CHANGING STATE TECHNOLOGIES

Flood Resilience for Communities

A Technical White Paper

How MPR™ Stable Vapour Cavity Technology Transforms Groundwater Management

August 2026

Executive Summary

Urban flooding is no longer a periodic inconvenience that communities can engineer their way around with bigger drains and taller stop banks — it is an accelerating structural challenge driven by climate change, sea level rise, and rainfall events of increasing severity that are rendering historical flood frequency data obsolete.

The most insidious and least well-understood dimension of this challenge is the role of the subsurface water table: when groundwater is already elevated — from prior rainfall, geological proximity to sea level, or tidal intrusion through porous coastal substrates — storm rainfall has nowhere to drain and minor events produce major flooding outcomes. This white paper examines two of New Zealand's most significant cases of groundwater-driven urban flooding.

In Christchurch's Flockton Basin, the 2010–2011 Canterbury earthquake sequence permanently lowered the land surface by up to 400mm through seismic subsidence and liquefaction, disrupting the hydraulic gradients that had previously allowed natural drainage to the Avon River and transforming 1,500 households from a marginal flood risk to a near-permanent flooding hazard. The response involved up to four 200mm diesel flood pumps at a mobilisation cost of NZD $15,000–$20,000 per deployment, sustained for over 18 months, before a permanent NZD $26 million bypass programme and NZD $10 million pump station were constructed: a total recovery cost in excess of NZD $50 million.

In South Dunedin, St Kilda, and St Clair — suburbs built on porous reclaimed sand just centimetres above the natural water table, with no gravity-fed drainage to the sea — the October 2024 emergency brought the area's most severe flooding in over a century: knee-deep water in streets, 100 evacuations, and a state of emergency that has since prompted a NZD $29.2 million traditional engineering programme and the deeply unwelcome prospect of managed retreat for up to 1,700 households. In both cases, the fundamental engineering problem is identical: not the storm rainfall itself, but the prior saturation of the subsurface that leaves the catchment with no capacity to absorb it. In South Dunedin, this problem is compounded by an additional and underappreciated pathway — tidal seawater percolating through and beneath the porous coastal sand dunes, raising the water table from the seaward side with every high tide, independently of rainfall.

This white paper proposes a three-component integrated flood resilience strategy for South Dunedin — and a simpler two-component strategy for Flockton Basin — that addresses the flooding problem from all sides simultaneously, at a fraction of the cost of the traditional engineering responses.

The first and central component is Changing State Technologies' MPR™ (Multi-Phase Rotor) Stable Vapour Cavity pump technology, which enables a proactive approach to flood management that no conventional pump can match. Rather than deploying emergency pumps reactively during flood events, the MPR™ operates 24 hours a day, seven days a week, from a surface-mounted installation drawing groundwater through a network of small-bore wellpoint spears — continuously creating and maintaining below-ground storage capacity in the catchment before storm rainfall arrives. This continuous proactive operation is made possible by two properties the MPR™ possesses simultaneously and no conventional pump technology does: true self-priming from an almost completely dry start, requiring no foot valves, priming tanks, or vacuum-assist equipment; and the ability to sustain stable operation at suction lifts of up to 9.5 metres as the water table drops and the air fraction at the inlet progressively changes — without cavitation, without loss of prime, and without operator intervention.

For Flockton Basin, a network of multiple 6-metre wellpoint spears connected by 850 metres of MDPE pipeline to a single surface-mounted MPR™ module is estimated at a total capital cost of NZD $600,000 — 1.2% of the NZD $50 million spent on the traditional response.

The second component, specific to South Dunedin, is the Forbury Park gravity siphon: a passive pipeline that transfers accumulated groundwater over the coastal dunes to an outfall at St Kilda Beach during low-tide windows, without pumping energy, the MPR™ bore network and siphon sharing a common discharge consent.

The third component is a continuous PVC vinyl sheet pile cut-off wall driven along the landward face of the St Kilda and St Clair coastal sand dunes, creating a subsurface impermeable barrier that intercepts the tidal seawater intrusion pathway through the dune base. This approach is directly modelled on the Launceston Flood Authority's (LFA) proven use of PVC sheet piling to prevent seepage and underflow beneath its river levee system — an application documented in the LFA's published annual reports and directly transferable to the South Dunedin coastal dune environment. PVC vinyl piling is the material of choice for the coastal application: it is inherently resistant to saltwater corrosion, UV degradation, and biological attack, requires no cathodic protection or anti-corrosion coatings, and carries a design life exceeding 50 years in marine environments. A preliminary order-of-magnitude cost estimate for a 1-kilometre coastal barrier is NZD $800,000–$1,500,000, rising to NZD $2.0–$3.75 million for the full 2.5-kilometre alignment from St Kilda to St Clair — a figure that must be set against a managed retreat programme that would cost hundreds of millions of dollars and disrupt a community.

The case presented in this white paper is grounded in real world examples, combining the logic of the MPR™ Stable Cavity Vapour drawdown, the gravity siphon technology and the PVC coastal barrier strategy which together form a compelling strategy. The technologies involved are individually well-established: the MPR™ is grounded in well-understood fluid dynamics theory and application and protected by a granted US patent (US12398725B2, August 2025); the gravity siphon exploits basic hydraulic principles that have been applied in drainage engineering for centuries; and PVC sheet piling is a commercially mature product with an extensive track record in flood defence applications across Australasia and Europe. What is new is not any single technology but their integration into a coordinated, three-component system that addresses groundwater flooding from the inland side, provides passive tidal-opportunistic discharge seaward, and closes the coastal seawater intrusion pathway that renders every other intervention less effective.

