CHANGING STATE TECHNOLOGIES

Trench Dewatering Reimagined

The Engineering and Commercial Case for MPR Pump Technology over Traditional Dewatering Spears - Transforming Groundwater Management

A Technical White Paper

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Executive Summary

Trench dewatering is one of the most routine yet consequential activities in horizontal infrastructure construction. Every metre of buried pipeline, cable duct or culvert laid below the water table depends on a temporary, well-managed drop in groundwater level to allow safe, dry, compactable working conditions. The methods used to achieve that dry condition, however, have changed little in half a century. Vacuum-primed dewatering spears feeding water to surface settling tanks remain the default approach on most sites, despite well-known limitations around priming reliability, cavitation, plant footprint and discharge water quality management.

This paper sets out the case for a step change in that practice through the adoption of Changing State Technologies' (CST) MPR ump — a Stable Vapour Cavity technology capable of drawing water from existing in-ground dewatering spears without priming, without cavitating under mixed air-water suction conditions, and without the need for an intermediate settling tank. In place of the traditional four-stage water handling train — spear, vacuum pump, settling tank, sediment treatment — the MPR approach compresses this to two stages: spear and pump, discharging directly through consumable filter bag screens.

The engineering rationale, comparative analysis and site-level outcomes presented below indicate that this is not an incremental improvement but a genuine change in the underlying hydraulic behaviour available to site engineers and contractors. The benefits flow through to programme, cost, health and safety, and environmental compliance outcomes that are material to any contractor, principal or regulator with an interest in the efficiency of underground infrastructure delivery.

1. Introduction and Purpose

The construction of buried pipelines, wastewater reticulation, stormwater culverts and cable ducts routinely requires excavation below the natural or seasonal groundwater table. Where this occurs, temporary groundwater control — dewatering — is required to maintain a dry, stable trench in which pipelaying, jointing, bedding and compaction can be carried out safely and to specification. Dewatering is not incidental to the works; it is frequently on the critical path, and its reliability governs both the safety of personnel working in the excavation and the long-term structural performance of the completed asset.

This paper has been prepared to compare the traditional method of trench dewatering — reliant on vacuum-primed wellpoint spears and surface settling tanks — with the pumping approach now offered by Changing State Technologies Ltd (CST), an Auckland-based pump technology developer. CST's core technology, marketed for trench dewatering applications as the MPR pump, is built around a Stable Vapour Cavity Pump principle that manages the liquid-to-vapour phase behaviour of the pumped fluid to avoid the two failure modes that most commonly interrupt conventional dewatering: loss of prime and cavitation.

The purpose of this paper is threefold: first, to describe the trench dewatering problem in engineering terms; second, to set out how the traditional and CST approaches each address that problem; and third, to draw out the practical outcomes — in programme, cost, safety, plant footprint and environmental compliance — that follow from the difference between the two.

2. Problem Statement

The underlying requirement is straightforward to state: to dewater a construction trench so that safe operations can be undertaken in a dry excavation. In practice this requirement carries several interlocking engineering demands that any dewatering system must satisfy simultaneously.

2.1 Groundwater ingress and soil stability

Where an excavation intersects the water table, groundwater will seek to flow into the trench along the hydraulic gradient created by the excavation itself. Left unmanaged, this inflow can mobilise fine soil particles at the point of seepage (piping and boiling), destabilise trench walls, undermine the excavation base, and in cohesionless soils can precipitate a rapid and dangerous loss of ground. Effective dewatering intercepts this flow before it reaches the excavation face, lowering the phreatic surface to a level safely below formation level for the duration of the works.

2.2 Health and safety obligations

Under New Zealand's Health and Safety at Work Act 2015 and associated excavation guidance, a wet, unstable trench is a foreseeable hazard that principal contractors are obliged to eliminate or minimise so far as is reasonably practicable. A dewatering system that is unreliable — that loses prime overnight, requires frequent manual intervention, or fails to keep pace with inflow — increases the frequency with which personnel are exposed to wet, less stable ground conditions, and increases reliance on emergency response rather than steady-state control.

2.3 Construction quality

Pipe bedding, haunching and backfill compaction are all moisture-sensitive operations. Water standing in the base of a trench, or repeated re-saturation of bedding material between dewatering interruptions, compromises compaction quality and can lead to long-term settlement of the completed pavement or land surface above the pipeline — a defect that is expensive and disruptive to remediate once the asset is buried and trafficked.

