mobile-power interfaces, separation and controls as required.	Existing restoration commitments known; additional retrofit total TBD—electrical and process assessment required.	Charge only corrective work not already in the rebuild or renewal program.
W2 stronger South CK assistance	Upgrade existing terminals and transfer duty; add only modelled pipe/boosting.	New 300 mm civil work: conditional \$1.1/\$1.6/\$2.5m per km; local station proxies below.	Route length and existing useful capacity determine E versus D.
W3 stronger Leamington/Union assistance	Meter/pressure control, donor agreement, receiving mains and optional pumping.	Whole option TBD—donor capacity, ownership, limits and quotation required.	Compare capital-sharing with purchased-water and standby charges.
W4 reciprocal South CK–Wheatley	W2 plus safe reverse duty, compatible controls and surviving donor surplus.	TBD whole option; price reverse-duty changes against one-way W2, not a second complete pipe.	Bidirectionality earns value only for a useful reverse outage.
W5 South CK normal supply and Wheatley reserve	Permanent transfer works; donor capacity; reserve treatment readiness and staffing.	TBD—normal-demand hydraulic design and reserve operating regime required.	Test loss of South CK and common main; reserve readiness can erase claimed savings.
W6 eventual closure	Replacement permanent supply, independent contingency, decommissioning and end-of-life works.	TBD—retain as distant lifecycle comparator.	No closure until equivalent service passes the Standard and lifecycle saving is demonstrated.

The 2024 DC schedule includes Wheatley/Tilbury booster estimates of \$2.4585 million and \$1.9903 million, plus \$2.0655 million for decommissioning. The rate-study description identifies the last item as the Tilbury inground reservoir and pumping station, not the Wheatley WTP. [40, Table 5-1; 41, Table A-1] Do not interpret

this entry as an approved Wheatley plant closure. Reconsider reservoir retirement if retaining usable local storage offers better contingency value.

At the proposed 5% two-year adjustment, those two booster references total \$4.90 million; the decommissioning reference becomes \$2.28 million. They are historical planned scopes, not the price of a reciprocal connection. A new booster of broadly comparable scale carries a derived proxy of approximately \$2.1/\$2.9/\$4.4 million from the Southeast station reference, before unconfirmed scope adjustments. A paired 5 km 300 mm civil main and one such station produces a partial allowance of \$7.6/\$10.9/\$16.9 million. Terminals, land, special crossings, standby power and other missing scope remain TBD. If the station already belongs to the planned path, only the changed duty belongs to the strategy increment.

8.7 Required western estimate breakdown

Obtain separate quantities and prices for transmission by diameter and route; booster pumps and buildings; pressure reducing/control equipment; meters; backflow prevention; tank/reservoir changes; electrical utility and switchgear work; physically separated standby equipment; mobile-generator connection; SCADA and communications; process modifications; design and commissioning; land/easements; tax; and contingencies. Identify recovered existing equipment and avoid charging restoration twice.

The 2024 operator account reported about 65 psi with the elevated tank full, 70 psi when pumping, and approximately 100 psi from Leamington when its valves were open. It made assistance conditional on donor availability. [39, verbal report] These are observations at that time, not certified current limits. They indicate pressure compatibility and donor rights are important estimate drivers. Reverse delivery cannot be priced as a simple valve change without checking the hydraulic grade.

Commission current transfer and integrated standby-power tests before deciding that transmission expansion is necessary. The lowest-cost W1 may be enough for some failures; it will not replace an intake or an entire plant unless surviving assistance meets the required essential demand.

9 Wallaceburg Dresden and Thamesville Analysis

9.1 Source diversity and existing constraints

Wallaceburg's source is Chenal Ecarte, connected to the St. Clair River. The ESR describes an aging plant originally built in 1946 and an intake/low-lift system vulnerable to flooding. It identifies an existing roughly 16 km, 200–250 mm emergency main toward Dresden with calculated conveyance below 4 ML/day. That is an engineering estimate, not a verified field-transfer guarantee. [13, Executive Summary]

Retaining a northern treatment source can reduce reliance on the Lake Erie pathways. Its strategic benefit must be measured against its own flood, intake, power and water-quality risks. Geographic diversity is valuable only if the alternate source is actually available under the hazard being assessed.

9.2 Older scheme and current reconsideration

The 2023 preferred concept called for 28 ML/day treatment, 34 ML/day raw supply, twinned raw mains and an 18.5 km treated-water route via Baldoon Road, Border Road, Elbow Line and Base Line. [27] The ESR's final preferred package estimate was \$117.1 million, including a 56 ML reservoir. Its conceptual estimate accuracy was approximately minus 30% to plus 50%; lifecycle evaluation used 50 years, 5% discount and 2% inflation assumptions. [13, Table ES-6 and Section 2.3]

The September PIC instead examines a 12 ML/day plant for Wallaceburg/Dresden and a 10 ML/day Wallaceburg-only plant, plus Chatham supply. It gives combined 2061 maximum-day demand of 11,024 m³/day for the regional alternative. [9] These are materially different demand and scope assumptions. The old package cannot be scaled by plant capacity ratio to price the new alternatives.

9.3 Comparable alternatives

Alternative	Treatment and source protection	Transmission and operation	Main decision condition
New Wallaceburg plant for Wallaceburg	Preserves northern source; can be modular.	Avoids compulsory Dresden reassignment; still needs external contingency.	Lowest compliant lifecycle cost if regional expansion adds little benefit.
New Wallaceburg plant for Wallaceburg and Dresden	Northern supply plus potential Chatham backup to Dresden.	Requires adequate route, dedicated pumping and pressure-zone controls.	Regional main and plant premium justified by contingency and demand benefits.
Wallaceburg Dresden and Thamesville regional supply	Could provide an alternate path for Thamesville.	Additional distance, pressure control, water age and transfer duty.	Reject unless incremental connection benefit exceeds its lifecycle burden.
Wallaceburg and Dresden dependent on Chatham	Can share treatment and staffing.	Larger central duty and outage consequence; long transfer exposure.	Must meet contingency standard without assuming Chatham never fails.
Hybrid modular Wallaceburg source with Chatham links	Preserves source diversity while staging demand and capacity.	More controls and emergency coordination; potentially useful shared backup.	Preferred comparator, not yet demonstrated cost winner.
Greater LAWSS assistance or supply	External source option already considered in northern studies. [27]	Contract availability, boundary capacity and donor obligations control benefit.	Evaluate a firm agreement before purchasing excessive CK standby assets.

No numerical lifecycle ranking is defensible for the current smaller options without updated route-specific estimates and operating data. A qualitative screening preference for the hybrid must not be presented as a modelled optimum.

9.4 Capacity and raw water requirements

Determine the normal design horizon, committed large-user loads, realistic household growth, unaccounted-for water and seasonal peaks. Size installed treatment in modules where feasible, reserving space and civil works for expansion instead of equipping the ultimate speculative demand at opening.

For each option, specify net treatment output with the largest process unit unavailable. A plant whose headline capacity only slightly exceeds future maximum-day demand may require storage, alternate supply or additional modules to satisfy the outage standard. Test backwash and process losses under difficult raw-water conditions.

Raw-water capacity must support the required treated output plus verified process losses within taking-water approvals and source availability. Inspect the existing intake, screen, low-lift pumps and raw mains. Evaluate a renewed upstream intake against continued use of the existing site, including flood elevations, ecological

effects, access, ice and debris. The older upstream recommendation is evidence of an evaluated option, not an automatic requirement for the smaller current plant.

9.5 Transmission routes and pressure zones

Use the old EA route as one candidate, not the mandatory alignment for a right-sized regional system. Compare reinforcement of the existing corridor, a route-diverse emergency connection, a dedicated regional main and limited tie-in through the Chatham network. Include easements, road restoration, watercourse crossings, utilities, geotechnical conditions and repair access.

Dresden and Thamesville must be represented as receiving zones with actual elevations, pressure controls and storage operation. Retain a functioning Chatham feed to Dresden where justified rather than creating a permanent single-ended branch from Wallaceburg. Evaluate whether reversal requires new pumps or bypasses; an existing check valve or pressure reducer may prevent the assumed direction of transfer.

A large trunk main serving little normal demand may create unacceptable residence time. A smaller transfer line coupled with storage and managed large-user curtailment may be more economical. Conversely, a line adequate for normal service can be too small for emergency refill and fire protection. Evaluate both modes explicitly.

9.6 Thamesville decision

Thamesville already receives Chatham supply and has local storage and rechlorination. [5] The northern ESR describes the wider North Kent pressure arrangement through Eberts. [13] There is no demonstrated reason to build a new long transmission route merely to make a northern region geographically tidy.

Recommended position: retain existing normal supply while testing whether a Dresden-area alternate route could backfeed Thamesville through existing infrastructure. Compare modest control and local reinforcement works before a dedicated new line. If the existing connection cannot deliver enough emergency flow, compare additional storage, improved central reliability and a new route on the same outage duration.

Reject compulsory northern reassignment if it introduces substantial new mains with little reduction in unmet essential demand. Source flexibility may be achieved without moving Thamesville's normal service boundary.

9.7 Lifecycle operating implications

Compare 30-, 40- and 50-year horizons. Include treatment staffing, licensed operator coverage, laboratories, chemicals, residuals, membrane or filter replacement, buildings, pumps, controls, standby equipment, fuel, transmission leakage, boundary metering and eventual retirement.

A smaller plant need not produce proportionately smaller costs because intake, staffing, safety and control obligations have fixed components. A central connection may avoid a building but increase pumping and central replacement costs. An external supply contract may lower capital but introduce purchased-water escalation and dependence on contract renewal.

Treat critical failure consequence as a separate constraint and then compare cost. A cheap option that cannot meet the adopted essential-service standard should not win through a weighted score that allows cost points to cancel a public-health failure.

9.8 Northern capital evidence and alternatives

The 2023 ESR's historical scope separates WTP \$39.3 million, 56 ML storage \$27.6 million, intake/low-lift \$7.9 million, raw main \$9.5 million and treated transmission \$32.8 million. [13, Table ES-6] The 2024 DC schedule has a larger northern envelope: plant \$58.6694 million, storage \$53.1318 million, intake/pumping \$13.5313 million and two transmission entries \$30.2287 million and \$33.4560 million, all in 2024 dollars. [40, Table 5-1] These schedules are successive/overlapping scope records, not five costs to add to the earlier \$117.1 million.

For the unchanged 2024 northern reference scope, the sum is \$189.0172 million, or \$200.53/\$208.39/\$216.41 million in 2026 at the proposed 3%/5%/7% escalation sensitivities. The later schedule is not an estimate for the 2026 10 or 12 ML/day options. The discrepancy requires reconciliation of revised scope, capacities, contingencies and inclusion boundaries.

A useful core benchmark is the three 2024 entries for plant, intake/low-lift and the first transmission item, subject to confirmation that the latter is the raw-water corridor. Their \$102.4294-million sum becomes \$112.93 million under the 5% adjustment. A separate 0.70–1.50 proxy uncertainty screen gives \$79.05–\$169.39 million. This is an unchanged historical core-scope reference, not a responsible quote for a new right-sized 10 ML/day plant. Its explicit use is to show that retaining an intake/raw-main chain can dominate costs even after removing regional storage and distribution expansion.