The recommended adoption pathway is structured and risk-managed — beginning with baseline groundwater monitoring, a coastal dune geotechnical investigation to confirm sheet pile design parameters, and a small-scale MPR™ proof-of-concept trial before scaling to the full combined system. The case for moving to that first step is urgent. In Christchurch, over NZD $50 million in traditional response and permanent infrastructure did not fully restore pre-earthquake flood protection for all 1,500 affected households.

In South Dunedin, St Kilda, and St Clair, the looming threat of forced relocation for up to 1,700 families from a community built by gold-rush settlers and occupied for generations demands that every technically credible alternative be rigorously evaluated before managed retreat is accepted as inevitable. By applying the combined MPR™, siphon, and coastal barrier system to these long-standing problems, communities can achieve measurably improved flood resilience at a fraction of the cost — and far sooner — than conventional engineering approaches could deliver. The physics is proven. The technology is patented. The application is logical. The case is urgent.

1. Introduction

There is no denying that flooding of communities around the world is becoming a major and accelerating problem in both coastal and inland settings. The convergence of climate change, sea level rise, and increasingly extreme rainfall events is rendering historical rainfall frequency charts obsolete and exposing millions of people in urban areas to flood risks that no longer respond to the engineering solutions of previous decades.

The most devastating consequences are well known: flooding of homes, buildings, transport routes, and essential infrastructure during storm events. But less well understood — and arguably more insidious — is the role of the subsurface water table in amplifying surface flooding risk. When the water table is already elevated, storm rainfall has nowhere to drain, surface water cannot percolate into the ground, and minor rain events produce major flooding outcomes.

This white paper examines two case studies of communities in New Zealand that have experienced severe and recurrent groundwater-driven flooding. It sets out the problem statement for each, describes the traditional engineering response actually deployed, and then proposes how Changing State Technologies' MPR™ (Multi-Phase Rotor) Stable Vapour Cavity pump technology offers a fundamentally different — and significantly more cost-effective — approach to long-term flood resilience.

The Core Insight	Flood resilience is not only about removing water during a storm. It is about proactively creating below-ground storage capacity before the storm arrives. The CST MPR™ pump — capable of lifting groundwater from up to 9.5 metres below ground level from a surface-mounted installation — makes continuous, proactive water table management economically and operationally viable for the first time.

2. Technology Background — The CST MPR™ Pump

2.1 How the MPR™ Works

Conventional centrifugal pumps are designed to avoid cavitation — the formation of vapour bubbles that occur when local pressure falls below the liquid vapour pressure. These bubbles collapse destructively, eroding impeller and seal surfaces and causing premature pump failure. This physical constraint forces conventional pumps to be installed at or near the water surface, requiring expensive civil works such as deep sumps, wet wells, and borehole casings.

The CST MPR™ takes a fundamentally different approach. Rather than avoiding cavitation, it operates deliberately beyond the cavitation barrier, entering a stable post-cavitation regime in which a controlled low-pressure vapour cavity is maintained inside the spinning rotor at approximately 2.3 kPa. At this pressure, water boils at ambient temperature – 20^0C. The stable cavity is sustained by specific inlet and outlet geometry, and the result is a device that behaves unlike any conventional pump:

Key MPR™ Operating Properties

- Self-priming from almost completely dry — no foot valves, priming tanks, or vacuum-assist systems needed
- Operates up to 9.5 metres above the water source — surface-mounted installation, no deep borehole required
- Tolerates and handles entrained air or gas in the inlet flow — does not cavitate, does not lose prime
- Delivers constant flow rate independent of system backpressure — simplified control
- Zero inlet seals — eliminates the primary pump failure mode (39% of all conventional pump failures)
- Compact footprint — up to 40% smaller than equivalent centrifugal pump packages
- Set-and-forget operation — VSD and inlet valve control only

2.2 Why This Matters for Flood Resilience

For groundwater management applications, the most critical properties of the MPR™ are its self-priming capability and its ability to operate continuously as the water table drops and the air-to-water fraction at the inlet changes. A conventional submersible bore pump requires a minimum submergence depth and will cavitate and fail as the water table is drawn down below it. A conventional surface-mounted pump will lose prime as air enters the suction line.

The MPR™ does neither. Installed at surface level on a simple concrete pad, it draws groundwater up through a small-bore suction pipe. By recirculating a small volume of water from its housing into the rotor and back, the system acts as a vacuum pump to continuously clear air and gas from the intake line. While a massive air leak may temporarily drop the vacuum pressure, the MPR™ never stops clearing gas—and the moment the intake is re-submerged in fluid, the system automatically self-primes and resumes pumping. This means the MPR™ can operate 24 hours a day, 7 days a week, in all weather conditions—continuously drawing down the water table before, during, and between storm events.

This proactive, continuous operation is the key to a fundamentally different flood resilience strategy: rather than deploying emergency pumps during a flood event (a reactive response), the MPR™ creates and maintains sub-surface storage capacity before rainfall occurs (a proactive response).

3. Case Study 1 — Flockton Basin, Christchurch

Figure 1: Theoretical Flockton Basin wellpoint network. MPR™ surface-mounted groundwater dewatering concept — vertical suction lift capability: 9.5 metres.

3.1 Problem Statement

Geological and Seismic Context

The Flockton Basin is a low-lying area of Christchurch's inner north that drains to the Dudley Creek catchment and ultimately to the Avon River. Under normal pre-earthquake conditions, the basin was subject to periodic surface flooding during significant rainfall events — a manageable if frustrating characteristic of its low-lying geography.