2.4 Environmental and regulatory constraints

Water removed from a trench cannot simply be discharged to a waterway or stormwater network. Regional or local council resource consents and network discharge consents typically impose limits on total suspended solids, and in some catchments on other contaminants, in any water discharged from a construction site. The dewatering system must therefore also function as the first stage of a water treatment train, not merely a means of moving water from one place to another.

A dewatering solution must therefore satisfy all four of these demands concurrently and continuously — often for weeks at a time, across shift changes, weekends and unattended overnight periods — while remaining economical to mobilise, run and demobilise. It is against this composite requirement that the traditional and CST approaches are compared below.

3. The Traditional Approach: Dewatering Spears and Settling Tanks

The conventional method of trench dewatering, in widespread use across New Zealand and internationally, follows a well-established sequence:

- Dewatering spears (wellpoints) are driven or jetted into the ground at intervals around the trench, penetrating below the required drawdown level.
- Each spear, or a manifold of spears, is connected to a vacuum-assisted centrifugal pump, which must be primed — its casing and suction line filled with water and purged of air — before it will draw water reliably.
- The pump lifts groundwater from the spears to the surface and discharges it into a settling tank or series of tanks.
- Water is held in the tank for a period sufficient to allow suspended sediment to settle out, sometimes assisted by flocculants or sediment socks and bags at the outlet.
- Only once treated to an acceptable water quality is the water discharged off-site, typically to a stormwater network or waterway under the conditions of a resource consent.

This approach is well understood and, when properly resourced and supervised, can be made to work. However, it is built around two hydraulic constraints that are intrinsic to conventional centrifugal pump design, and which drive most of the operational difficulty experienced on site.

3.1 The priming constraint

Conventional centrifugal pumps rely on a continuous column of liquid within the casing and impeller to generate the pressure differential needed to move fluid. Air is far less dense than water, and an impeller designed for liquid cannot generate useful lift when a significant proportion of the fluid entering it is gas. A spear system must therefore be primed at start-up, and — critically — reprimed whenever air is drawn into the suction line. This happens routinely in dewatering applications: as the water table is drawn down, individual spears can begin to draw a mixture of air and water (an increasing gas volume fraction), the pump loses prime, output falls, and the pump must be manually or automatically re-primed before dewatering can resume. On an unattended overnight shift, or over a weekend, a lost prime can mean hours of uncontrolled water ingress before the fault is discovered.

3.2 Cavitation

The second constraint is cavitation. As suction lift increases, or as air entrainment increases the effective vapour content of the fluid at the impeller eye, local pressure can fall below the vapour pressure of water, causing vapour bubbles to form and then collapse violently as they move into the higher-pressure region of the pump. This produces characteristic noise, vibration, reduced flow, and progressive mechanical damage to the impeller and casing. Because cavitation risk rises sharply exactly when a dewatering system is working hardest — at maximum drawdown, with entrained air present — it tends to occur at the least convenient time and is a recurring cause of pump wear and unplanned downtime on dewatering contracts.

3.3 Consequences on site

These two constraints drive a cascade of practical consequences: additional plant (vacuum-assist units, standby pumps) to manage priming; larger crews and more frequent site visits to monitor and reprime; a settling tank (or several) and associated sediment control measures, with the standing area, desludging and maintenance that these require; and an extended water handling train between the trench and the point of discharge, each stage of which represents an opportunity for delay, spillage or non-compliance with discharge conditions.

4. The CST MPR Pump Approach (MPR = Multiphase Rotor™)

CST's MPR pump is built around what the company describes as a Stable Vapour Cavity principle — a pumping technology designed to manage the liquid-to-vapour phase behaviour of the fluid being pumped, rather than simply excluding air and treating its presence as a fault condition to be manually corrected. In public statements on its broader technology programme, CST has described a pump capable of eliminating cavitation, the phenomenon it calls “the scourge of pumps everywhere,” and of operating reliably under conditions that would stall or damage a conventional centrifugal unit.

Applied to trench dewatering, this principle translates into three practical capabilities that directly address the constraints described in Section 3:

- Suction lift from existing in-ground spears without the need for manual or vacuum-assisted priming — the pump remains able to draw water even where the suction line contains a mixture of air and water.
- Reliable operation under combined air-water (two-phase) lift, without the onset of cavitation that would otherwise accompany the increasing gas volume fraction seen as drawdown progresses.
- Direct discharge through filter bag screening, removing much of the suspended solids at the point of discharge rather than requiring a dedicated settling tank and residence time upstream of discharge.