Northern alternative	Current engineering scope to price	Capital comparison available now	Unpriced decision items
N1 modern Wallaceburg only	10 ML/day concept; new intake, low-lift and raw main; modular treatment, local storage and power. [9]	Historical core reference above; current total TBD.	Treatment train and firm duty, intake route, storage sizing, geotechnics and included owner costs.
N2 Wallaceburg and Dresden	12 ML/day concept plus regional treated-water corridor, receiving controls and storage. [9]	N1 is not simply scaled by 12/10; extra main can use local unit proxies once its size/length is modelled.	Marginal process module, Dresden demand and dual-feed terminal arrangement.
N3 N2 plus limited Thamesville backfeed	Use existing Dresden–Chatham distribution where feasible; add controls/local bottleneck work first.	Increment over N2 TBD; extra 300 mm pipe allowance only if quantities are established.	Flow reversal, pressure zones, donor headroom and quality.
N4 permanent Thamesville supply	N2 plus permanent-demand conveyance and revised north/central allocation.	Total TBD; no evidence supports pricing or selecting a new dedicated trunk now.	Route, peak/fire duty, remaining central use and redundant terminal facilities.
N5 Chatham supplies Wallaceburg/Dresden	Chatham restoration/expansion as needed, transmission, pumping, storage and independent contingency.	2025 review gives an \$18–\$20m 2024 pipeline-only reference; normalized below. [42, p. 23]	Central bottleneck, full route scope, major crossings, firm capacity and loss-of-Chatham contingency.
N6 modular northern source with central assistance	Right-sized N1/N2 plus retained/improved Chatham–Dresden link and useful reciprocal capability.	Additional assistance provision TBD; estimate alongside civil and electrical design.	Common-source outage duty, reverse operation and valve independence.

Northern alternative	Current engineering scope to price	Capital comparison available now	Unpriced decision items
N7 LAWSS or other external supplier	Firm purchased-water/standby agreement plus boundary main, pumping and quality facilities.	Total TBD—no firm supply quotation or executable contract verified here.	Donor capacity, route, reservation price, curtailment rights and long-term tariff.

The Municipal VU review's \$18–\$20-million pipeline reference adjusts to approximately \$19.1–\$22.9 million for 2026 using the proposed 3%/7% bounds; the midpoint at 5% is \$20.95 million. [42, p. 23; paper calculation] It is a dated feasibility benchmark, not a quotation for the current Chatham-supply alternative. It excludes whatever additional Chatham treatment, raw-water resilience, storage, pumping and independent backup that option needs. Comparing that pipe alone with a complete northern WTP/intake/reservoir scheme would produce a false winner.

9.9 What right sizing can remove and what it cannot

The 56 ML reservoir and large greenhouse-serving expansion are not automatic requirements of the 2026 10/12 ML/day options. Treatment expansion beyond committed demand, oversized transmission and some remote growth mains may be omitted or deferred. Intake, raw-water conveyance, adequate treatment barriers, residuals handling, firm pumps, electrical protection and sufficient local storage remain necessary where the new plant depends on them. Smaller flow does not remove their fixed costs.

If the 2024 storage scope is replaced, its \$53.1318-million historical estimate becomes a \$58.58-million 2026 reference at 5%. That is the maximum gross line displaced before buying the substitute storage, not \$58.58 million of confirmed saving. Similarly, dropping a regional trunk requires retaining or renewing the service arrangement it would replace. Future optional modules should reserve site/civil space and interfaces; buying idle process trains at opening needs a demonstrated business case.

Specify base project quantities for land, site works, intake, low-lift station, raw mains, treatment trains, residuals, high-lift pumps, local reservoir/tower, standby power, SCADA, regional mains, pressure stations, engineering, commissioning, contingencies and modular provisions. Compare revised project estimates with the historical entries using a reconciliation sheet. Do not inherit the older 56 ML reservoir merely because it appears in a financing model.

9.10 Northern screening decision

N6 is the recommended design comparator because it preserves source diversity and assistance options. N1 can win if moving Dresden adds substantial fixed cost without sufficient benefit. N2 can win if its marginal treatment and transmission costs provide reliable two-source protection to Dresden and reduce central investment. N3 should be tested before N4. N5 can win only after its central and independent-contingency obligations are priced; N7 can win only after firm supply and tariff terms are established.

The public evidence is insufficient to rank 30-, 40- or 50-year dollar totals among these current designs. Publishing synthetic plant prices would obscure the central decision. Require common-engineer concept estimates for the shortlist and a single lifecycle workbook before selecting the plant and route. The existing plant's condition sets the deadline for decision and interim repairs, not a preferred alternative's historical schedule.

10 Chatham System Analysis

10.1 Production and the raw water chain

The September PIC reports field-test values of 55,300 m³/day for Chatham and 17,867 m³/day for South CK, below their rated values. It also reports inconsistent Chatham future demand figures across northern alternatives, which require reconciliation before capacity decisions. [9]

The 2026 R26-205 scope describes one raw-water pumping station drawing from Lake Erie, approximately 24 km of 900 mm concrete pressure pipe, Cedar Springs standpipe, Chatham surge tower and two receiving tanks. [17] Each component can constrain production; adding downstream demand without examining this chain is premature.

Proposed engineering assessment: obtain test protocols, dates, raw-water quality, sustained duration, net output and limiting components. Determine whether the test limit arose in intake, pumping, air management, surge control, treatment or another dependency. Correcting that limitation must be followed by repeat testing and separately by outage testing.

10.2 History of raw water redundancy

The April 2018 addendum identifies W42A chamber rehabilitation and W42B twinning of approximately 23 km of 900 mm raw main. W42B carried a \$27 million planning allowance and a 2028–2032 window. [12] The difference between that described length and the later procurement's approximately 24 km should be reconciled against the exact endpoints.

A 2017 federal funding announcement separately lists twinning from the Chatham high-lift pumping station to Grand Avenue. [28] That treated-water project is not proof that the Lake Erie raw-water route was twinned. The projects protect different parts of the supply chain.

The later raw-water procurement establishes continuing investigation and describes a single pumping station and pipeline chain. It does not verify completion of W42B. The paper cannot certify the extent of any partial twinning, installed bypasses, chamber upgrades or formally cancelled scope. Request as-built drawings, commissioning records and a status report for each historical project identifier.

10.3 Alternatives to full twinning

Compare full raw-main twinning with staged critical-section duplication, selective route diversity, enhanced isolation and air management, spare repair materials, local bypass connections, additional usable treated storage and independent treated-water assistance.

Full parallel twinning may survive a pipe break yet share the same intake, station, road corridor, flood exposure or common terminal manifold. Route diversity may cost more but protect against a wider set of failures. A sectional approach may be affordable but leave unprotected segments as the controlling risk. The model should identify the residual consequence after each stage.

A connection from another CK plant could bypass Chatham treatment as well as its raw-water main, which is a broader benefit. However, it may be unable to replace Chatham's large demand. Partial assistance should be valued for the essential demand it can sustain and the additional time it buys, not described as whole-system backup.

10.4 Electrical and pumping redundancy

Inventory utility feeders, transformers, switchgear, transfer switches, generator capacity, fuel runtime, high-lift pumps and critical controls. Draw the dependency chain and identify components shared by normal and standby supply. Review the electrical failure case in Section 6 against the current configuration after repairs.

Verify low-lift and high-lift pumping independently. Multiple high-lift pumps cannot compensate for loss of the raw-water station or source. Generator tests should include the limiting starting load and the practical combination of pumps and treatment equipment needed for essential service.

10.5 Storage and outage consequences

The planned storage project should be tested for access during a plant outage, pump-station outage, electrical failure and main isolation. A ground reservoir cannot supply an elevated receiving zone without an available pump and power source. Compartments, mixing and isolation affect how much stored water remains usable during maintenance.

Do not equate the incident report's operating reservoir volume with the system-wide sum of physical storage. Operating levels, contact volumes, fire reserves and inaccessible zones explain why headline capacity and available emergency hours differ.

A prolonged central outage can affect remote communities as well as Chatham. Model each zone rather than allocating stored water by municipality-wide population. The output should show time to loss of acceptable pressure, essential demand unmet and the earliest available alternate supply under realistic activation times.

10.6 Central capital ledger and raw water choices

The 2024 DC schedule carries Chatham transmission at \$38.973 million, raw pumping at \$3.6284 million and storage at \$19.788 million in 2024 dollars. [40, Table 5-1] The rate study describes storage increase and forecasts related expenditures, while the 2026 procurement describes a 20 ML reservoir design. [41, Table 2-1; 16] These are overlapping planning/design records; reconcile project IDs and quantities before treating the figures as current contracts.

Central component	Monetary basis	Proposed 2026 reference	Required distinction
Historical full raw-main twinning	\$27m 2018 allowance, W42B. [12]	\$34.20/\$39.89/\$46.39m at 3%/5%/7% for eight years.	Price sensitivity only; no proof of present route, condition or completed scope.
Later Chatham transmission entry	\$38.973m, 2024 DC schedule. [40]	\$41.35/\$42.97/\$44.62m under two-year sensitivities.	Confirm it represents the same raw-water project; do not add to W42B.
Raw pumping entry	\$3.6284m, 2024 schedule. [40]	\$4.00m base at 5%.	Renewal/expansion versus independent pump train and electrical dependencies.
Storage entry	\$19.788m, 2024 schedule. [40]	\$21.82m base at 5%.	Match current 20 ML design; usable volume and powered delivery, not tank size alone.
Current R26-205 investigations	Hydraulic testing and optimization scope. [17]	Fee/remaining construction TBD.	Existing work; resilience scenarios added only through defined authorized scope.

Central component	Monetary basis	Proposed 2026 reference	Required distinction
Isolation, restart, air release and limited duplication	Quantity-based corrective works.	TBD; civil main quantities can use a diameter-appropriate proxy.	New work must bypass the actual failure, not only improve normal flow.
Utility feed, switchgear, standby and mobile power	Electrical design and load schedule required.	TBD—utility/contractor quotation required.	Separate normal and backup dependencies; do not presume another feed is independent.
Critical high-lift/low-lift pump redundancy	Component-out hydraulic and electrical test.	TBD—pump curves and quotations required.	Spare pumps do not replace common suction, switchgear or intake.
Treated-water assistance from another source	Modelled route, capacity and agreement.	TBD total; quantity-conditioned civil/booster allowances available.	Does it bypass Chatham WTP, raw chain or only a local main?

The proposed uncertainty screen of 0.70–1.50 applied to the later \$42.97-million transmission reference gives approximately \$30.08–\$64.45 million. It is not a consultant-certified range. Historical twinning and the later entry are alternative references to reconcile, not two additions to the strategy.

Compare C1 full raw-main duplication, C2 critical-section duplication and independently maintainable air/isolation facilities, C3 route-diverse replacement/second path, and C4 targeted raw-chain work plus usable storage and independently sourced treated-water assistance. Each must include a surviving intake, pumping, power and terminal arrangement appropriate to its claimed failure protection. A raw-water twin still relies on Chatham treatment; treated-water assistance can cover different failures but may sustain only essential demand.

A critical-section allowance cannot be a percentage of the full main price without defining the section. Use inspected length, diameter, crossings, valves and terminal connections. Where the available local 300/600 mm proxies differ materially from the required 900 mm design, use the matched Chatham historical project or an engineered takeoff; do not extrapolate cost solely by diameter ratio.

10.7 Potential central avoided capital

The 2024 DC schedule includes a \$210.834-million Chatham WTP entry; the rate forecast is also based on major expansion. [40, Table 5-1; 41, Table 2-1] The 2026 PIC tests restoration of dependable output and revised northern assignments before deciding longer-term expansion. [9] At the proposed 5% two-year adjustment, the historic entry is \$232.44 million in 2026 terms. This is exposure for scope reconsideration, not a saving certified by this paper.

Some expansion may be deferred or resized if field-tested production improves, Dresden remains independently supplied where justified, growth changes or committed demand is lower. Conversely, resilience and future growth may still require process and raw-water investment. Never count the entire WTP entry as avoided unless the revised model demonstrates no replacement scope and the responsible authority removes the commitment. Deferral has a timing value; it is not complete avoidance of an asset's future cost.