The 2010–2011 Canterbury earthquake sequence fundamentally changed this situation. Seismic subsidence and widespread liquefaction caused significant and permanent land sinking across large areas of Christchurch, including the Flockton Basin. In the Flockton area, land dropped by up to 300–400mm in some locations. The effect on drainage was immediate and severe: what had previously been a marginal flood risk became a near-permanent flooding hazard for some 1,500 households.

The subsidence did not merely lower the ground surface — it effectively raised the relative groundwater table. The pre-earthquake hydraulic gradient that had allowed groundwater to drain naturally to the Avon River system was disrupted. Stormwater drainage systems designed for pre-earthquake ground levels were suddenly operating with reduced gravity fall, causing ponding and backflow. Sewer networks, already damaged by the earthquakes, were susceptible to groundwater infiltration and surface flooding overflow.

The April 2014 Storm Event

On 14 August 2014 a Mayoral Flood Taskforce was established to find urgent short-term solutions for the 1,500 most vulnerable households in the Flockton Basin. Prior to this formalisation, however, the April 2014 storm event had already demonstrated the severity of the crisis: a major rainfall event overwhelmed the already-compromised catchment, causing extensive surface flooding in Carrick Street, Thornton Street, Harrison Street, and surrounding areas.

3.2 Traditional Approach

Traditional Solution — Flockton Basin

- Deployment of bunds and sandbags to affected streets and individual properties
- Deployment of surface pumping during storm events — reactive emergency response
- Up to four 200mm skid-mounted diesel flood pumps deployed to transfer water from Flockton Basin to downstream Dudley Creek and the Avon River (approximately 2,000–3,000 m^3/hr combined capacity)
- Around-the-clock operation requiring 24/7 servicing and refuelling
- Standby operation maintained for over 18 months until a permanent solution was completed

Cost of the Traditional Response

The emergency response costs were substantial. Each mobilisation and set-up of the temporary skid pump system cost approximately NZD $15,000–$20,000. The standby operation continued for over 18 months, with the pumps deployed for every significant rainfall event during that period. Each rain event triggered a new mobilisation cost.

The Christchurch City Council's longer-term response approved on 13 August 2015 involved a NZD $26 million piped bypass and channel works programme (Stapletons Road, Petrie Street, Randal Street bypass) to return the Flockton Basin to pre-earthquake flood risk levels. A stormwater pump station was also constructed to divert flows from the Flockton catchment to the Styx River catchment to the north, at a cost of approximately NZD $10 million.

Cost Item	Traditional Approach	CST MPR™ Solution
Emergency skid pump mobilisation (per event)	NZD $15,000–$20,000 per deployment	Eliminated — MPR™ operates continuously
18-month standby operation costs	~NZD $500,000+ (fuel, labour, maintenance)	Replaced by low-cost continuous MPR™ operation
Permanent stormwater pump station	NZD ~$10,000,000	Potentially reduced or eliminated
Piped bypass and channel works ($26M programme)	NZD $26,000,000	Scope significantly reduced
Voluntary property buy-outs (1,500 households at risk)	Additional substantial cost	Properties retained — community preserved
Total approximate flood recovery cost	NZD ~$50,000,000+	CST MPR™ installation: est. NZD $500,000

3.3 CST MPR™ Approach

Concept Design

Rather than deploying skid-mounted emergency pumps reactively during each storm event, the CST MPR™ approach would be to establish a connected network of small-diameter (100mm) bores drilled along the most severely affected streets — Carrick Street, Thornton Street, and Harrison Street — each fitted with a groundwater spear, and connected by a common header to one or more CST MPR™ Stable Vapour Cavity pumps. The system would operate continuously — 24 hours a day, 7 days a week — with the specific purpose of maintaining the water table well below ground surface to provide sub-surface storage capacity for storm rainfall infiltration.

The number and capacity of bores, spear spacing, and pump sizing would be determined by hydraulic modelling based on the design storm (typically the 1% or 2% Annual Recurrence Interval event for residential flood protection). The discharge would be directed to the adjacent Dudley Creek catchment.

CST MPR™ Solution — Flockton Basin

- A connected network of a grid of 100mm small-bore dewatering spears (6m depth) drilled along Carrick, Thornton, Harrison Street and the known areas of habitable floor flooding
- 600 metres of 100mm MDPE pipeline (suction header collecting from spears)
- 250 metres of 200mm MDPE pipeline (rising main to Dudley Creek discharge)
- Single or multiple CST MPR™ Stable Vapour Cavity pump — surface-mounted, no borehole required
- Continuous 24/7 operation to proactively maintain below-ground storage capacity
- No emergency deployment required — system is permanently operational
- Scalable — additional spears or pump modules can be added as required

Comparison with Submersible Pump Alternative

One alternative to the CST approach would be the use of conventional submersible pumps in each bore. However, this approach presents significant practical difficulties that the MPR™ avoids entirely:

- Submersible pumps require a much larger groundwater sump or wet-well constructed below ground to accommodate the pump body — substantially increasing civil works cost
- Power and control equipment must be installed at each individual well site
- If surface-mounted centrifugal pumps are used instead, they require priming and are vulnerable to cavitation as air entrains — resulting in higher operation and maintenance cost and frequent pump failure
- The MPR™ eliminates all of these issues: single surface-mounted unit, self-priming, air-tolerant, continuous operation

