
DESIGN AND IMPLEMENTATION OF WATER POSITIVE CONSTRUCTION SITES: A SCIENTIFIC LITERATURE REVIEW

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ABSTRACT

Water is an essential resource during construction, yet its use is often treated as a routine site requirement rather than a resource-management issue. Activities such as concrete work, curing, dust suppression, cleaning and worker facilities can create a considerable demand for freshwater. At the same time, rainfall, groundwater encountered during excavation and wastewater generated on site are frequently managed as separate streams. The water-positive approach brings these streams together with the aim of reducing freshwater demand, increasing reuse and supporting water replenishment within the local hydrological system. This review examines research on water-positive construction and related approaches such as Water-Sensitive Urban Design (WSUD), Sponge City practices, regenerative design and net-positive water certification. The literature also highlights practical measures including rainwater harvesting, site water recycling, groundwater recovery, treatment and smart monitoring. Published cases from Australia, Taiwan, Brazil and other contexts show that these measures can be technically useful when planning, regulation and project management are considered together. For Construction Management, the main lesson is that water positivity should not be treated only as a technical treatment problem. It needs clear responsibilities, monitoring, reuse planning, cost consideration and coordination from the early stages of a project. The review identifies gaps in standard methods, implementation guidance and construction-specific assessment criteria and proposes a practical management-oriented direction for future work.

Keywords: *Water-positive construction, construction management, water conservation, rainwater harvesting, water reuse, groundwater recovery, sustainable construction.*

1. INTRODUCTION

The construction industry depends on water for a wide range of activities, but site water use is often less systematically managed than materials, labour and energy. Freshwater may be used for dust suppression, concrete mixing and curing, equipment cleaning and worker facilities. In water-stressed regions, this creates an avoidable burden on local resources. Recent research therefore argues for a shift from simply reducing water consumption toward water-neutral or water-positive approaches in which a project aims to reduce withdrawals and create a beneficial balance with the surrounding water system [2], [4].

The term water-positive is not used in one single way across the literature. In general, it refers to a project that goes beyond efficiency and attempts to return, recharge, treat or otherwise replenish more water than it takes from external sources, although the boundary of the

assessment must be defined clearly [3]. This distinction is important because a building may save water without actually improving the local water balance. The Living Building Challenge, for example, treats water as a site-based ecological cycle and requires projects to manage and release water in ways that respect natural flows [6].

Related planning approaches broaden this idea beyond an individual building. WSUD promotes integrated management of water supply, stormwater, wastewater and landscape systems, while Sponge City practice uses ecological storage, soil, vegetation and drainage measures to reduce runoff and improve water retention [11]. Regenerative design takes the argument further by asking whether the built environment can restore environmental functions rather than only reduce negative impacts [7].

2. OBJECTIVES OF THE REVIEW

1. To review major concepts and frameworks related to water-positive development and their relevance to construction projects.
2. To identify practical water conservation, collection, treatment, reuse and replenishment measures reported in previous studies.
3. To compare lessons from published construction and urban water case studies and examine their value from a Construction Management perspective.
4. To identify regulatory, financial, technical and planning barriers that affect implementation.
5. To highlight research gaps and suggest a practical management-oriented direction for water-positive construction sites.

3. CORE CONCEPTS AND FRAMEWORKS

Net-Positive Water and Regenerative Thinking

The strongest conceptual shift in the literature is the move from efficiency to regeneration. A green project usually tries to consume less water; a water-positive project seeks a wider benefit by capturing, treating, reusing or replenishing water within the system boundary. The Living Building Challenge illustrates this principle through requirements for on-site water capture and treatment and by linking water use to the natural flows of the site [3]. Regenerative design similarly moves “beyond zero” by considering whether buildings and infrastructure can actively improve environmental conditions [7].