11 Four Source Regional Architecture

11.1 Recommended provisional architecture

Operating region	Normal arrangement to test	Emergency arrangement to test
North	Renewed modular Wallaceburg source; Dresden reassignment optional.	Chatham–Dresden and northern assistance retained; LAWSS agreement tested.
Central	Chatham and existing surrounding service areas; Thamesville retained initially.	Raw-water and electrical improvements plus partial cross-system assistance.
South	South CK with Blenheim and, subject to commissioning tests, Ridgetown/Highgate.	Regional storage, independently useful alternate path and selected well retention.
Western source within the broader network	Active Wheatley treatment serving its current western area including Tilbury.	Stronger reciprocal South CK and neighbouring-system assistance.
External eastern supply	Bothwell's agreement-based supply maintained.	Agreement and outage contingencies reviewed separately.

This is a proposed topology, not a pipe-routing plan. It deliberately preserves a fourth active surface-water source while using three broad planning regions. The starting three-region hypothesis is therefore modified: the objective is resilient service, not achieving a predetermined plant count.

11.2 Connections should follow specific failure benefits

Every proposed link must identify which failure it bypasses, the customers protected, sustainable flow and duration, activation time and donor consequences. Retain a link that meaningfully reduces unmet essential demand; reject one that merely connects two map areas while sharing the failed asset.

Do not require universal full-capacity bidirectional operation. Some links may be justified as one-way or limited emergency assistance. Bidirectional capability has value only where the return direction serves a credible scenario and can meet pressure, disinfection and backflow requirements. Report its limits openly.

11.3 Common cause protection

Test a Lake Erie source-quality event affecting several intakes, widespread electricity loss, flooding, telecommunications failure, chemical interruption and a cyber or controls incident. A network whose plants all depend on the same fuel delivery, switchgear design or communications platform has correlated vulnerabilities.

Northern source diversity deserves an explicit benefit assessment. It should not be monetised through an invented probability of a lake-wide event. Use scenario constraints, consequence analysis and sensitivity ranges, and identify the additional annual cost residents would pay to retain that protection.

11.4 Regionalization and centralization

Regionalization strengthens treatment nodes, regional storage and verified assistance. Centralization moves permanent customers to fewer nodes. A useful interconnection can permit regionalization without closure. Conversely, transferring normal demand to a single long main can centralize risk even when the municipality labels it a regional system.

The working network has four active surface-water sources: North—Wallaceburg; Central—Chatham; South—South CK; West—Wheatley. The north and west are geographically separate treatment nodes, not reserve assets presumed idle. Ridgetown groundwater retention is an additional option; Bothwell's existing external supply stays a separate contract-based arrangement.

Connection to test	Normal role	Emergency role	Bidirectional decision
Wallaceburg–Dresden and existing Chatham–Dresden system	Dresden assignment conditional; central feed retained where useful.	Limited assistance around northern or central failure.	Justify both directions only with surviving donor output and independent valves.
Chatham–South CK	No permanent CK-wide backbone assumed.	Protect specific central/south zones if modelling finds a viable path.	New corridor is optional; first test useful capacity of existing interfaces.
South CK–Wheatley/Tilbury	Wheatley remains normal western source.	Reciprocal partial essential supply or useful one-way assistance.	W4 must outperform less expensive one-way W2/W3.
Leamington/Union–western CK	Purchased/standby assistance by agreement.	Supplement local recovery and treatment outage.	Reverse supply needs external approval, hydraulic and water-quality evidence.
Dresden-area–Thamesville	Retain Chatham normal supply.	Modest backfeed through existing network where feasible.	Evaluate controls/local reinforcement before new dedicated transmission.

This table is proposed topology, not an assertion that every listed connection already exists or delivers sufficient flow. A continuous north–central–south–west trunk is not mandatory. An external feed to the west or local independent well may provide better protection per dollar than a municipality-length spine.

11.5 Wallaceburg and Wheatley as complementary design cases

Issue	Wallaceburg prospective regional source	Wheatley restored western source
Asset starting point	Aging plant with replacement/servicing decision. [9, 13]	Restored treatment and remaining completion work. [8, 38]
Capital opportunity	Include modularity, independent power and assistance terminals in concept design.	Retrofit useful assistance and correct demonstrated common dependencies.
Storage question	Size from adopted demand and activation time; do not inherit 56 ML automatically.	Verify current towers/reservoir and reassess proposed Tilbury retirement.

Issue	Wallaceburg prospective regional source	Wheatley restored western source
Supply assistance	Design contingency operation before commissioning new normal service.	Formalize lessons from temporary treatment, South CK and Leamington/Union aid.
Principal fiscal trap	Oversize for uncommitted demand or compare full plant cost with pipe-only alternative.	Treat restored plant as needing immediate whole replacement, or count recovery costs as new resilience.
Selection test	Lowest lifecycle cost among alternatives meeting defined outage duty.	Extend useful operation only where condition, costs and emergency readiness support it.

They are counterparts in network function, not identical plants. Their treatment processes, raw-water hazards, intake assets, current condition and renewal needs require separate design. Wheatley demonstrates why a new northern node should be built with tested assistance interfaces and temporary-treatment/power connection provisions. It does not demonstrate that any particular northern pipe diameter or reservoir size is correct.

12 Alternative Configurations Considered

12.1 Retain all treatment systems with targeted renewal

This alternative is the proper baseline. It includes necessary renewal, compliance and known corrective work rather than a fictitious zero-cost status quo. It may be best where transmission distances are large, local assets retain useful life or regional demand is insufficient to justify new pipes.

Its weakness is continued duplication of facilities and limited assistance where local supply fails. Improve the baseline with proportionate interconnections before comparing it against consolidation. Otherwise the regional alternative receives credit for benefits that could be achieved more cheaply without closing plants.

12.2 Three principal plants with Wheatley closure

This is not recommended for the next planning stage. It requires proof that South CK can sustain the additional normal and emergency obligations, and that western customers retain a practical alternative after donor or route failure. Reserve the option for a future replacement decision with updated costs and condition data.

12.3 Chatham as the dominant backbone

This can be economical under some demand and capital assumptions, but its appraisal must include added central capacity, transmission, backup power, raw-water resilience and a geographically independent contingency. It should not be selected using unused licensed capacity alone.

12.4 Four active surface sources with selected regional connections

This is the recommended reference architecture for the next modelling round. It offers flexibility to stage demand transfers and protects the option of independent northern and western treatment. Its disadvantage is continued fixed operating cost at more sites and greater network coordination.

12.5 Regional hubs supported by external contracts

Compare increased assistance from neighbouring systems with CK-owned duplication. Contracts must specify firm availability, pressure, flow, duration, curtailment priority, water quality, metering, cost, renewal and dispute provisions. The external donor's own outage and maximum demand must be included.

The preferred alternative may differ by community. CK can retain an external eastern arrangement, strengthen a western regional system and consolidate selected southern treatment without adopting a uniform consolidation rule.

12.6 Common scenario comparison

Scenario	Capital pattern	Operating premium or saving	Failure consequence to test
A Current Planned Path with targeted improvements	Necessary renewal, compliance, growth and already justified correction.	Baseline plant and network expenditure.	Remaining single-source, common-power and long-main failures.
B four active sources with strategic links	A plus defined redesign/new links, less actual superseded scope.	More fixed plant readiness; new transfer and control costs; possible shared-resource saving.	Local loss with donor assistance, including simultaneous source/power stress.
C three principal sources with eventual Wheatley consolidation	Avoid western plant renewal only at actual lifecycle decision; add donor/transfer/backup works.	Potential western operating reduction minus reserve/transfer duty.	Donor/main loss reaching western territory; independent emergency source.
D Chatham-dominant supply	More central treatment, raw-water chain and long conveyance; displaced local works.	Potential plant consolidation saving minus pumping, trunk maintenance and standby.	Largest shared outage and limits of remaining alternate sources.
E hybrid with external agreements	Boundary conveyance, compatible controls and reserved external capacity.	Purchased-water/tariff cost versus internal duplication.	Donor outage, curtailment and contract renewal.

Compare A–E with identical demand, fire duty, outage durations, climate/source scenarios, water-quality constraints, 30/40/50-year horizons, price assumptions and borrowing conditions. Do not credit B with free standby or D with unlimited Chatham output. If A can meet the Standard cheaply, adopt it; the regional architecture is a means, not a mandatory construction outcome.

13 Proposed Water Resilience Standard

13.1 Adoption and limitations

Adopt the following as a proposed CK planning and reporting standard after PUC engineering, operator and regulatory review. It supplements statutory compliance. It does not authorise lower drinking-water quality, reduced legal monitoring or emergency bypass of required treatment.

Begin with essential-service continuity and adopted urban fire protection. Test unrestricted demand as a separate higher service level. Costs should be disclosed for both, so Council and the PUC can choose the service commitment with its rate implications.

13.2 Proposed performance criteria

Criterion	Proposed objective	Verification
Single critical process failure	Maintain compliant essential service for the design outage; record normal-demand shortfall separately.	Model and witnessed component-out test where safe.
Total treatment-source loss	Activate a source independent of the failed plant before usable local storage reaches minimum safe level.	Source agreement, transfer test and operating procedure.
Largest critical transmission segment unavailable	Maintain adopted essential demand and pressure through another path or independent local supply.	Valve isolation model and field confirmation.
Critical pumping unavailable	Apply Ontario pumping firm-capacity guidance to each pressure-zone arrangement.	Pump curves, drawdown test and electrical loading.
Loss of utility electricity	Sustain essential treatment, dosing, controls and pumping; evaluate average-day capability.	Integrated loaded transfer test.
Standby runtime	Initially evaluate 24, 48 and 72 hours; proposed target 72 hours where justified by local risk.	Fuel at usable level, actual load and resupply evidence.
Storage bridge	Usable volume covers verified activation/recovery time plus proposed 25% time margin.	Dynamic zone model and real operating levels.
Long plant outage	Evaluate 7- and 30-day scenarios with sustainable donor or temporary supply.	Capacity, staffing, chemical and fuel plans.
Fire protection	Meet the adopted urban fire-flow and duration in the stated emergency scenario, or disclose the specific exception.	Fire-service review and hydraulic model.
Water quality after transfer	Meet licence, regulatory and operational requirements throughout activation and recovery.	Water-age, residual and mixing review; sampling protocol.

The hours and margin are policy assumptions for pressure testing, not existing Ontario legal thresholds. A fixed 72-hour generator requirement may be uneconomic where another secure power arrangement performs better. A fixed storage-hour target may overbuild small systems; the bridge criterion relates storage to realistic recovery time.

13.3 Objective risk classifications

Green requires every mandatory essential-service criterion to pass for each defined credible single failure, supported by current evidence. Alternate supply must survive the same failure; storage must bridge activation; required quality and pressure must be maintained. Green does not mean zero risk or compliance with every extreme multi-event scenario.

Yellow applies where statutory compliance is maintained in normal operation but an outage test shows restricted normal service, a limited contingency margin, or a verified dependency needing mitigation. Essential-service criteria may pass, but a vulnerable operating margin or common dependency remains. A time-limited remediation plan is required.

Red applies where a credible single failure produces unmet essential demand, unsafe pressure or inability to supply adopted critical facilities before the available bridge expires. A high-consequence unmitigated source or transmission dependency also triggers Red when its outage scenario fails.

Add Grey for unverified systems. Missing evidence must never produce Green. Where records already establish a high-consequence failure mechanism, classify the affected scenario provisionally Red rather than using Grey to conceal the risk. Publish the evidence status and validation deadline.