Estimated Capital Cost — CST MPR™ Installation

Ref	Description	Cost (NZD)
1.0	Preliminaries & Mobilisation — site setup, traffic management, utility locating	$30,000
2.0	Dewatering Bores (Spears) — drilling, installing and supplying (say) 50 × 6m spears	$125,000
3.0	100mm MDPE Pipeline — trench, supply, lay, and backfill 600 metres	$120,000
4.0	200mm MDPE Pipeline — trench, supply, lay, and backfill 250 metres	$80,000
	Direct Construction Cost Subtotal	$355,000
	Overheads & Contingency — corporate overheads, margins, standard contingency	$50,000
	Estimated Total Construction Cost	**$405,000**
	CST MPR™ Pump Module (surface-mounted, including installation)	$100,000
	Contingency (~20%)	$95,000
	TOTAL ESTIMATED PROJECT COST	**$600,000**

3.4 Benefits and Outcomes

Flood Resilience Benefits — Flockton Basin

- No emergency deployment of temporary pumps — response to storm events is passive and automatic
- Dramatically reduced surface equipment, maintenance, and refuelling burden
- Creates and maintains sub-surface flood resilience storage capacity before events occur — proactive rather than reactive flood management
- Sustainable long-term solution — scalable permanent infrastructure rather than repeated emergency expenditure
- Capital cost of approximately NZD $600,000 compared with NZD $50M+ in traditional response and permanent infrastructure
- Community resilience restored with minimal surface footprint — no intrusive pump station or bypass channels
- Potential to retain at-risk properties rather than costly voluntary buy-out programme

4. Case Study 2 — South Dunedin, St Kilda and St Clair

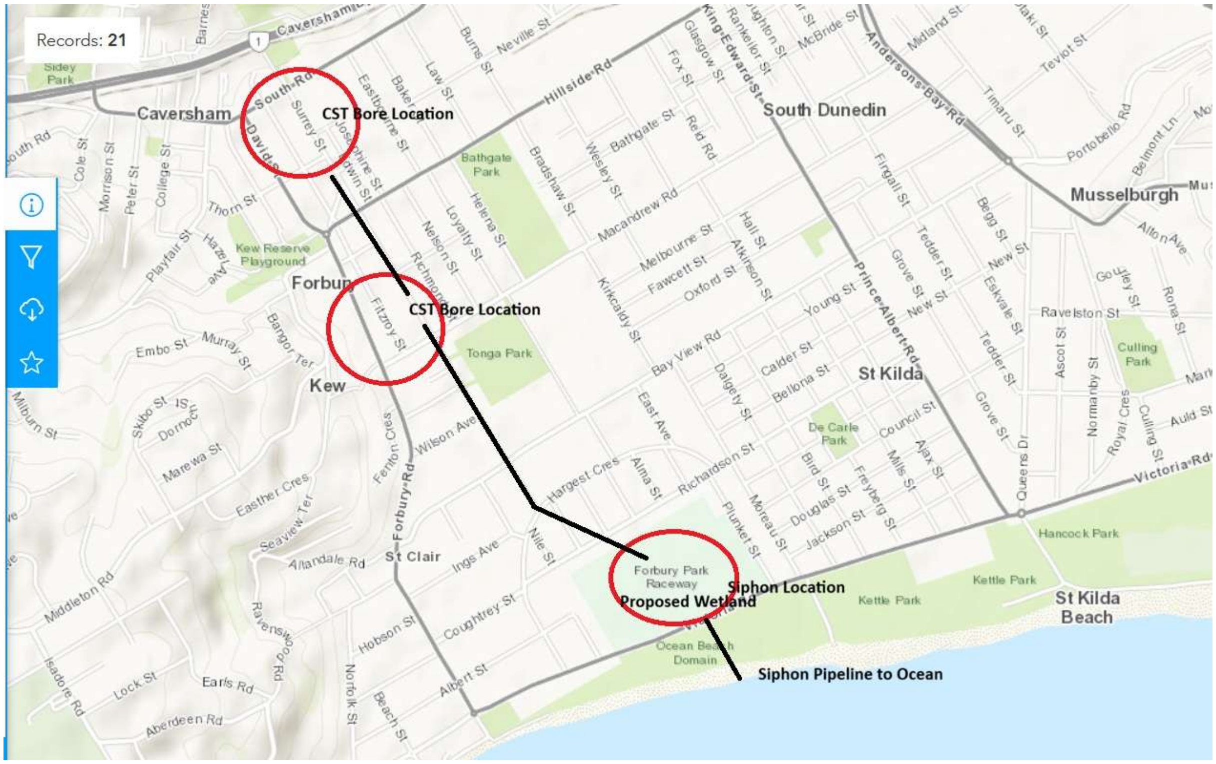

Figure 2: MPR™ groundwater management concept applicable to South Dunedin — surface-mounted pump array maintaining continuous water table drawdown across the flat, together with the water siphon over the dunes.

4.1 Problem Statement

Geographical and Historical Context

South Dunedin and the suburbs of St Kilda and St Clair constitute one of the most densely populated low-lying residential areas in New Zealand, and arguably its most chronically flood-prone urban settlement. The area is known locally as 'The Flat' — a designation that precisely describes both its topography and its flood vulnerability.

The geological history of the area is instructive. The Flat was originally a low-lying coastal wetland and tidal mudflat, formed by the accumulation of estuarine sediments over thousands of years. During the 19th-century gold rush, European settlers drained the marshland and reclaimed it by dumping sand excavated from the adjacent St Kilda coastal dunes. This reclamation was shallow — the area was built on soft, porous sediment just centimetres above the natural water table, forming an urbanised basin with no natural gravity-fed drainage outlet to the sea.