WSUD and Integrated Water Cycle Management

WSUD is particularly relevant because it connects water supply, stormwater, wastewater, landscape and urban design rather than managing them as isolated systems. Research from Australia shows how integrated water cycle management can be applied from precinct to city scale, combining water efficiency with stormwater control and alternative sources [15]. For construction management, the practical implication is that water planning should be coordinated across site activities, temporary works, drainage, storage and future building operations rather than being left to individual contractors.

Sponge City and Blue-Green Approaches

The Sponge City concept focuses on retaining, storing, infiltrating and treating rainfall close to where it lands. It uses blue-green infrastructure, source control, drainage measures, vegetation and permeable surfaces to reduce runoff and support hydrological balance [11]. Research on integrated blue-green architecture also shows the value of combining technical and ecological measures rather than relying on hard infrastructure alone [13]. These principles can inform temporary and permanent site planning, especially where runoff and seasonal rainfall are important.

Table 1. Key approaches identified in the literature

Approach	Main focus	Construction relevance	Key references
Net-positive water	Reduce demand and manage water within site limits	Sets the overall water-positive objective	[3]
WSUD / IWCM	Integrate supply, stormwater, wastewater and landscape	Supports coordinated site water planning	[15]
Sponge City / LID	Retain, infiltrate and treat rainfall	Useful for runoff control and recharge	[11]
Regenerative design	Restore environmental functions	Encourages site practices that create wider benefits	[7]

4. IMPLEMENTATION STRATEGIES FOR CONSTRUCTION SITES

Water Collection and Local Reuse

One practical direction is to collect water that would otherwise be lost. Site-level studies describe collection wells, basic filtration, settling and storage systems that can support non-potable uses such as dust suppression and curing [5]. These measures are relatively simple compared with high-end treatment systems, but their success depends on matching water quality to the intended use and maintaining the storage and filtration system. The literature also reports the reuse of recovered water for construction activities when quality requirements are satisfied [24].

Groundwater Recovery

Excavation work can intercept groundwater, which is often pumped away as a temporary nuisance. The Taichung case demonstrates a different management approach: groundwater from construction-site wells was evaluated as a potential supply during a severe drought, and water from nine sites was reported to support about 400,000 people through municipal coordination [2]. A Fortaleza case similarly examined groundwater drainage water for garden irrigation and found that its suitability depended on the intended use [8]. These studies show that groundwater recovery can be valuable, but it requires quality assessment, legal permission and coordination with public agencies.

Recycling, Treatment and Smart Monitoring

Water recycling systems may use pumps, settling tanks and multi-stage filtration so that collected water can be used more than once for lower-grade applications [12]. The literature also points to sensors, flow meters and IoT-based monitoring as tools for tracking consumption and identifying abnormal losses [10]. BIM has been proposed as a framework for integrating water-efficiency information into sustainable design and construction management, helping project teams identify where water demand and management decisions occur across the project [25]. These technologies are useful, but technology alone does not make a site water positive; management procedures and accountability remain necessary.

5. CHALLENGES AND RESEARCH GAPS

Regulatory and Economic Barriers

Regulation remains one of the practical barriers to water-positive construction. Research from Colorado notes that water rights and legal restrictions can affect rainwater capture and greywater reuse, and that early coordination with authorities can prevent later technical and economic problems [21]. Indian research also points to a gap between the presence of policy and its effective enforceability for water circularity in construction [28]. Cost is another concern because storage, treatment, monitoring and reuse infrastructure can increase initial expenditure even where long-term savings are possible [23].

Technical and Planning Gaps

A repeated issue in the literature is the lack of simple, construction-specific frameworks that connect site water use with measurable water-positive outcomes. Many studies focus on buildings, urban districts or individual technologies rather than the management of water during the construction stage itself. Green infrastructure can also be limited by fragmented urban space and conventional land-use rules [17]. The wider market for circular construction practices is still developing in some locations [18].

Emerging Research Directions

Future research needs clearer parameters for concepts such as nearly zero water buildings and urban water communities [26]. There is also a need for more decentralized green water infrastructure, particularly in water-scarce and climate-sensitive areas [29]. A life-cycle perspective is another important direction because water is connected with the carbon and resource performance of construction rather than existing as an isolated issue [27]. More importantly for Construction Management, future studies should translate these ideas into site-level responsibilities, measurable indicators, decision criteria and implementation sequences.