13.4 Demand and pressure criteria

Essential demand should include household indoor needs, hospitals, long-term care, emergency services and other critical facilities, plus unavoidable process demand needed to prevent a safety or environmental incident. Agree staged curtailment of nonessential industrial and outdoor use with affected customers. Do not assume reductions without examining enforceability and operational consequences.

As a proposed screening floor, test at least 140 kPa residual pressure at designated distribution nodes during the adopted contingency/fire scenario, subject to the higher applicable local, regulatory and design requirements. Ontario distribution guidance should be checked for the final design criteria. [29] Pressure at a model node is not the same as pressure inside every building; verify elevations, services and critical customers.

Report both minimum node pressure and duration below the adopted level. A brief transient and a sustained low-pressure condition require different investigation. No colour score can authorise continued distribution where public-health direction requires protective action.

13.5 Required service area record

Each record must identify primary source; alternate source; rated, demonstrated, firm and emergency capacity; largest single point of failure; raw and treated transmission paths; critical pumps; electrical feeds; generator capacity and runtime; usable storage and hours; emergency connections; sustainable flow in each direction; main condition and confidence; treatment asset life; growth and industrial demand; adopted fire flow; source risks; and emergency procedures.

Attach test date, reviewer, data confidence, assumptions and corrective project. Revalidate after a major operating or demand change and through annual risk review. Proposed testing intervals are annual integrated power testing, annual controlled emergency-link exercise where safe, and full hydraulic/contingency review at least every five years or sooner after material change.

13.6 How to apply the standard today

Do not issue definitive colours to whole communities from this paper. The failure cases justify priority investigations, while the required output, transfer and pressure evidence remains incomplete. Begin with Chatham raw-water and electrical scenarios, Wheatley treatment-loss scenarios, Wallaceburg source/plant renewal, and the proposed Ridgetown donor and main dependencies.

Publish a public summary with flow and duration performance, risk status and mitigation dates. Keep exact security-sensitive access, control and vulnerability details in controlled engineering records. Transparency does not require publishing instructions that could facilitate disruption.

14 Financial Analysis

14.1 Financial baseline and affordability

The November 2024 Water Financial Plan forecasts water debt principal of approximately \$23.5 million in 2026, \$526.0 million in 2030 and \$511.2 million in 2031. It forecasts approximately \$734.46 million cumulative tangible-capital acquisitions for 2024–2031, with cash declining to about \$2.98 million by 2031. These are unaudited forecasts, not actual debt or approvals. [30, Tables 4-1 and 4-3]

These forecasts make affordability a central decision criterion. Update the baseline using actual balances, the revised growth forecast and projects retained after the master-plan review. Do not add the DAMP funding gap, the financial-plan acquisition total and individual regional estimates into a single cost total; the scopes overlap and use different accounting bases.

14.2 Common lifecycle method

Calculate option net present cost as initial remaining capital plus discounted operation, maintenance, energy, renewals, purchased water, exercise and standby costs, less supportable residual value and genuinely avoided future costs. Evaluate 30 and 50 years, with 40 years as a check. Use a single constant-dollar base year and real discount rates of 2%, 3.5% and 5% as proposed sensitivities.

Do not mix nominal inflation with a real discount rate. If a nominal model is used, make both inflation and discount treatment explicit. Historical source estimates retain their original price basis until properly rebased. Include engineering, land, crossings, utility relocation, restoration, commissioning, contingencies and nonrecoverable tax consistently.

The old Wallaceburg conceptual accuracy range is specific to that study. It is not a universal Class D range applicable to every CK estimate. The Southeast costs are labelled preliminary here because the record reviewed does not establish a construction-level estimate class. An awarded engineering fee is a different cost category entirely.

14.3 Scale of operating and financing differences

Illustrative calculation, not a CK estimate: an additional \$100,000 annual cost has present value of approximately \$1.96 million over 30 years at 3%, or \$2.57 million over 50 years. Conversely, a claimed \$200,000 annual staffing saving cannot justify a large transmission investment until its full pumping, maintenance and renewal costs are deducted.

Illustrative debt sensitivity: \$10 million financed over 30 years costs approximately \$510,000 annually at 3%, \$651,000 at 5%, or \$806,000 at 7%, assuming level annual payments. These values exclude issuance costs and do not establish CK borrowing terms. The rate model must translate the approved net financing burden into customer bills, with affordability and large-user allocation shown.

14.4 Energy comparison

For planning, pumping energy per cubic metre is approximately 0.002725 multiplied by total dynamic head in metres and divided by combined pump/motor efficiency. This follows from gravitational energy divided by 3.6 million joules per kWh. At 40 m head and 75% efficiency, the illustrative value is 0.145 kWh/m³. Moving 10,000 m³/day at that duty requires about 530,000 kWh/year; at an assumed \$0.15/kWh, energy alone is about \$79,600/year.

These are examples, not route estimates. Actual head includes elevation and friction; actual tariffs include time and demand charges. Obtain pump curves and route profiles for each option. Compare treatment energy as well as transmission energy and assess how emergency operation changes efficiency.

14.5 Funding and financial controls

CK's development-charge page identifies the 2024 water/wastewater study and by-laws 30-2024 and 33-2024, with growth-related charges contributing toward infrastructure expansion. [31] Assign only legally recoverable growth-related costs to DC funding. Existing-user renewal and resilience must not be labelled growth simply to shift their cost into a restricted fund.

The provincial Municipal Housing Infrastructure Program includes housing-enabling and health/safety water streams. These are potential funding routes subject to eligibility, timing, application and agreement conditions. [32, 33] Screen federal and provincial opportunities against the exact scope; assume no unawarded grant in the base affordability case. Distinguish already-awarded project funding from potential future assistance.

Use rate-supported reserves for their authorised purpose and debt through the required municipal approvals and borrowing framework. Review restrictions, current commitments, debt servicing and reserve floors. A separate resilience reserve may improve tracking but creates no money by itself. Do not use general accumulated surplus or the book value of pipes as available cash.

14.6 Proposed expenditure classification

Recommendation	Expected category	Required reconciliation
Chatham production and restart investigation	Existing scope plus possible limited redesign	Compare R26-205 deliverables against additional outage tests.
Integrated power and transfer testing	Operating addition or expanded maintenance	Cost staff time, safe test arrangements and repeat intervals.
Ridgetown tank	Existing initiative	Retain project identity and actual commitments.
Ridgetown second path or retained well	Potentially new scope	Compare incremental cost with useful contingency output.
Wheatley reciprocal assistance	Redesign or new scope	Existing links and restoration costs excluded from incremental total.
Wallaceburg modular alternative	Replacement or redesign	Remove superseded future package before counting revised work.
Chatham raw-main redundancy	Acceleration, redesign or new appropriation	Establish historical scope, current budget and as-built status.
Condition assessments	Existing program plus targeted acceleration	Credit work already funded; focus on high-consequence gaps.

A priced capital program should follow these reconciliations. This paper does not authorise a new municipality-wide spending envelope.

14.7 Gross and incremental accounting

Use A–F as expenditure tags, with separate status fields:

Tag	Meaning	Treatment in the comparison
A existing renewal obligation	Necessary replacement/rehabilitation for safe continuing service.	Baseline remaining cost; changing its design may create D or replace A.
B approved funded or underway	An actual appropriation, funding agreement or contract, with its specific scope.	Record commitments and spending separately; B does not imply whole-project construction is funded.
C planned not committed	Master-plan, EA, DC or rate forecast scope without verified construction commitment.	Reconcile current approval and engineering status; exclude superseded alternatives from the current baseline.
D resilience redesign	Additional cost to make an existing project withstand a defined outage.	Count the difference between baseline and revised project, including missing interfaces.
E new resilience infrastructure	Additional assets that would not otherwise be built.	Count full forward cost and renewal/O&M; justify useful failure protection.
F superseded or avoided capital	Baseline work removed or resized because of the selected alternative.	Credit only remaining avoidable cost, net of replacement/cancellation obligations.

A is a service obligation and B/C are statuses, so they must not be treated as mutually exclusive amounts to subtract twice. Split a project's scope into baseline, redesign and new components, then record funding and commitment against each. Identify F with the displaced project ID.

Net Incremental Resilience CAPEX equals the remaining capital cost of the selected resilience program minus the remaining capital cost of the Current Planned Path, in the same price year and service horizon. Equivalently it is additional redesign plus new works plus transition/cancellation costs, less genuinely avoidable baseline work. Existing reserves or grants change financing exposure, not the physical resource-cost difference. A project can reduce rate-supported borrowing while still using valuable municipal reserves.

Net New Municipal Exposure is the additional unfunded cash requirement after confirmed contributions and available, authorized financing allocations. It is not necessarily equal to Net Incremental Resilience CAPEX. Show gross remaining program funding and incremental borrowing side by side; funds committed to the baseline cannot also pay the increment.

14.8 CK wide capital register

Table 14A covers principal decisions, rather than all distribution renewal. Amounts are \$millions in provisional 2026 terms using the Section 1.4 assumptions. Historical references are retained to expose overlapping capital already contemplated. These references are not priced current designs. Confidence distinguishes the documented source figure from its applicability to the new project.

Project or component	Region	Gross planning CAPEX	Existing renewal obligation	Already funded or planned	Incremental resilience CAPEX	Potential avoided or superseded cost	Net new municipal exposure	Estimate basis	Confidence
CK DC water envelope	All	601.7 reference	Not isolated	C; 2024 schedule	TBD	TBD	TBD	Historical 545.8 at 5% for 2 years [40]	Source high; current scope low
Southeast package	South	91.98 base reference	Reservoir/tank portion; TBD split	C; tank design B	D/E TBD	Displaced old Southeast rows, not an extra saving	TBD	2025 EA plus assumed 5% [14]	Preliminary
Northern old scope	North	208.39 reference	Renewal core; TBD split	C; current redesign	TBD	Removed scope less substitutes	TBD	Five 2024 northern rows at 5% [40]	Historical high; current low
Northern right sized options	North	TBD	Necessary safe replacement supply	Study; current construction funding unverified	TBD versus updated A	Modular/storage/trunk differences	TBD	Current 10/12 ML concepts [9]	Engineering required
Chatham raw main	Central	42.97 later reference	TBD condition based	C; status reconcile	D or E TBD	Alternative sections only if full scope replaced	TBD	2024 transmission row [40]	Scope match needed
Chatham raw pumping	Central	4.00 reference	TBD	C	D TBD	Changed pump scope	TBD	2024 row [40]	Historical
Chatham storage	Central	21.82 reference	Renewal/growth split TBD	C; design B	D TBD	Alternative usable storage scope	TBD	2024 row plus 2026 design [40,16]	Current estimate needed
Chatham major WTP expansion	Central	232.44 reference	Recovery/renewal split TBD	C; reconsidered	TBD	Deferral/resizing only; not bankable	TBD	2024 row at 5% [40]	Growth and scope uncertain
Western planned boosters	West	4.90 reference	Duty dependent	C	D/E only added duty	Replaced scopes TBD	TBD	Two 2024 rows [40]	Historical

Project or component	Region	Gross planning CAPEX	Existing renewal obligation	Already funded or planned	Incremental resilience CAPEX	Potential avoided or superseded cost	Net new municipal exposure	Estimate basis	Confidence
Tilbury reservoir retirement	West	2.28 reference	Not replacement	C; re-evaluate	Retention/ renewal delta TBD	Retirement entry may be removed	TBD	2024 scope clarified by rate study [40,41]	Service test required
Wheatley recovery commitments	West	6.714 original construction budget ex HST	Recovery	B; partly spent	Zero for prior recovery; new work separate	Sunk expenditure never credited	Remaining commitments/c laims TBD	March 2026 minutes [38]	Budget verified, outturn unknown
New transfer mains and terminals	Cross network	Quantity allowances plus TBD	No baseline unless replacing a main	D/E; no whole network approval verified	TBD; partial examples in Appendix G	Existing compatible scopes only	TBD	CK civil/booster proxies [14]	Low; quantities required
Power controls well and testing work	All	TBD	Some normal maintenance	A/B/C status reconcile	D/E TBD	Duplicated studies/renewal only	TBD	Electrical/ process scopes and quotations needed	Unquantified

The rows are not additive. The DC envelope includes regional entries; the Southeast total includes its main and tank; raw-main histories may describe one project; and Wheatley recovery is a different cash/decision boundary. This prevents a misleading municipality-wide sum.