As a result, The Flat has been subject to chronic and severe flooding throughout its history. During extreme high tides, much of the area lies below the high-tide water level. The porous sandy substrate means that tidal and groundwater levels are in close hydraulic communication — as the tide rises, so does the water table beneath the streets and houses. There is effectively no drainage buffer between surface rainfall and the water table.

The October 2024 Disaster

In October 2024, Dunedin, a city of 130,000 people, experienced its wettest day in over a century. In less than 48 hours, the city received more than double its typical October rainfall — approximately 160mm in the urban flat and 180mm in the surrounding hills. A state of emergency was declared. Approximately 100 evacuations were carried out across The Flat. Streets in St Kilda (Young Street) and South Dunedin (Surrey Street, Forbury Road) were inundated in knee-deep water, with many residents reporting conditions worse than the significant 2015 flood event.

The immediate cause was not simply the exceptional rainfall — it was the interaction of that rainfall with an already-saturated substrate and a water table already at or near ground surface from prior wet weather. The storm rainfall had effectively nowhere to go: no percolation into the ground was possible because the ground was full, and the stormwater drainage system was overwhelmed by simultaneous surface runoff and groundwater inflow.

Scale of the Problem	South Dunedin is a far more complex and extensive flood challenge than Flockton Basin. The area has a water table naturally near ground level, is subject to tidal influence below high-tide level and has no natural gravity-fed drainage to the sea. The CST MPR™ solution must therefore work in combination with other infrastructure to address the problem comprehensively.

The Traditional Infrastructure Response

The Dunedin City Council (DCC) and the Otago Regional Council (ORC) are executing a multi-tiered traditional engineering response to the flooding problem. Current and planned initiatives include:

Traditional Approach — South Dunedin / St Kilda / St Clair

- Temporary flood barriers and portable pumps deployed along Surrey Street during active rain events
- Rapid street closures for public health protection during wastewater contamination events
- NZD $29.2 million engineering package (2025–2034): Forbury Road aqueduct capacity upgrade, Surrey Street wastewater network renewals, Hillside Road stormwater main disconnection and rerouting
- Deployment of emergency pumping by fire and emergency services during flood events
- Contractor engagement to clear and jet-clean blocked stormwater sumps and mains
- Evacuation of affected residents to temporary accommodation during major events
- Long-term climate adaptation proposals under development — including potential managed retreat of up to 1,700 properties from the most vulnerable areas

The proposal for managed retreat — in which up to 1,100–1,700 households could be relocated out of their homes — represents an admission that the traditional engineering approach may not be sufficient to protect the existing community in the long term. It also represents an enormous human and economic cost: the disruption, displacement, and loss of community identity that such a programme would entail are difficult to overstate.

4.2 CST MPR™ Approach

Concept Design

The CST MPR™ solution for South Dunedin is more complex than the Flockton Basin case, reflecting the scale and nature of the problem. The key elements are:

CST MPR™ Solution — South Dunedin / St Kilda / St Clair

- Network of small-bore dewatering wells (100mm) distributed throughout the worst-affected streets of South Dunedin, St Kilda, and St Clair, each fitted with a groundwater spear
- Multiple CST MPR™ Stable Vapour Cavity pump modules connected to the wellhead network, operating continuously 24/7
- Continuous drawdown of the water table — up to 9 metres below ground level — to maximise sub-surface storage capacity before storm events
- Complementary gravity siphon system operating from Forbury Park, discharging over the sand dunes to an outfall at St Kilda Beach (see Section 4.3)
- PVC sheet pile coastal barrier along the St Clair and St Kilda dune face to prevent tidal seawater intrusion through and beneath the dunes (see Section 4.4)
- The combined system provides continuous water table management, tidal-opportunistic gravity discharge, and coastal seawater exclusion — together maximising below-ground storage capacity available for storm rainfall

Critical Design Considerations

Several factors make the South Dunedin application more demanding than Flockton Basin and require careful hydraulic analysis and modelling:

- Tidal influence on groundwater — the water table responds to tidal fluctuations due to sea water passing through the porous sand dunes. MPR™ system operation must be designed to take advantage of low-tide periods when the natural hydraulic gradient allows more effective drawdown
- Proximity to sea level — at high tide, much of the area is below mean high-water springs. The MPR™ system must work against this tidal head during adverse tidal conditions
- Scale of affected area — the catchment is substantially larger than Flockton Basin; a distributed wellpoint network will require careful hydraulic design to achieve adequate drawdown across the full area
- Interaction with existing stormwater and wastewater infrastructure — hydraulic modelling must confirm that groundwater drawdown does not create differential settlement problems for existing buried services or buildings

- Design storm ARI — the number and spacing of spears, and the total pumping capacity, must be modelled on the 1% or 2% ARI design storm for the specific catchment characteristics
- Seawater intrusion through the dune barrier — tidal seawater percolating through and under the coastal sand dunes contributes directly to the elevated water table under The Flat; this pathway must be addressed to maximise the effectiveness of the MPR™ drawdown.

4.3 The Forbury Park Gravity Siphon — Complementary System

Siphon Concept

A key complementary element of the South Dunedin solution is a gravity siphon operating from Forbury Park, discharging over the coastal sand dunes to an outfall at St Kilda Beach. This siphon would use natural gravity to transfer groundwater from the inland basin to the sea during low-tide conditions, without any pumping energy.

The siphon would operate automatically whenever there is a hydraulic head difference of approximately 1 metre between the free water surface at Forbury Park and the low-tide sea level at St Kilda Beach. During high tide or when the head difference is insufficient, the siphon is inactive; during low tide it operates passively, augmenting the continuous MPR™ pumping by taking advantage of the natural tidal cycle.