6. DISCUSSION FROM A CONSTRUCTION MANAGEMENT PERSPECTIVE

The literature suggests that water positivity should be treated as a management objective supported by technical measures. The most useful sequence is to reduce unnecessary demand first, then identify opportunities for reuse, capture additional water, and finally consider replenishment or recharge. This hierarchy helps avoid a common weakness in sustainability

projects: adding a treatment system without reducing the underlying demand. Construction managers can support this process through water-use planning, allocation of responsibilities, monitoring of consumption, control of wastage, coordination with subcontractors and documentation of performance.

A practical construction-site framework can therefore be organised around five management actions: establish a water baseline from available project information; identify high-consumption activities; assign suitable alternative water sources to lower-grade uses; monitor reuse and losses; and review the balance between water withdrawn and water recovered or replenished. This does not require a predictive model or a new software system. It mainly requires disciplined planning and consistent site-level implementation. The literature on BIM, smart monitoring and integrated water systems can support this process, but the management framework should remain understandable and workable for normal project teams [10], [25].

Another clear finding is that water-positive performance is context dependent. Rainfall, groundwater conditions, regulations, available space and local water quality all influence what is feasible. Therefore, a single fixed solution is unlikely to work equally well for every construction site. A better approach is to use a common management framework with site-specific choices of collection, reuse, treatment and replenishment measures. This is consistent with the broader shift from isolated technology selection toward integrated water-cycle thinking [15].

Practical Implication for Construction Projects

From a practical project-management point of view, the literature supports a simple water management sequence rather than a technology-heavy solution. The first step is to understand where water is being consumed and where avoidable losses occur. The second is to reduce demand through good housekeeping, controlled application and appropriate construction practices. The third is to substitute freshwater with collected or treated water wherever the quality requirement permits. The final step is to consider recharge or replenishment so that the project contributes a positive outcome beyond its own consumption. This sequence is consistent with the integrated water-cycle approach reported in WSUD and regenerative studies [7].

For a Construction Manager, implementation can be organised through a small number of routine controls. Water requirements can be included in work planning, procurement and subcontractor coordination. Storage tanks, collection points and reuse lines should be assigned clear ownership, while meters or simple records can be used to track major sources and uses. Water-quality requirements should be linked to end uses so that potable water is not used where a lower-grade source is adequate. This is especially relevant to groundwater recovered from excavation, because published cases show that the same source may be suitable for irrigation or dust control but unsuitable for uses requiring high potability [8].

The literature also suggests that performance needs to be documented, not only claimed. Useful indicators may include freshwater use per unit of construction activity, volume of water reused, volume of rainwater captured, volume of groundwater recovered, quantity sent

for recharge, and the proportion of non-potable demand met through alternative sources. Such indicators can support routine monitoring without requiring a complex prediction model. BIM and IoT tools may improve visibility where they are already available, but the basic management process can still work through standard site records and periodic review [10], [25].

8. CONCLUSION

The literature shows a clear movement from simple water efficiency toward more integrated and regenerative approaches in the built environment. Rainwater harvesting, wastewater reuse, groundwater recovery, treatment, monitoring and blue-green measures can all contribute to reducing freshwater demand and improving the overall water balance of a project. However, water-positive construction is not achieved by a single technology. It depends on how water is planned, monitored, reused and replenished throughout the project.

For Construction Management, the strongest research opportunity lies in converting broad sustainability principles into a practical site-management approach. Published cases demonstrate technical potential, but the field still needs clearer construction-stage indicators, implementation procedures and project-level decision guidance. A well-structured water-positive management framework can bridge this gap by linking water conservation and reuse measures with responsibilities, monitoring, feasibility and implementation planning. This direction is more realistic for construction projects because it focuses on management of available resources rather than assuming that every site requires a complex new engineering system.

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