A reproducible selected reference basket is \$376.34 million: the old northern reference scope, three central references for raw main/pumping/storage, the two western booster references and Tilbury retirement, plus the Southeast EA replacing earlier overlapping southern entries. Appendix G shows the calculation. It deliberately excludes the \$232.44-million central expansion reference and routine distribution renewal. The basket is an analytical scope register, not the selected strategy, approved funding, or a current program estimate. Adding excluded items mechanically would perpetuate incompatible assumptions.

14.9 Avoided and superseded cost tests

Candidate displacement	Potential gross exposure	What must be bought or retained instead	Credit allowed now
Old 56 ML northern reservoir	\$58.58m 2026 reference	Modelled local/regional storage and pumps, fire reserve and outage bridge.	None banked; subtract substitute cost in a revised design.
Major Chatham WTP expansion	\$232.44m 2026 reference	Required production recovery, firm duty, actual growth and process renewal.	None banked; test resizing and timing, not automatic cancellation.
Northern regional trunk if Dresden stays central	\$36.89m 2026 reference for later northern transmission row	Safe existing Dresden supply and useful north/central assistance; confirm row scope.	None banked until service and project mapping established.
Tilbury reservoir/pump retirement	\$2.28m historical reference	Condition-based retention, inspection and maintenance if storage remains useful.	Removal of retirement cost only, less added retention cost.
Duplicate Ridgetown local treatment renewal	TBD	Connection, receiving storage and independent contingency; optional retained well.	Forward replacement costs only, after engineering verifies substitute.
Temporary treatment or purchased water	Historical full emergency cost TBD	Contracted contingency, tests, donor reservation and readiness.	No expected annual saving without credible scenario frequency; report event-cost exposure.
Shared laboratory maintenance and staffing	TBD	Licensed operator coverage, travel, emergency staffing and equipment.	Only a documented forward staffing/service budget reduction.

The first three references come from the 2024 DC schedule under the stated price assumption. [40] They are candidate scope exposures rather than additive avoided costs. Do not count removing a reservoir as a saving and simultaneously omit all replacement storage from the alternative. A future plant-renewal saving should be discounted from the actual renewal date; a deferral should retain the later cost.

A cancellation can involve design write-offs, contract termination, grants that must be repaid, land costs and temporary service. Already paid fees are disclosed as sunk costs, but a legally unavoidable future termination payment belongs in the forward comparison. A reserve balance is not a saving created by cancellation.

14.10 Lifecycle comparison over 30 40 and 50 years

For A–E in Section 12.6, calculate a resource-cost present value before financing: remaining CAPEX plus discounted annual operations and replacements, less credible residual value and genuine forward cost displaced. Apply the same demand and outage constraints. Then prepare a separate annual cash/rate model incorporating grants, DC receipts, reserves, borrowing, debt principal/interest and replacement contributions. Do not add debt principal repayment to upfront capital in the resource-cost present value.

Cost stream	Four source network B	Consolidation C or D	External hybrid E
Plant operators and licensed coverage	Retain site readiness; quantify sharing and relief coverage.	Savings only after duties disappear; preserve emergency/central coverage.	Reduced plant duties may be offset by boundary and agreement management.
Chemicals membranes filters laboratory residuals	Process and raw-quality specific; include minimum fixed obligations.	Higher donor throughput and treatment-risk concentration.	Purchased-water price includes some treatment costs; avoid duplicate counting.
Energy and pumping	Normal and emergency transfer hours separately.	Added permanent conveyance and central pumping.	Boundary pumping and tariff/demand charges.
Treatment and trunk maintenance	Existing plant work plus new links.	Fewer plant sites but more critical trunk exposure.	Boundary assets and renewal contributions in agreement.
Reservoir and tower maintenance	Retain only useful storage; inspections, coatings, mixing and renewal.	Receiving storage can increase after remote supply.	Existing receiving storage still required.
Generators fuel tests exercises SCADA	Each active source and transfer station needs readiness.	Larger shared dependencies can require more costly independence.	Donor readiness guarantees plus CK interfaces and exercises.
Mechanical electrical replacement	Asset-specific cycles and remaining lives.	Displaced local components versus added donor/network replacements.	Contract renewal/tariff reset and owned equipment replacement.
Event response	Temporary treatment, rentals, staff and purchased water under each defined event.	Same event durations and service level.	Same event plus donor curtailment scenario.

Plant-level current budgets and replacement schedules are not sufficiently disaggregated in the reviewed public record to publish reliable total lifecycle costs for the new architectures. The calculation below makes the four-source premium transparent without claiming to measure it.

Proposed sensitivity: four active sources cost an additional \$0.25/\$0.50/\$1.00 million annually in net fixed readiness after genuine staffing efficiencies. Those are analytical assumptions, not CK expenditure findings. At a 3.5% real discount rate, the present-value premium is:

Additional annual fixed cost	30 years PV \$m	40 years PV \$m	50 years PV \$m
\$0.25m	4.60	5.34	5.86

Additional annual fixed cost	30 years PV \$m	40 years PV \$m	50 years PV \$m
\$0.50m	9.20	10.68	11.73
\$1.00m	18.39	21.36	23.46

For the \$0.50-million annual case over 40 years, the premium is \$13.68 million at 2% real discount, \$10.68 million at 3.5%, and \$8.58 million at 5%. These values exclude extra plant renewal CAPEX. If a four-source option saves \$10 million initially but adds \$0.50 million annually, its 40-year resource cost is already about \$0.68 million greater before renewal differences. If retaining a plant also adds major replacement expenditure, the gap grows. Resilience is not free.

Conversely, a consolidated option that cannot sustain the defined essential-service contingency is infeasible even if it has the lowest cost. Among feasible options, compare the four-source premium with the number of customers/critical facilities protected, service preserved and residual common-source risk. Council/PUC can choose to pay a transparent premium for geographic independence; do not monetize that choice with invented outage probabilities.

Calculate scenarios at 30/40/50 years and 2%/3.5%/5% real discount. Test mechanical lives of 15/20/25 years and electrical/control lives of 10/15/20 years as proposed sensitivities, then replace them with asset-specific schedules. A new item near the horizon needs consistent residual-value treatment; do not penalize one alternative by charging an end-horizon replacement while assigning no remaining value.

14.11 Illustrative debt and ratepayer effects

Ratepayer analysis must start with the updated financing forecast, not an extra charge on every historical project. Table 14B reports annual level debt service per \$10 million of additional principal. Rates are proposed 3%/5%/7% sensitivities, not Infrastructure Ontario offers. Terms are 20/25/30 years; financing must reflect the actual asset life, legal debt framework and borrowing approval.

Financing term	At 3% annual \$	At 5% annual \$	At 7% annual \$
20 years	672,157	802,426	943,929
25 years	574,279	709,525	858,105
30 years	510,193	650,514	805,864

Amounts exclude issue costs, construction-period interest, refinancing, new O&M and renewal contributions. Capital references above are constant-dollar purchasing-power comparisons; a future borrowing schedule must include actual expected construction-year prices and draw dates.

The following examples are financing sensitivities, not estimates of the CK network. The documented 2026 forecast of 39,622 total water customers is used only for an equal-account illustration; it includes differing customer classes and uses different aggregation from the detailed meter tables and needs reconciliation. [41, Tables 1-2, 6-1 and 6-2] Do not interpret it as a count of residential households or a proposed equal charge.

Illustrative additional financed principal	Annual debt service at 5% 30 years	Equal account equivalent per month	Total paid over 30 years
\$5m	\$325,257	\$0.68	\$9.76m

Illustrative additional financed principal	Annual debt service at 5% 30 years	Equal account equivalent per month	Total paid over 30 years
\$10m	\$650,514	\$1.37	\$19.52m
\$15m	\$975,772	\$2.05	\$29.27m
\$30m	\$1,951,543	\$4.10	\$58.55m
\$50m	\$3,252,572	\$6.84	\$97.58m

For a \$20-million extra-scope example, gross borrowing is \$20 million if no cash contributions are assigned. If \$4 million of reserves and \$2 million of legally eligible, received contributions are actually available and authorized, borrowing would be \$14 million. These are assumed amounts, not verified CK balances. At 5% over 30 years, debt service drops from approximately \$1.301 million to \$0.911 million. Reserves have opportunity and replenishment costs, and growth receipts cannot be assumed before collection.

In a contingent grant sensitivity, a signed \$5-million award against that same example would reduce borrowing further to \$9 million and annual debt service to approximately \$0.585 million. The base case excludes that award. This example must not be cited as a CK funding application, eligibility decision or promised grant.

New annual O&M of \$0.50 million would add another \$1.05 per month in the equal-account illustration, before renewal contributions. Thus a \$10-million debt-financed increment plus that O&M is about \$2.42 per account per month under these assumptions. Existing rates still have to pay the baseline program. A debt-only estimate is not the full cost of resilience.

For a residential-use illustration, the rate study uses 188 m³/year and forecasts an urban water-only bill of \$718.29 in 2026, increasing under its modeled capital and cost assumptions. [41, Table ES-1] This is a historical forecast, not confirmation of the current approved tariff or an incremental resilience charge. The official rates page identifies changes effective January 1 2026. [43] Reconcile actual tariff and the current capital plan before calculating any percentage increase. Do not add the full network reference basket to a rate path that already finances many of its components.

A volume-only allocation of the \$650,514 annual debt service for \$10 million at 5% over 30 years, divided by the study's forecast 13.251389 million m³ billed in 2026, is about \$0.0491/m³. [41, Table 1-2; paper calculation] That would be approximately \$9.23/year at 188 m³ and \$4,909/year at 100,000 m³. A large 1,000,000 m³ user would pay about \$49,090/year under that artificial allocation. This is a sensitivity, not a proposed tariff: CK uses fixed and declining-block volume charges, so the actual class impacts will differ. Show residential, rural, large-user and bulk/external allocations and their cost-of-service rationale.

Large-user growth affects both capital demand and expected funding. If a greenhouse or processor's demand does not materialize, fixed debt remains while projected volumes and DC receipts fall. Run demand downside alongside cost and interest upside. Do not make public-health contingency depend on nonbinding curtailment promises.

14.12 Funding strategy and current program constraints

Prioritize existing authorized design/capital envelopes for added scenario testing where contracts allow. Finance eligible renewal from water rates and appropriate lifecycle reserves, subject to availability and approvals. Use growth DCs only for the legally attributable share under the current study and by-law; an old DC benefit split is not automatically valid for a redesigned project. Front-ending, developer-servicing and

neighbouring-utility cost-sharing agreements need legal review, clear asset ownership and no duplicate reimbursement. The DC study describes external-services and developer responsibilities. [40, policy section]

The rate study's \$870.174-million inflated water program identifies significant DC financing and non-growth debt alongside lifecycle reserves. [41, Table 4-2] Those are forecast funding streams, not cash on hand. Publish actual reserves, restricted balances, claims, commitments, debt headroom and collected DCs. A grant or insurance receipt reimbursing one project is not automatically available for unrelated works.