The CST MPR™ pump and bore network would have its own outlet to the ocean and could share the outfall on the downstream side of the siphon, thus using the same discharge consent. This simplifies the consenting process and reduces the infrastructure footprint at the dune discharge point. Further information on the water siphon technology applicable to this application can be found at watersiphon.co.nz/flood-solutions/.

System Integration	The two systems — CST MPR™ continuous drawdown pumping and the Forbury Park gravity siphon — are designed to work together. The MPR™ provides constant drawdown independent of tidal conditions. The siphon provides additional passive discharge during favourable tidal windows. Together they maximise the below-ground storage available to absorb storm rainfall across the South Dunedin flat.

4.4 Coastal Seawater Exclusion — PVC Sheet Pile Barrier Along the Dune Face

The Problem: Tidal Seawater Intrusion Through the Coastal Dunes

A factor that significantly exacerbates the groundwater flooding problem in South Dunedin, St Kilda, and St Clair is the intrusion of seawater through and beneath the coastal sand dunes that form the barrier between The Flat and the Pacific Ocean. The dunes between St Kilda Beach and St Clair Beach, while providing some degree of coastal buffering, are porous sandy structures that allow seawater to percolate laterally and vertically during high tides and storm surge events. This tidal seawater intrusion raises the local water table beneath The Flat from the seaward side, compounding the already-elevated groundwater conditions driven by rainfall infiltration from the landward side.

During extreme high tides and coastal storm surge events — which are becoming more frequent and more severe as sea level rises — this seawater intrusion pathway can temporarily raise the water table beneath the coastal suburbs to at or above ground surface level, even in the absence of significant rainfall. Any comprehensive flood resilience strategy for South Dunedin should therefore address not only the groundwater drawdown from the inland side (through the MPR™ wellpoint network and Forbury Park siphon) but also the seawater intrusion pathway from the seaward side.

The Seawater Problem	The porous sand dunes between the ocean and The Flat act as a two-way hydraulic connection. During low tide, groundwater drains seaward (useful). During high tide and storm surge, seawater intrudes landward (harmful). A subsurface cut-off barrier along the dune face would intercept this intrusion pathway, allowing the MPR™ drawdown system to operate against a controlled, reduced hydraulic head rather than a freely connected tidal boundary.

The Launceston Precedent — Sheet Piling for Seepage Control

A directly applicable precedent for this approach exists in Launceston, Tasmania, where the Launceston Flood Authority (LFA) has deployed an extensive sheet pile network as a core component of the city's flood defence infrastructure. Launceston manages flood threats from three rivers — the North Esk, South Esk, and Tamar — using a combination of levee embankments and sheet pile cut-off walls that prevent seepage and underflow beneath the stop banks during high-water events.

The LFA's approach to sheet piling provides a directly transferable model for the South Dunedin coastal dune application, both in the choice of materials and in the installation methodology. The key lessons from the Launceston experience are:

Launceston Flood Authority — Sheet Pile Application Lessons

- Seepage control: sheet piles driven deep into riverbanks and levees create a subterranean barrier, preventing water from 'piping' or seeping underneath stop banks during flood events — exactly the mechanism needed to prevent tidal seawater from piping through the South Dunedin dune base
- PVC/vinyl sheet piles are the preferred material: highly resistant to saltwater corrosion, UV degradation, and rotting — essential in a coastal seawater environment where steel would require cathodic protection and regular maintenance
- Rehabilitation of vulnerable sections: sheet piling is driven at interfaces between different soil types or structural materials to bridge gaps and stabilise differential settlement — applicable to the variable dune stratigraphy along the St Kilda/St Clair dune face
- Small footprint: PVC sheet piles act as freestanding flood walls or subsurface cut-off walls without requiring widening of the physical structure — preserving the existing dune form and amenity
- Embedment depth: the LFA drove piles over a 10-metre embedment length in critical sections, combined with pressure-grouting voids with bentonite slurry to ensure total impermeability — a similar approach would be required through the mixed sand and alluvial sediment of the coastal dunes

Proposed Application — South Dunedin Coastal Dune Barrier

The proposed application of PVC sheet piling to the South Dunedin coastal dune system would involve driving a continuous line of interlocking PVC vinyl sheet piles along the landward face of the coastal dune barrier between St Kilda and St Clair, embedded to a depth sufficient to penetrate below the seasonal high-tide infiltration zone into the underlying less-permeable alluvial or marine sediment. The sheet pile wall would create an impermeable subsurface cut-off barrier that intercepts the horizontal seawater intrusion pathway without disturbing the dune surface or its vegetation.

This approach differs from the Launceston riverbank application in an important respect: the South Dunedin dune barrier is a natural sandy structure rather than an engineered earth levee. The installation methodology would therefore need to be adapted for sand conditions, using vibration-driven pile installation techniques rather than the impact-driving methods more common in cohesive soils. Specialist geotechnical investigation along the dune alignment would be required to confirm soil conditions and determine appropriate pile section, embedment depth, and installation equipment.

Integration with the MPR™ Wellpoint and Siphon Systems

The PVC sheet pile barrier works in direct synergy with the MPR™ groundwater drawdown system and the Forbury Park siphon. Once the landward seawater intrusion pathway is intercepted by the cut-off wall, the MPR™ wellpoint network operates against a more controllable and predictable hydraulic boundary: rather than pumping against a freely-connected tidal head that rises and falls by 1–2 metres with each tidal cycle, the system operates against the slower-varying residual groundwater pressure on the landward side of the barrier. This materially improves the effectiveness of the drawdown system and reduces the pumping energy required to maintain target water table levels.