The practical effect is that the MPR pump connects directly to the same in-ground spear network already used in conventional dewatering but removes both of the failure modes — lost prime and cavitation — that drive unplanned intervention, additional plant and larger settling infrastructure in the traditional approach. Where a traditional system requires a vacuum pump, a settling tank and a sediment treatment stage in addition to the spears themselves, the CST approach requires only the pump and a bag screen at discharge.

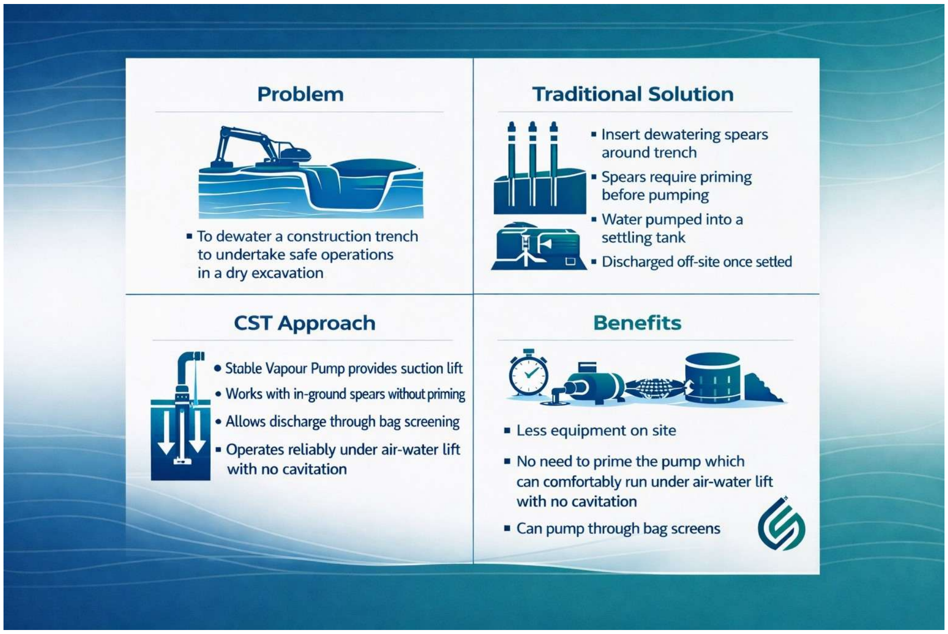

Figure 1 — Problem, traditional solution, CST approach and outcomes at a glance (Changing State Technologies Ltd).

5. Hydraulic Rationale: Why the Difference Matters

The distinction between the two approaches is not a matter of degree but of underlying pump physics and is worth setting out explicitly for an engineering audience.

5.1 Net positive suction head and suction lift

Conventional centrifugal pumps require an adequate margin of net positive suction head available (NPSHa) over the manufacturer's required value (NPSHr) to avoid cavitation. Because atmospheric pressure sets an absolute ceiling on the suction lift a purely atmospheric (self-priming) system can achieve, and because that available margin shrinks as entrained air increases the effective vapour fraction at the impeller eye, traditional spear systems are constrained to a practical lift envelope that narrows precisely as drawdown approaches its target depth. A Stable Vapour Cavity Pump architecture that manages the liquid-vapour phase transition directly, rather than relying solely on a flooded suction condition, is not bound by the same narrowing margin, allowing consistent lift performance to be maintained through the two-phase conditions typical of a spear nearing the base of its drawdown envelope. The CST MPR pump’s ability to lift on intake is only limited by the liquids vapour pressure characteristics.

5.2 Cavitation onset and gas volume fraction

Cavitation in a conventional impeller becomes increasingly likely as the gas volume fraction (GVF) of the fluid entering the pump rises — most centrifugal pumps used in dewatering service tolerate only a low single-digit percentage GVF before performance degrades sharply. A dewatering spear network operating at or near its design drawdown will routinely present a mixed air-water inflow at some or all of its connected spears, which is precisely the condition a conventional pump is least able to tolerate. A pump designed to manage both entrained-gas and the change of state between liquid and vapour, rather than to exclude entrained-gas and vapour altogether, removes this constraint as a limiting factor in system design and operation.

5.3 Consequences for system design

Because the traditional system must avoid the two conditions described above, its design response is to add plant: a vacuum-assist unit to maintain prime, oversized suction lines to reduce velocity and air entrainment, and standby pumps to cover the periods when a unit is out of service being re-primed. Each of these responses adds capital cost, fuel and generator run-time, and a further point of mechanical failure. A pump that tolerates two-phase suction conditions by design removes the need for this compensating plant, which is the principal driver of the comparative outcomes presented in Section 6.