Ontario's housing-enabling and health/safety water streams are potential routes, but application windows, starts/completion deadlines and agreements matter. The published Health and Safety Water Stream page gives June 30 2026 commencement and March 31 2029 completion requirements for its specified intake. [44] Do not assume a new October 2026 proposal fits that intake. Verify successors and open calls. The current non-DC municipalities stream has eligibility tied to the absence of residential DCs as of March 30 2026; CK's DC position must be tested rather than treating every MHIP stream as universally available. [46]

Federal housing/water and the Build Communities Strong Fund streams can be screened for eligible scope and delivery conditions. Federal program material includes water infrastructure and housing-enabling purposes. [45] No unawarded contribution is included in the base case. Seek independent confirmation of eligible project dates, procurement and domestic-content conditions, stacking limits and the municipal share before committing expenditures in anticipation of reimbursement.

A firm interutility agreement can share boundary infrastructure and standby duties. Require a price for capacity reservation, volume, energy, metering and renewal. Compare its present cost with owned duplication and include contract expiry/curtailment. The benefit is service availability under a defined event, not merely signing an assistance memorandum.

14.13 Four financial conclusions

Required fiscal result	Best supportable statement now	What prevents a tighter current figure
1 gross infrastructure represented	\$545.78m 2024 DC water envelope, about \$601.72m at assumed 5% to 2026; separate overlapping \$870.17m inflated 2025–2034 rate forecast. Selected non-additive basket: \$376.34m.	Different horizons, scopes and price bases; current PIC design and commitments unresolved.
2 projects planned or required anyway	Renewal/corrective work and major listed plant, storage, Southeast and western scopes are already contemplated; current remaining-cost baseline TBD.	Actual project ledger, revised growth and plant capacities, appropriations and spend-to-date.
3 potential avoided or superseded spending	Candidate gross entries quantified in Section 14.9; no savings banked.	Replacement scope, asset condition, timing, contracts and approved removals.
4 net incremental resilience CAPEX	CK-wide total TBD—engineering required. Some new-main/booster partial allowances are bounded; no justified full-program low/base/high exists yet.	Transfer duties and routes, plant modules, source changes, electrical design, usable storage, well condition and baseline overlap.

The answer to the central fiscal question is conditional: intelligent renewal design can create valuable resilience without rebuilding every system, but the public record does not yet prove that the full four-source network has a small incremental price. Low-cost tests and interfaces should be explored first. If a long trunk or major plant addition is necessary, the premium could be material and must be justified against less costly targeted or external alternatives.

The next Council/PUC financial deliverable should be a priced shortlist showing gross remaining cost, baseline cost, substituted scope, net increment, annual O&M premium and actual class-specific rate effect. This paper provides an auditable framework and documentary references for that decision; it does not supply a spending authorization.

15 Governance and Legal Authority

15.1 Roles

The PUC is a local board of Council functioning as the regional water and wastewater utility. Its responsibilities include treatment and delivery of safe drinking water. [34] The actual licences, permits, delegations and municipal governance instruments must determine who approves a particular change.

Authority	Role in the proposed strategy
Council	Municipal policy, land-use alignment, applicable budgets, borrowing and by-laws; requests joint reporting and approves matters within its authority.
PUC	Utility service planning, technical and operating direction, rates and capital decisions within its mandate; manages compliance and operator arrangements.
Administration and operators	Develop studies and budgets, procure under delegated authority, maintain assets, execute emergency procedures and provide evidence.
MECP	Drinking-water licensing, works permits, taking-water and applicable environmental oversight; sets and enforces provincial requirements.
Public Health	Drinking-water health protection and advisory coordination within its authority.
Conservation authorities and source-protection bodies	Applicable regulated-area review, flood/erosion information and source-protection functions.
Neighbouring utilities and municipalities	Approve their own assistance, connections, operating responsibilities and supply agreements.
Provincial and federal funding agencies	Determine grant eligibility, contribution agreements and reimbursement conditions; grants do not replace approvals.

The standard-of-care duty attaches to persons with relevant decision-making or oversight responsibilities under the Safe Drinking Water Act; delegation does not make oversight optional. [35] A mayoral policy announcement cannot issue a provincial licence, direct another utility to transfer water or make a plant alteration legally operable.

15.2 Approval and consultation sequence

For each project, identify its owner, applicable works permit and licence, taking-water approval, operator requirements, environmental process, land/easement requirements, source-protection implications and any conservation or federal watercourse approvals. Obtain legal and regulatory confirmation at initiation and before tendering.

Ontario's financial-plan regulation requires approval and public availability of qualifying plans. [36] A major revised capital program should trigger reconciliation of the rate study, cash forecast and financial plan rather than leave materially outdated assumptions in place.

Conservation-area permissions depend on location and applicable exemptions and regulations. [37] Neither a Council motion nor an environmental-assessment document alone establishes that every site-specific permit has been obtained. Engage the relevant conservation authority early on intake, shore, floodplain and crossing works.

The September PIC itself notes possible changes to the municipal assessment process in early 2027. [9] Treat that as a requirement to verify the applicable process when proceeding, not a basis to assume future exemptions. Maintain public and Indigenous consultation appropriate to the project and governing duties.

15.3 Proposed joint oversight

Use a joint Council/PUC reporting schedule with a clear division of approvals. PUC engineering should own the technical register and testing program. Municipal finance should reconcile debt, grants and capital commitments. Planning staff should align growth assumptions. The Clerk and legal staff should provide a decision-authority schedule.

Avoid creating a separate operating corporation solely to implement the resilience strategy. Institutional restructuring has legal and financial consequences beyond the pipe-network question and would require its own assessment. Existing utility governance can support the proposed engineering and reporting work.

16 Implementation Priorities

16.1 First 90 days after adoption

Confirm the technical sponsor and prepare a single evidence register. Reconcile service boundaries, current licences, operating test results, critical assets and capital commitments. Request the Chatham 2025 and 2026 incident reviews and the Wheatley recovery ledger. Preserve already-authorised essential repair and renewal work.

Commission a gap review of existing model and consulting scopes before issuing new contracts. Add resilience tests through existing engagements where procurement and contract terms permit. Specify any genuinely additional work and its capped budget for approval.

16.2 First year

Publish provisional scenario risks with evidence confidence and mitigation dates. Complete integrated generator and emergency-link tests where safe. Establish donor transfer agreements and verified activation procedures. Update large-user demand and curtailment assumptions.

Run the common alternative comparison for Wallaceburg and southern servicing. Identify improvements that can be incorporated before existing designs are finalised. Obtain independent engineering review of the

largest irreversible decisions: treatment closure, regional source selection and major new transmission corridors.

16.3 Construction sequence

Build and commission enabling treatment, pumping, power and receiving storage before transferring permanent demand. Confirm normal and contingency performance with the new connection in service. Maintain transitional supply capability until acceptance tests pass and operators have demonstrated the emergency procedures.

Coordinate road and main works to reduce restoration duplication, but do not defer a high-consequence repair solely to wait for a distant road project. Set explicit hold points for funding, permits, tender prices and acceptance performance.

16.4 Staged program with decision gates

Timing below is a proposed sequence from adoption in late 2026, not a construction promise. Urgent condition or safety work proceeds when required; northern renewal must not wait behind southern construction if its asset risk is greater. The stages can overlap and have separate approvals.

Stage and timing	Trigger and prerequisite	Planning CAPEX	Funding route	Hard stop
1 measure and secure 2026–2027	Critical failures documented; calibrated model, condition/register gap review, integrated power and transfer tests.	Remaining existing investigations plus defined incremental study/test scope; TBD fee and repair quantities.	Authorized studies/maintenance first; additional capped scope through normal approval.	No assumed firm capacity or Green status without evidence; urgent repair cannot be deferred for a study.
2 Southeast connection 2026–2031	Verified South CK output; current EA/design, receiving storage and alternate activation plan.	\$91.98m provisional unchanged-package reference; remaining baseline and redesign split TBD.	Water capital, eligible DC share, debt/reserves and awarded assistance.	Donor/pressure/quality test fails, unaffordable tender or contingency not commissioned.
3 northern decision 2026–2028 then delivery by approved risk-based schedule	N1/N2/N5/N6 shortlist priced; condition sets maximum safe interim period.	Current right-sized option TBD; historical core/full references in Section 9.8 are not its budget.	Replacement/rate capital; justified growth share; verified external sharing.	No oversized uncommitted demand; no long Chatham dependency without acceptable contingency.
4 western readiness 2027–2031 subject to earlier corrective needs	Rebuild completion/condition verified; actual donor transfer tests and firm agreements.	Existing booster reference \$4.90m; W1–W4 incremental package TBD; quantity examples available.	Existing lifecycle work, rate capital, interutility sharing and eligible awarded grants.	Shared fire/electrical vulnerability unmitigated; reciprocal flow not sustainable or affordable.

Stage and timing	Trigger and prerequisite	Planning CAPEX	Funding route	Hard stop
5 selected cross-network links 2030 onward	Stages 1–4 identify a remaining high-consequence gap with a cost-effective link.	Modelled quantities only; 300/600 mm civil proxies in Appendix G, plus missing scope.	Staged rate capital/debt; compatible neighbouring contributions.	No compulsory municipality-length grid; reject a link with little useful outage protection or poor water quality.

Each gate report should include a no-extra-network comparator, concept estimate, escalation date, annual O&M, replacements, donor agreement and acceptance tests. Carry stage contingency supply until normal and emergency operation has been demonstrated. An early stage does not authorize the next one, and affordable staging must not strand an essential trunk without donor or receiving works.

16.5 Early design measures to test for low incremental cost

When a facility already needs renewal, request alternate prices for independently isolatable treatment modules, reserved land and interfaces, maintainable valves, emergency/mobile equipment connections, accessible standby-power transfer, separate critical controls and useful reciprocal terminal duty. Include commissioning tests in the tender where justified. The incremental amount may be modest compared with later retrofitting, but obtain actual alternates; do not claim a universal percentage saving.

A second distant raw-water intake or route-diverse interregional main is different: it can require major new civil works. The design should separate inexpensive provisions for later expansion from prematurely buying the full expansion. Preserve an interface only if its future purpose and maintenance consequences are understood.

17 Five Ten Twenty and Thirty Year Roadmap

Horizon from adoption	Proposed outcome	Conditions for proceeding
5 years to approximately 2031	Verified resilience register; central corrective works; commissioned justified southern connection; selected northern alternative underway or completed according to approved schedule.	Capacity, permits, financing and contingency tests passed.
10 years to approximately 2036	Regional operating links and storage aligned with actual growth; northern and western contingency performance demonstrated; highest-consequence main risks mitigated.	Updated demand and lifecycle review; donor availability remains credible.
20 years to approximately 2046	Renew pumps, controls, treatment equipment and standby systems as condition requires; reassess service boundaries and source protection.	Asset-specific condition and economic evidence, not automatic age replacement.
30 years to approximately 2056	Re-evaluate plant count and major transmission architecture before the next substantial renewal cycle.	Compare retaining, expanding or consolidating each source using updated costs and hazards.

These are proposed decision horizons, not promised completion dates. The current master-plan process must establish realistic sequencing and expenditure. Review progress annually and the overall strategy at least every five years.

For lifecycle modelling, use separate service lives for civil structures, pipes, mechanical equipment, electrical assets and controls. As provisional scenario assumptions, test major civil and trunk-main lives of 50–75 years, pumps/process equipment of 15–25 years and controls of 10–15 years. These are analytical assumptions to replace with asset-specific evidence, not guarantees or mandatory replacement ages.

18 Risks and Tradeoffs

18.1 Consolidation and source retention

Consolidation may reduce staffing and treatment duplication but makes more customers dependent on shared infrastructure. Source retention preserves options but carries fixed compliance, staffing and replacement costs. The decision should identify the annual premium paid for the additional protection and whether another measure could provide it more cheaply.