The three-system combination — MPR™ continuous groundwater drawdown, Forbury Park gravity siphon during low-tide windows, and PVC sheet pile coastal seawater cut-off — represents a comprehensive, integrated flood resilience strategy that addresses the problem from all sides simultaneously:

- From above: proactive groundwater drawdown creates sub-surface storage before storm rainfall
- From seaward: PVC sheet pile barrier intercepts tidal seawater intrusion through the dune base
- To the sea: Forbury Park siphon passively discharges accumulated groundwater during low-tide windows

Combined System	The MPR™ drawdown system, the Forbury Park gravity siphon, and the PVC sheet pile coastal barrier form a three-component integrated flood resilience system. Each component addresses a different pathway in the flood mechanism; together they provide a level of protection that no single component could achieve alone.

Cost and Implementation Considerations

PVC vinyl sheet piling is a well-established commercial product available from multiple suppliers in New Zealand and Australia. Unit costs for vinyl sheet piling in NZ vary with section type and embedment depth but are substantially lower than equivalent steel sheet piling when lifecycle costs are considered — PVC requires no cathodic protection, no anti-corrosion coatings, and has a design life exceeding 50 years in marine environments without maintenance.

A preliminary cost estimate for the St Kilda/St Clair dune barrier would require a site investigation programme and survey of the dune alignment to determine pile length and quantity. As an order-of-magnitude indicator, coastal PVC sheet pile installation in comparable sandy coastal conditions in Australasia typically costs NZD $800–$1,500 per linear metre (including supply and installation), suggesting that a 1-kilometre barrier wall could be constructed for NZD $800,000–$1,500,000 — a fraction of the NZD $29.2 million DCC engineering package or the cost of managed retreat for the affected households.

Component	Estimated Cost Range (NZD)	Notes
Geotechnical investigation and survey	$40,000 – $80,000	Cone penetration testing and survey of dune alignment
PVC vinyl sheet pile supply (per lineal metre)	$200 – $450/lm	Depends on profile, section depth, and embedment
Installation — vibration driving (per lineal metre)	$600 – $1,050/lm	Sand conditions — vibration method preferred
Void grouting with bentonite slurry (if required)	$50,000 – $150,000	At tide interfaces and geologically variable sections
Total — 1 km barrier (indicative)	**$800,000 – $1,500,000**	Order of magnitude only — subject to site investigation
Total — full 2.5 km barrier (St Kilda to St Clair)	**$2,000,000 – $3,750,000**	Indicative only — subject to geotechnical investigation

All cost figures are preliminary, order-of-magnitude estimates for planning purposes only. They should not be used for procurement or financial investment decisions without independent geotechnical investigation, detailed design, and quantity surveying. Costs are NZD excluding GST.

4.5 Benefits and Outcomes

Flood Resilience Benefits — South Dunedin / St Kilda / St Clair

- Proactive water table management — below-ground storage created and maintained before storm events occur
- Tidal seawater intrusion intercepted by PVC sheet pile coastal barrier — water table no longer driven up by each high tide through the dune base
- Reduced dependence on emergency surface pumping during events
- Potential to avoid or substantially reduce the managed retreat of 1,100–1,700 households from the most vulnerable areas
- Combined CST MPR™ pumping, gravity siphon, and coastal barrier maximises use of natural tidal and hydraulic gradients
- Scalable and expandable — additional wellpoints and pump modules can be added as hydraulic modelling refines required capacity
- Significantly lower capital cost than traditional infrastructure packages (NZD $29.2M DCC programme does not include climate adaptation costs)
- Sustainable long-term solution — operationally simple, low maintenance, continuously active

5. Comparative Analysis — Traditional vs CST MPR™

Characteristic	Traditional Approach	CST MPR™ Solution
Response timing	Reactive — deployed during or after flood event	Proactive — continuous operation creates storage before event
Flood mechanism addressed	Surface water management (pumping away floodwater)	Groundwater table management (creating below-ground storage)
Seawater intrusion	Not addressed — tidal seawater percolates through dunes freely	Intercepted by PVC sheet pile coastal barrier
Pump installation	Submersible bore pumps or surface pumps with deep wet wells	Surface-mounted — no borehole, no wet well, simple pad foundation
Self-priming	No — foot valves, priming tanks, or vacuum-assist required	Yes — operates from dry start, handles entrained air continuously
Air entrainment response	Loss of prime, cavitation, pump failure or trip	Stable operation — air-tolerant by design
Water table drawdown limit	Limited by pump submergence minimum	Up to 9.5m below ground from surface installation
Continuous operation capability	Limited — conventional pumps degrade on air ingress	Yes — designed for continuous 24/7 operation at any table level
Maintenance	Crane required for submersible pull; confined space entry	Surface access — standard tools; no confined space
Emergency deployment	Required for every storm event — labour, fuel, logistics	Not required — system is already running
Community impact	Reactive, visible emergency response; evacuation risk remains	Invisible, proactive; reduces emergency event frequency and severity

6. Design and Modelling Methodology

6.1 Hydraulic Modelling Requirements

A successful CST MPR™ groundwater management installation for flood resilience requires a structured hydraulic analysis and design process. The following steps would be required for any new application:

- Baseline groundwater level survey — installation of monitoring bores to establish the static water table level, seasonal variation, and tidal response where applicable
- Aquifer characterisation — permeability testing (falling head or pumping tests) to establish the hydraulic conductivity and specific yield of the substrate

- Catchment delineation and rainfall analysis — identification of the contributing catchment and calculation of design storm runoff volumes (1% ARI and 2% ARI for residential protection)
- Drawdown simulation — numerical or analytical groundwater modelling to determine the wellpoint spacing, bore depth, and pumping rate required to achieve target drawdown
- Infrastructure interaction assessment — review of existing buried services (sewer, water, stormwater) to confirm no differential settlement or hydraulic impact from drawdown
- Discharge hydraulics — design of the collection header, rising main, and discharge point to confirm adequate capacity and compliance with discharge consent requirements

While the approach of providing flood resilience by actively managing groundwater levels may be a relatively new concept in New Zealand, it has been the cornerstone of flood management in places like the Netherlands, where without active groundwater management, some parts of the country could be up to 6.7 metres under water.

