NWG ENGINEERING BRIEFING NOTE

SUBJECT	Small/medium emergency drawdown siphon design for NWG reservoir sites to improve drawdown capacity
REASON FOR GUIDANCE	Guiding design principals for small/medium emergency drawdown siphon design for NWG reservoir sites
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1. AIMS AND OBJECTIVES

A number of Northumbrian Water's (NWG) portfolio of reservoir sites and their existing drawdown capacities have been investigated and a drawdown deficit has been identified in relation to the *Guide to drawdown capacity for reservoir safety and emergency planning* (EA, 2017). To increase the capacity at various reservoir sites to align with the EA guidance, one of the preferred solutions is to design, construct, and commission a new independent emergency drawdown siphon(s) from the reservoir basin to discharge to the downstream watercourse and / or spillway structure at the reservoir. The purpose of this briefing note is to set out the guiding principles for standardisation of emergency drawdown siphon design across NWG reservoir sites.

This briefing note includes specific preferences identified by NWG Operations teams for aspects of siphon design that, where possible, should be followed. The following preferences are not an exhaustive list of considerations for siphon design but set out particular NWG requirements for some aspects of design, water management, construction and commissioning. The guidance published in October 2023 by *CIRIA, Siphons in dams – design, installation, operation, management and testing (C813)*, provides greater detailed consideration that shall be followed in conjunction with this briefing note when designing an emergency drawdown siphon at a NWG reservoir. The Qualified Civil Engineer (QCE) and Supervising Engineer (SupE) appointed for the reservoir shall be consulted throughout the design process to ensure compliance with any statutory obligations and confirm that reservoir safety is suitably managed.

2. SIPHON DESIGN CRITERIA

The following aspects of key design criteria, which may vary on a site-by-site basis, shall be agreed with the QCE, NWG stakeholders, and documented during the design stage:

- Drawdown capacity (in m^3/s and/or m/day) required to address the identified shortfall,
- Siphon operating range (e.g. capable of drawing down 5 m from FSL),
- Time required to prime and operate siphons to their design capacity (where the guide of a maximum of one-hour for priming and operation duration in *C813* is not able to be followed),
- Future system exercising regime, including duration of valve tests and frequency of testing etc,
- Sub-atmospheric pressure limit of -7.9 mWC unless agreed otherwise,
- Any other site-specific design criteria (e.g. can or can't construct through watertight element) etc.

3. SIPHON ARRANGEMENT

3.1 Siphon Alignment

The alignment of the siphon design will vary on a site-by-site basis and shall give due consideration to critical structures and services when planning the alignment. It is recommended the new siphon main should be routed **around the existing water-tight element** rather than through, and **avoid the dam embankment where possible.**

Where routing the siphon around the water-tight element cannot be avoided as it is not always practical, refer to *CIRIA*, *Dam and reservoir conduits (C743)* for guidance.

3.2 Priming Arrangement

When the reservoir is at full supply level (FSL), the preference is for the siphon to be **self-priming**, where the crown of the siphon through the dam crest will be equal to or lower than the FSL of the reservoir. Although, it is acknowledged that a self-priming system is not always reasonably practicable. As such, to prevent an uncontrolled discharge from the siphon system, an **isolation guard valve** shall be provided at the crest / high point in the system. The range over which the siphon will be self-priming, if possible, shall be determined on a site-by-site basis with agreement from the QCE.

Where the reservoir top water level is below the crown of the siphon or when self-priming is not a feasible option due to dam safety concerns in going through the watertight element, the preference is for a **vacuum primed system**. Venturi vacuum priming or vacuum pump priming eliminates the requirement for a submerged inlet valve within the reservoir basin, which would be difficult to access to maintain and poses a risk of oil leaks into the reservoir basin (if the valve were to be hydraulically actuated).

When the siphon is not in operation, it is recommended to be left in an **un-primed state**, pending agreement with the QCE and asset owner. Please see tables 6.8 and 6.10 of *C813* for guidance.

3.3 Pipework Arrangement

Consideration shall be given to install a **minimum of two independent siphon pipes** in parallel to provide drawdown resilience in the event that one of the siphon pipes becomes inoperable. This arrangement also allows for each siphon to be tested over its full range independently, every six months. As a result, this reduces the discharge impact on any downstream watercourse. All discharges must be covered by a Section 166 discharge consent, see Section 3.5.

The alignment, depth and height of the pipework positions either above or below the existing topography shall be determined on a site-by-site basis, with agreement from QCE and other key stakeholders. Where there are bends or joints in the siphon(s), thrust restraint systems should be provided to adequately transfer thrust forces to the supporting ground/structures.

For future operation and maintenance of the Mechanical & Electrical (M&E) equipment, the preference is to have the control arrangement outside of the dam embankment and can be operated by a single operative. **Confined spaces should be avoided** where possible from an operator's safety perspective, and to allow for independent operation of the asset.

3.4 Inlet Arrangement and Screens

A suitable **screen** shall be designed and **installed at the inlet** of the siphon to reduce debris or larger obstructions entering the pipework, and any third-party entry (e.g. the inlet arrangement may not be submerged during summer seasons of low reservoir elevation). The inlet screen arrangement should consider maintenance required to prevent blinding and be sized larger than the inlet of the siphon pipework. The screen is recommended to include a **solid top** as part of the design on the inlet to reduce air entrainment and increase operating range. Vortex checks shall be undertaken to limit issues on the operational range of the siphon.