18.2 Transmission and storage

Long mains add repair exposure, energy and water age. Larger storage extends response time but can require mixing, cleaning, rechlorination and additional pumping. Oversized infrastructure built for uncommitted growth imposes cost on existing customers while operating below its intended turnover.

18.3 Operational complexity

A flexible network requires clear pressure-zone control, training, tested valve sequences and coordinated source changes. More physical connections can increase the number of operating modes and opportunities for error. Standardise operating procedures and provide manual fallback without defeating treatment or safety interlocks.

18.4 Demand and climate uncertainty

Large-user growth can materially alter peak demand and contingency availability. Stage investment with binding service commitments and monitored demand rather than assuming every potential development proceeds. Conversely, essential protection should not depend on optimistic reductions in leakage or conservation that have not been demonstrated.

Test flooding, shore and intake hazards, heat-driven demand, difficult source water and prolonged outages. Multiple Lake Erie plants may provide asset diversity while retaining shared exposure to some source hazards. The northern source should be assessed against the same common-event scenarios.

18.5 Cost of excessive standards

An uncompromising requirement for unrestricted supply after every conceivable double failure could consume capital needed for routine renewal. Adopt a credible single-failure standard, a defined essential-demand tier and separately costed extreme scenarios. Where complete redundancy is uneconomic, identify the residual risk and fund realistic recovery arrangements.

19 Hard Stops and Conditions for Reconsideration

Stop or redesign a demand transfer if the donor cannot demonstrate required net output and contingency margin under relevant source-water conditions. Do not commission a connection that depends on bypassing required treatment or leaves the receiving zone unable to maintain approved pressure and quality.

Do not retire an independent plant or well until its replacement and contingency arrangement are commissioned, tested, funded and legally operable. Do not count an external donor without a verified agreement and sustainable transfer test. Do not count storage that is inaccessible in the outage being assessed.

Reconsider a regional route if water age, surge, ecological constraints, land access or pressure-zone changes materially alter the business case. Reconsider oversizing if major-user demand is uncommitted or revised growth eliminates the need. Reject compulsory Thamesville integration where targeted central improvements or limited backfeed provide better value.

Reopen financing if tender costs exceed the authorised affordability envelope, grants fail, debt service breaches applicable limits or reserve balances fall below approved requirements. Do not compensate for cost escalation by quietly removing essential redundancy that justified the project.

Require formal review if an acceptance test fails, incident data contradicts the model or a common dependency defeats the proposed alternate source. No sunk-cost argument should prevent correcting a design before further irreversible spending.

Financial and operating conditions added in Version 2

Reconsider four active sources if the same Standard can be achieved at lower lifecycle cost through three-source or external assistance without unacceptable common failure exposure. Reconsider a new regional trunk if local wells, storage, existing-main reinforcement or a nearby contracted source achieve the same essential service more cheaply.

Stop financial approval if the paper's historical price proxies are presented as tender prices, if sunk Wheatley restoration is charged as new resilience, if a financing forecast is presented as cash or if old and revised packages are added together. Require repricing when scope, base date or contingency cannot be reconciled. A bidirectional label without tested useful reverse output is not a quantified benefit.

Pause dependence on an external donor if firm reservation, peak-demand availability, outage priority, term or tariff is unresolved. Pause plant retirement if actual transfer and restart tests have not passed. A retirement-saving claim cannot be used to fund the contingency that is still missing.

20 Proposed Council and PUC Actions

The following are proposed motions for adaptation by the Clerk, legal staff and PUC. They do not assume Council can exercise every utility or regulatory power directly.

1. Council endorse the principle of evaluating drinking-water service by demonstrated continuity under credible critical-asset failures and request that the PUC incorporate this evaluation into the ongoing master-plan update.
2. The PUC direct staff to develop the proposed Water Resilience Standard, with defined essential demand, pressure, urban fire protection, source independence and evidence requirements, and return it for approval after engineering and regulatory review.

3. Council and the PUC request a joint service-area risk register and a reconciled capital/financing ledger identifying existing, accelerated, redesigned, replaced and genuinely new expenditure.
4. The PUC require a common hydraulic and lifecycle comparison of renewed Wallaceburg-only treatment, Wallaceburg–Dresden treatment, a Thamesville extension, Chatham supply and a modular hybrid with external assistance.
5. The PUC require verified South CK output and contingency performance before permanent transfer of Ridgetown/Highgate demand, and a costed comparison of selected groundwater retention against other emergency measures.
6. The PUC retain Wheatley treatment as the reference operating case for the next planning stage, with Tilbury assessed as part of that system and reciprocal assistance evaluated without precommitting to closure.
7. The PUC request a documented status report on Chatham raw-water redundancy proposals, current corrective contracts, incident findings and the alternatives to full twinning.
8. Council and the PUC require approved financing, applicable permits, public reporting and performance acceptance before each major construction or retirement decision, with expenditure authorised through existing budget and procurement processes.
9. The PUC publish annual resilience results and corrective dates, keeping operational security details in controlled records.

Additional Version 2 direction

Require a Current Planned Path and priced shortlist before major architecture selection, using the A–F register, 2026 constant-dollar resource costs and an execution-year cash model. Request common 30/40/50-year lifecycle comparisons for A–E and the northern shortlist, including the four-source fixed-cost premium.

Request reconciliation of the March 2026 Wheatley construction budget, actual final restoration/outage expense and insurance recovery, and a complete temporary-treatment chronology distinguishing its initial operation from its 2025 return to service. Require separate remaining-life assessments for civil, electrical, treatment and transmission assets. [38, 39]

Require each proposed stage to identify gross remaining cost, superseded project IDs, net incremental resilience CAPEX, funded share, additional debt, ongoing O&M and class-specific rates. Do not treat the \$601.7-million normalized historical envelope or the \$376.3-million selected reference basket as a new program appropriation.

21 Sources

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Appendix A Engineering Data and Verification Register

The following information is required to convert the screening recommendations into a final engineering and financial recommendation. Its absence is not evidence of noncompliance.

Evidence required	Decision affected	Responsible technical lead
Current licences, permits and taking-water conditions for each subsystem	Legally available capacity and alteration process	PUC compliance and legal staff
Plant field-test reports with sustained net output and limiting conditions	Donor capacity and staging	PUC operations and consulting engineer
Largest-component-out treatment and pump tests	Firm capacity and required modules	Process and hydraulic engineers
Electrical single-line drawings, utility dependencies, load tests and fuel logs	Power independence and runtime	Electrical engineer and operators
Calibrated GIS, elevations, valves, pipe diameters, roughness and pump curves	Normal and reversed transfer feasibility	Hydraulic modelling team
Metered transfer traces and donor/receiver pressure logs	Sustainable emergency assistance	PUC and neighbouring operators
Storage compartments, operating bands, contact volume and minimum pressure	Usable bridge hours	Process and hydraulic engineers

Evidence required	Decision affected	Responsible technical lead
Five-year break, leakage and isolation register	Main renewal and consequence ranking	PUC asset management
Physical condition coverage by criticality, count and value	Confidence in remaining life	PUC asset management
Dated Ridgetown project decisions and budget revisions	Deferral chronology and cost bridge	PUC engineering and finance
Wheatley incident, recovery and final expenditure ledger	Lessons and long-term option cost	PUC operations and finance
Chatham 2025/2026 incident reviews and work orders	Electrical and restart corrective scope	PUC operations and engineering
As-built status of W42A, W42B and related later project IDs	Completed versus outstanding redundancy	PUC engineering
Updated capital ledger, actual debt, reserve and grant balances	Affordability and double-count prevention	Municipal and PUC finance
Current population, committed large-user demands and curtailment agreements	Capacity and emergency demand	Planning, economic development and PUC
Source-water risk and permit review for all regional options	Source diversity and intake choice	PUC, MECP and source-protection bodies

Additional Version 2 verification requirements

Missing input	Required output	Fiscal or resilience decision
Current project ledger with spend and commitments	Approved, funded, spent and remaining balances by unique ID.	Current Planned Path and net increment.
Northern current concept quantities and estimate base	Priced N1/N2/N5/N6 shortlist with full inclusion schedules.	Replacement versus regional premium.
2024 DC and 2025 EA cost bridge	Matched capacities, routes, growth shares, price year and contingencies.	No double counting or unjustified DC financing.
Chatham raw-main project mapping	W42B, later transmission row, new-main versus twinning endpoints and work status.	Current correction and residual dependency.
Wheatley final recovery ledger	Final construction, emergency O&M, temporary plant, insurance receipts, claims and unpaid commitments.	Separate recovery from future resilience.
Rebuilt subsystem condition and commissioning tests	Asset-specific useful life and residual common fire/electrical dependency.	W1–W6 forward costs and readiness.

Missing input	Required output	Fiscal or resilience decision
Plant-specific O&M and licensed staffing schedules	Avoidable versus continuing costs and transfer/standby premiums.	30/40/50-year lifecycle ranking.
Customer classes and current billed volume	Reconciled account/meter profiles, large-user demand and actual tariff.	Residential and large-user rate impacts.
Current reserve debt grant and DC status	Restricted/unrestricted cash, actual debt headroom and awarded contributions.	Annual affordability and borrowing.
Emergency scenario service metrics	Sustainable transfer, local demand, storage bridge, activation and affected critical customers.	Quantified benefit and risk classification.

Appendix B Required Hydraulic and Water Quality Scenarios

Build a calibrated extended-period model using metered demand and actual reservoir/tower levels. Define each failure as a specific unavailable asset, including the isolation valves and common terminal facilities. Record the assumed repair time and alternate activation delay.

Scenario	Required outputs
Average day and seasonal minimum demand	Water age, turnover, residual and pump efficiency.
Coincident maximum day	Net treatment requirement, donor headroom and tank recovery.
Peak hour plus adopted urban fire flow	Pressure, pump duty, storage withdrawal and recovery.
Largest treatment unit unavailable	Compliant net output and unmet normal/essential demand.
Raw intake or raw-main segment unavailable	Surviving source, bridge duration and restoration sequence.
Treated trunk segment or common manifold unavailable	Independently useful transfer path and affected zones.
Critical pump or switchgear unavailable	Effective firm pumping and shared dependency.
Utility power lost and standby starting	Starting loads, pressure transient and sustainable output.
Donor also at maximum demand	Guaranteed export and donor service consequences.
Plant outage for 7 and 30 days	Chemicals, fuel, operators, purchased water and temporary supply.
Source-quality event affecting several plants	Independently available source and treatment response.
Controlled restart after isolation	Air release, transient pressures, refill and quality recovery.

Proposed calibration acceptance should be set by the modelling engineer for flow and pressure measurement accuracy, season and operating state. Do not adopt an arbitrary universal tolerance in this policy paper. Validate critical emergency results in the field where safe, using controlled steps rather than intentionally creating a service emergency.

Appendix C Capacity Storage and Transfer Calculations

For steady conditions, available transfer is the lowest of donor spare dependable treatment, donor pumping, link hydraulic capacity, receiving capacity and agreement allowance. Include water-quality and duration limits. In a multi-source network, calculate these simultaneously; the same donor surplus cannot support two recipients at once unless the model demonstrates it.

For a constant emergency deficit, bridge hours equal usable storage in cubic metres divided by the deficit in cubic metres per hour. If surviving supply meets demand, storage does not deplete in that simplified balance. Real operation requires a time-varying model with minimum levels, peak use and hydraulic accessibility.

Illustrative case: 1,000 m³ usable storage and a 2,000 m³/day supply deficit provide 12 hours before reaching the assumed minimum. If activation takes eight hours, a proposed 25% time margin requires ten hours, so this simplified volume passes the timing test. It still fails if pumps or pressure cannot deliver the water, or quality cannot be maintained. This is an example, not a result for Thamesville or another CK community.