6.2 System Sizing Principles

For the Flockton Basin case study, the initial installation of a network of 6m spears at 60m centres along three streets, connected to a single CST MPR™ pump, was estimated as part of a first-phase. Formal hydraulic modelling would refine this design and may indicate a different number of spears, closer spacing, or additional pump capacity for design storm conditions.

For South Dunedin, the scale and complexity of the application would require a more comprehensive modelling programme, including calibration of a numerical groundwater model against observed flood behaviour during the 2024 event and earlier events. The tidal interaction, siphon hydraulics, and the hydraulic effect of the PVC sheet pile coastal barrier would need to be specifically modelled to size the combined system and quantify the benefit of each component individually.

6.3 Resource Consent and Discharge Considerations

Groundwater abstraction and discharge in New Zealand requires resource consent under the Resource Management Act 1991. For the flood resilience applications described in this paper, the relevant consents would include:

- Groundwater take consent — for the continuous abstraction of groundwater from the wellpoint network
- Discharge consent — for the discharge of abstracted groundwater to a watercourse (Dudley Creek in Christchurch; St Kilda Beach in Dunedin)
- Coastal permit — for the installation of PVC sheet piling within the coastal environment under the New Zealand Coastal Policy Statement and regional coastal plan

The CST MPR™'s constant, stable discharge flow simplifies the discharge consent process: unlike conventional pump systems with variable output, the MPR™'s predictable flow rate allows inline filtration for suspended solids management, and the stable flow makes monitoring and compliance straightforward.

7. Pathway to Adoption

The following incremental pathway is recommended for councils and regulators considering the CST MPR™ approach:

Phase	Activity	Description
1	**Technology Briefing**	Council engineering staff and elected members receive a structured briefing on the MPR™ operating principle, supported by demonstration of the physics and review of the patent documentation
2	**Site Characterisation**	Commission a baseline groundwater survey, aquifer test programme, and coastal dune geotechnical investigation to quantify the problem hydraulics and confirm MPR™ sizing parameters and sheet pile design requirements
3	**Proof-of-Concept Trial**	Install a small-scale MPR™ wellpoint system (2–3 spears, single pump) at a monitored location within the flood-affected area; measure water table response over 6–12 months through at least one significant rainfall event
4	**Hydraulic Modelling**	Use trial data to calibrate a groundwater model; model the effect of the PVC sheet pile barrier and Forbury Park siphon; scale up the combined system design to the full catchment
5	**Full Installation**	Construct the full wellpoint network, MPR™ pump system, Forbury Park siphon, and PVC sheet pile coastal barrier based on the validated design; commission with monitoring programme
6	**Review and Optimise**	Annual performance review against flood event records; adjust system capacity as required based on observed performance

8. Conclusion

This white paper has set out the hypothetical case for a fundamentally different approach to urban flood resilience — one that addresses the root cause of many of New Zealand's most severe urban flooding problems rather than managing the symptoms.

The two case studies presented — Flockton Basin in Christchurch and South Dunedin/St Kilda/St Clair in Dunedin — share a common hydraulic characteristic: their flooding vulnerability is driven not primarily by inadequate surface drainage but by the proximity of the water table to the ground surface. In both cases, storm rainfall has nowhere to go because the subsurface is already saturated. The traditional engineering response — emergency surface pumping, pipe upgrades, and costly bypass channels — addresses the flood event but does nothing to increase the below-ground storage capacity or cut-off the recharge pathway which are fundamental elements of flood resilience.

The CST MPR™ pump technology offers a proactive, continuous, cost-effective solution. By operating 24 hours a day from a surface-mounted installation, drawing the water table down through a network of small-bore wellpoints, the MPR™ continuously creates and maintains the below-ground storage capacity that allows the catchment to absorb storm rainfall before it becomes surface flooding. For South Dunedin, the MPR™ wellpoint system operates in combination with the Forbury Park gravity siphon and a PVC sheet pile coastal barrier along the St Kilda and St Clair dune face — the three-component system addressing the flooding problem from all directions simultaneously.

The estimated capital cost of the Flockton Basin installation — NZD $600,000 — represents ~1.2% of the NZD $50 million+ that was spent on the traditional emergency response and permanent infrastructure. For South Dunedin, where the alternative to effective technical intervention may be the forced relocation of thousands of families, the case for investigating the CST MPR™ approach — in combination with the Forbury Park siphon and PVC coastal barrier — is compelling.

Final Word	By applying these new technologies to long-standing problems, communities could benefit from improved flood resilience at a much lower cost and much sooner than conventional approaches could achieve. The physics is proven. The technology is patented. The application is logical.

This white paper is recommended to councils, regional authorities, engineers, and community representatives who are dealing with chronic urban flooding, and are invited to discuss the hydraulic modelling and design pathway for any candidate site.

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