6. Comparative Outcomes

The table below summarises how the traditional spear-and-settling-tank approach and the CST MPR pump approach compare across the considerations most relevant to a site engineer, project manager or consent holder.

Consideration	Traditional Spear / Wellpoint System	CST MPR Pump System
Priming	Required before every start-up; lost repeatedly as the water table falls and air enters the spears	Not required — the pump tolerates entrained air and self-recovers without operator intervention
Cavitation risk	Rises sharply as gas volume fraction increases near the end of drawdown	Designed to run stably through a mixed air/water phase without cavitation collapse
Suction performance	Limited by conventional NPSH margins and atmospheric suction-lift constraints	Maintains reliable lift performance under two-phase (air/water) suction conditions
Water handling train	Spears → collection manifold → settling tank → sediment treatment → discharge	Spears → MPR pump → bag screen → discharge
Plant on site	Spear rig, vacuum pump, settling tank(s), sediment bags, generator	MPR pump unit, bag screen, generator
Operator attention	Frequent monitoring and re-priming, particularly overnight and over weekends	Materially reduced — the system is tolerant of unattended fluctuation in inflow
Footprint / laydown area	Larger — settling tank(s) need standing area and access for desludging	Smaller — no settling tank required

Consideration	Traditional Spear / Wellpoint System	CST MPR Pump System
Discharge consent compliance	Dependent on settling time and tank performance; risk of non-compliant TSS if under-sized	Bag screens selected to manage solids at the point of discharge, simplifying operating set up while still meeting resource consent requirements for TSS
Mobilisation	Rig, prime and commission spears and tank before dewatering begins	Connect to existing in-ground spears and start pumping

7. Wider Benefits to the Delivery Programme

7.1 Programme and mobilisation

Removing the settling tank and its associated desludging and standing-area requirements shortens the mobilisation sequence at the start of dewatering and simplifies demobilisation at completion. Where dewatering sits on the critical path — as it frequently does ahead of pipe-laying — a faster, more reliable set-up reduces exposure to weather windows and shortens the overall excavation-to-backfill cycle.

7.2 Health and safety

A dewatering system that continues to operate reliably through unattended periods reduces the frequency with which personnel must re-enter the site, out of hours, to correct a lost prime or a failed pump. This directly reduces exposure to the hazards associated with working around excavations, plant and traffic outside normal supervised hours, and reduces reliance on reactive rather than planned maintenance.

7.3 Site footprint and neighbourliness

A smaller plant footprint — no settling tank, less standby equipment — is a material benefit on constrained urban sites, where laydown area is at a premium and where fewer generators and pumps running for shorter periods also reduce noise and emissions, an increasingly important consideration for construction in residential and commercial areas.

7.4 Environmental compliance

Managing suspended solids at the point of discharge, using consumable bag screens (down to 53 microns), rather than relying on settling time in a tank that must be correctly sized, maintained and desludged, simplifies the task of demonstrating ongoing compliance with resource consent discharge conditions, and reduces the consequence of a missed or under-performing settling stage.

7.5 Cost

The combined effect of less plant, less standby capacity, less crew time spent re-priming and monitoring, and a shorter mobilisation and demobilisation sequence is a lower whole-of-contract cost for the dewatering component of the works, even before accounting for the reduced risk of a costly unplanned inundation event.

8. Conclusion and Recommendation

Trench dewatering has, for decades, been designed around the limitations of conventional centrifugal pumps: the need to prime, and the need to avoid cavitation as air enters the suction line. Contractors have compensated for those limitations with additional plant, additional crew time and additional treatment infrastructure, accepting these as the unavoidable cost of keeping a trench dry.

CST's MPR pump, built on a Stable Vapour Cavity principle that manages the liquid-vapour phase behaviour of the pumped fluid directly, removes the two constraints that drive most of that additional cost and risk. Connected to the same in-ground spear networks already familiar to dewatering contractors, it offers reliable suction lift without priming, tolerance of two-phase air-water inflow without cavitation, and direct discharge through bag screening in place of a settling tank.

On the basis of the engineering rationale and comparative analysis set out in this paper, the CST approach represents a genuine improvement in the reliability, footprint, safety profile and environmental compliance of trench dewatering, rather than an incremental variation on established practice. It is recommended that contractors and principals evaluating dewatering methodology for below-water-table excavation works give active consideration to the MPR pump as an alternative to the traditional spear-and-settling-tank system on the projects described in this paper.

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