Convert L/s to m³/day by multiplying by 86.4. A link delivering 35 L/s continuously supplies 3,024 m³/day. Continuous operation, pressure and donor availability must be established before using that figure as an emergency daily volume. This conversion is arithmetic, not proof of a tested CK transfer rate.

Report rated plant capacity, demonstrated net output, largest-component-out output and emergency transfer in separate fields. Keep gross process flow, backwash/reject losses and treated delivery distinct. Avoid comparing a source's gross taking-water allowance directly with a receiving community's treated demand.

Appendix D Common Financial Comparison Template

Input or output	Required treatment
Remaining initial capital	Same price year; include land, works, engineering, restoration and commissioning.
Already-spent cost	Disclose; exclude from forward decision except recoverable value and cancellation consequences.
Treatment O and M	Staff, chemicals, laboratory, residuals, energy and facility maintenance.
Transmission O and M	Energy, leaks, valves, crossings, surge devices, metering and repairs.
Emergency readiness	Tests, standby equipment, contracts, fuel and temporary treatment arrangements.
Renewal schedule	Asset-specific replacement intervals with sensitivity and residual value.
Grants and DC receipts	Approved versus speculative; cash timing and legal eligibility.
Financing	Annual debt service, borrowing headroom, reserve floors and rate effect.
Lifecycle output	30-, 40- and 50-year present cost, with consistent real/nominal assumptions.

Input or output	Required treatment
Resilience output	Essential demand unmet, outage hours, critical customers affected and residual common risks.
Decision	Pass service constraint, then compare cost and risk sensitivity; no unverified numerical ranking.

The base case must fund the approved service without assuming an unawarded grant or uncommitted industrial demand. Present a grant-supported case separately. Evaluate cost changes and demand changes together, because a large-user shortfall can reduce DC receipts while leaving fixed debt service unchanged.

Appendix E Source Conflicts and Historical Questions

Issue	Established distinction	Required resolution
South CK rated capacity	Annual sources differ by 1 m3/day.	Use current licence and standardise rounding.
Wheatley temporary plant timeline	2024 PUC records establish initial operation before the 2025 return to service; 2025 end dates differ.	Confirm original startup, return to service, supply cessation and dismantling.
Chatham future demand in northern options	PIC option slides contain differing central values not clearly reconciled to the change in Dresden assignment.	Publish demand allocation and corrected scenario totals.
Water DAMP funding percentage	Stated figures calculate about 79%, while a sentence prints 65.73%.	Correct the text and reconcile lifecycle/acquisition scope.
Plant counts	PUC overview and asset plan use different treatment-plant counts.	Distinguish systems, sites and Ridgetown treatment subsystems.
Raw-main length	Historical twinning describes about 23 km; later procurement describes about 24 km.	Establish exact endpoints and as-built chainage.
Ridgetown first proposal and deferrals	Earlier program and revised windows located; complete annual decision trail not established.	Retrieve original 2012 report and intervening PUC/budget decisions.
Raw-water twinning completion	Proposal and current investigation established; full completion not certified.	Produce project status and commissioned as-built record.
Wheatley emergency costs and flow	Assistance established; complete costs and sustained transfer by route not verified.	Publish reconciled incident ledger and measured performance.

Appendix F Decision Record for Each Major Project

Before approval, the project report should identify the documented service problem, affected customers, baseline renewal obligation and proposed measurable improvement. State alternatives rejected and the actual reason for rejection. Attach the model scenario, estimate basis, financing bridge and operator review.

Record the largest residual single point of failure after completion. Identify whether the project restores existing capacity, adds growth capacity, provides source diversity, adds another path or merely extends response time. A project can provide several benefits, but each claimed benefit needs evidence.

The acceptance plan should specify permitted output, pressure, quality, restart, power transfer, emergency-flow and storage performance. Retain contingency supply until these tests pass. Provide annual public reporting on performance and the remaining corrective work.

CK can evolve toward a resilient network if investments are selected by these tests. The evidence supports that direction while leaving the final plant count and community assignments open to engineering and lifecycle results.

Appendix G Capital Arithmetic and Conditional Allowances

All calculations below are this paper's proposed price/quantity sensitivities. They do not replace engineering estimates. Monetary outputs are rounded to avoid false precision; original documentary figures remain in Sections 7–10. No full plant price is scaled by capacity.

Item	Original basis	Price or quantity adjustment	Result and limitation
2024 DC envelope	\$545.7799m in 2024 [40]	Multiply by 1.05 squared	\$601.7223m; historical unchanged scope, not current program.
Northern historical reference	58.6694 + 53.1318 + 13.5313 + 30.2287 + 33.4560, \$m [40]	\$189.0172m multiplied by 1.05 squared	\$208.3915m; no claim this is current 12 ML/day cost.
Northern core reference	Plant + intake/pump + first transmission row [40]	\$102.4294m multiplied by 1.05 squared	\$112.9284m; raw-main mapping must be verified.
Central three-row reference	38.9730 + 3.6284 + 19.7880, \$m [40]	\$62.3894m multiplied by 1.05 squared	\$68.7843m; overlaps later design/investigation.
Western planned booster and retirement references	2.4585 + 1.9903 + 2.0655, \$m [40]	\$6.5143m multiplied by 1.05 squared	\$7.1820m; retirement is Tilbury storage/pumping.
Southeast unchanged reference	\$87.601960m published [14]	Assumed 2025 base multiplied by 1.05	\$91.9821m; confirm estimate price date/inclusions.
Selected reference basket	Northern + central three rows + western three rows + Southeast replacement scope	208.3915 + 68.7843 + 7.1820 + 91.9821	\$376.3399m, rounded \$376.34m; not current strategy estimate.
300 mm civil proxy	\$24.667875m / 16 km [14]	Assumed 2025 base multiplied by 1.05	\$1.61995m/km base; proposed uncertainty 0.70–1.50 gives \$1.13–\$2.43m/km.

Item	Original basis	Price or quantity adjustment	Result and limitation
600 mm civil proxy	\$7.371m / 2.4 km [14]	Assumed 2025 base multiplied by 1.05	\$3.225m/km base; proposed uncertainty gives \$2.26–\$4.84m/km.
Comparable booster proxy	\$2.80125m [14]	Assumed 2025 base multiplied by 1.05	\$2.9413m base; proposed uncertainty gives \$2.06–\$4.41m.

The text's rounded 300 mm planning sensitivity uses \$1.1/\$1.6/\$2.5m per km; the 600 mm sensitivity uses \$2.3/\$3.2/\$4.8m per km. They are local civil proxies at the published scope boundary. They exclude unconfirmed special crossings, land, terminals, process/electrical work and missing engineering/owner/tax costs. Their broad multipliers are proposed stress tests, not empirically calibrated confidence intervals. Never apply a second contingency to an original contingency without first identifying what it covers.

Hypothetical quantity of genuinely new civil main	300 mm low/base/high \$m	600 mm low/base/high \$m
1 km	1.1 / 1.6 / 2.5	2.3 / 3.2 / 4.8
5 km	5.5 / 8.0 / 12.5	11.5 / 16.0 / 24.0
10 km	11.0 / 16.0 / 25.0	23.0 / 32.0 / 48.0
20 km	22.0 / 32.0 / 50.0	46.0 / 64.0 / 96.0

These are not CK route lengths or required diameters. They show how new long trunks can change the fiscal answer. If a pipe replaces a main CK must renew anyway, the incremental amount is the difference in actual project estimates; the entire proxy is not new exposure. A 900 mm raw-water main needs matched project scope or a takeoff, not one of these diameter bins.

No numeric generic allowance is assigned here to generator/switchgear upgrades, meter/backflow stations, one-well retention or a new northern treatment train. Ratings, electrical layout, process quality, duty and civil requirements are too important to infer from a different facility. Obtain quotations and concept quantities before putting these items into a total.

Appendix H Lifecycle and Financing Calculation Method

For level annual real O&M, multiply the annual cost by the annuity present-value factor: one minus the reciprocal of one plus the real discount rate raised to the number of years, divided by the real discount rate. At 3.5%, the factors are approximately 18.3920 for 30 years, 21.3551 for 40 and 23.4556 for 50. The displayed tables use unrounded calculation values. Check replacements and residual values separately.

For equal annual debt payments, multiply principal by the interest rate divided by one minus the reciprocal of one plus that interest rate raised to the repayment term. These debt payments are nominal and do not use the lifecycle real discount rate. Terms and interest sensitivities are analytical assumptions. Include actual issue costs and construction interest in the approved financing forecast.

Equal-account monthly equivalence is annual extra revenue divided by account count and 12. Volume equivalence is annual extra revenue divided by billed cubic metres. A real cost-of-service model must allocate

the revenue requirement across fixed and volume charges and customer classes. Do not apply both equivalences together as separate surcharges.

The incremental annual revenue requirement is additional debt service plus net extra O&M plus required additional lifecycle contributions and financing costs, less firm recurring support. Baseline debt already in rates remains in the baseline; approved grants/reserves offset principal only to the extent available and not already committed. Do not assume avoided annual costs that operations cannot actually remove.

Appendix I Quantified Resilience Benefit Reporting

For each A–E scenario and each major service area, report the same event-specific results. Use metered coincident demands, calibrated storage and verified transfer capacities. Missing numbers stay TBD; absence of data cannot become a favourable score.

Metric	Calculation or evidence	Present finding
Customers/population affected by loss of largest source	Model affected service zones, including rural/bulk customers; reconcile billing and GIS.	Current region-specific served counts not verified here; do not use community population as system population.
Essential demand maintainable	Surviving net treatment and accessible storage/transfer under defined event.	TBD by service zone and event.
Maximum sustainable transfer	Lowest compatible donor, link and receiving limit, with duration and agreement.	Wheatley actual route-specific limits not established; north old calculated emergency main below 4 ML/day is not tested guarantee. [13]
Normal demand fraction maintained	Compliant delivered flow divided by the same-time baseline demand.	TBD; do not divide by unrelated daily peaks.
Usable emergency bridge hours	Accessible storage divided by net event deficit, time-varying where required.	Chatham incident's roughly 18-hour account is event evidence, not a system-wide certified rating. [23]
Activation and severe-restriction timing	Tested valve/pump/power startup plus water-quality clearance; simulated depletion.	TBD; include failed start and donor activation delays.
Critical facilities protected	Named hospitals, care facilities, emergency assets and necessary process service maintained.	Facility-by-facility outage model required.
Residual single points of failure	Shared intake, source, road corridor, valve terminal, power, control or donor dependency.	Explicitly register each residual mechanism.
Recovery options	Repair, restart, alternate treatment, mobile power and purchased-water duties with duration/cost.	Wheatley proves multiple methods were useful, not unlimited donor capability. [8,38,39]

As a limited screening calculation, less than 4 ML/day on the older northern emergency main compared with the PIC's future 11.024 ML/day maximum-day regional demand is less than about 36.3%. [13; 9; paper calculation] That is not a demonstrated transfer ratio or an essential-service result: the main, donor output,

operating direction and future demands must be tested together. It explains why having a pipe cannot be equated with full replacement supply.

The 2024 Wheatley verbal report's temporary-treatment output of 5.28 ML/day provides observed response evidence for that week. [39] It is neither the maximum emergency source output nor a measurement of South CK/Leamington transfer. Publish separate source and boundary meters so temporary treatment and donor assistance are not combined into an invented link capacity.

The final engineering comparison should show extra dollars per unit of essential service preserved and customers protected for each specified event. Such ratios complement the mandatory service constraints; they are not expected-loss calculations and must not attach invented failure probabilities.