If the reservoir is used for recreational sailing, it is recommended that **signage** and **visibility markers** are installed to prevent boat impact.

Screens shall be constructed of **stainless steel** and be compliant with NWG's Engineering Standard E0101 – *Eng Spec for Civil Engineering Work, DWI*'s *Advice Sheet 5 – Products made from Recognised Grades of Materials,* and *DWI's Annex 3 –Recognised materials for use in the manufacture or assembly of products*. It is recommended that screens have a **maximum opening of 100 mm as a starting point to prevent solids/third parties entering the system.** The screen should be sized on a site-by-site basis depending on pipe size, head losses, and air entrainment, with agreement from QCE.

3.5 Discharge Arrangement

As the pipework alignment will vary on a site-by-site basis, the siphon may discharge into the following:

- An existing structure, such as a spillway, overflow, stilling basin or tailbay,
- An intermediate chamber on the downstream abutment (ideally off the embankment), whereby flows are then conveyed by gravity to a watercourse or existing structures via a pipe or channel,
- Directly into a downstream watercourse via an energy dissipation structure.

Once the hydraulic design is complete, the **Section 166 discharge consent** for the reservoir shall be amended or requested (where the discharge requires a new consent) to account for the increased discharge flows and/or new outfall location into the existing watercourse and increased regular statutory exercising of the siphon(s), with the discharge rates expected on each six-monthly test. The Section 166 consent application should include due consideration for the data collection, construction and commissioning phases.

Assessment of the **impact of any regular exercising** (i.e. six-monthly or other frequency agreed with the QCE) and full capacity testing on the **downstream receptor** should be undertaken during design with documentation and agreement from QCE and NWG.

3.6 Air Management

The siphon(s) should have a **mechanism of capturing/storage of air** (and releasing air where vacuum system permits) at the high point in the system.

With the siphon(s) left in an **un-primed state**, it is recommended that an equal tee and riser pipe is provided on both sides of the isolation guard valve at the crest, at the high point of the siphon, sized as large as possible considering site constraints, with a hydrant and/or isolation valve on top. When the siphon is not operational, the hydrants/ isolation valves shall be left open to allow the water level in the upstream and/or downstream leg of the siphon to rise and fall with the reservoir level or tail water level, where applicable.

3.7 Siphon Operation

For future exercising of the siphon(s), it is recommended that the starting point for operation is based on a **six-monthly operation** by NWG Operations (Ops), to its **full capacity** (with full reservoir head on the day of testing) for **five minutes of discharge or until flows run clear**. This requirement shall be agreed with key stakeholders, including QCE, SupE and NWG Ops during the design.

It is anticipated that NWG operatives will be attending site on a six-monthly basis for regular testing, with ad hoc operation and maintenance visits and emergency incidents requiring drawdown. The design shall be based upon **one NWG operator** attending site unless agreed otherwise. A single NWG operator shall be able to drive to site, have all facilities available on site to enable operation without need to hire or collect plant from operations yards (e.g. valve keys, portable actuators, power supply, etc) and be capable of having the siphon system operational within **one hour of arriving to site**. All equipment and **critical spares** required for operation and maintenance of the siphon, determined through liaison with NWG Ops through design, should be provided as part of the capital scheme.

The design arrangement shall be such that **one NWG operator** on site has **suitable sight lines** from the control kiosk to assess discharges and ensure there is no adverse flooding, scouring or pollution in the downstream discharge location, if reasonably practicable.

There is **no requirement for the siphon to be operated remotely** (e.g. remote valve actuation via telemetry) or for valve status, flow rates, etc be communicated back to NWG Control Room via SCADA. Local control and system operational status (e.g. valve positions, etc) shall be provided within a **site kiosk with suitable lighting provided within to assist a single NWG operator**.

The security of key components (e.g. valves, kiosks, chambers etc) needs to be discussed and agreed with NWG Ops and NWG Business Continuity on a site-by-site basis and documented during the design phase. Due consideration of third-party attack/vandalism on the siphon system shall be risk assessed and suitable measures in place to prevent uncontrolled discharges. Refer to *Engineering Standard E0121 – Specification for Security Systems* along with *Section 4.9* of *CIRIA C813.*

Actuated valves (electric and/ or hydraulic) shall be provided and operated from a **control kiosk(s)** to minimise resource requirements and timely activation of the emergency drawdown in an incident. The control kiosk(s) shall not be located on the dam embankment (where possible) but located such that sightlines permit view of key siphon operation (e.g. discharge arrangement). Valve control shall also include a second form of manual operation should the power or actuator fail, enabling an operative to operate valves during an incident (e.g. hand wheel, t-key, portable actuator, etc). All equipment needed for secondary operation of the asset should be provided as part of the capital scheme.

3.8 Power Supply

Mains power supply shall be provided to siphon system where possible. The preference is for electrical operation of the priming arrangement (e.g. compressor, valve actuation, etc) and siphon control valves to minimise manual valving works, where possible. In addition to the mains supply, **emergency power back-up connection** shall be provided, so that a temporary power generation supply can be brought to site (e.g. diesel generators from NWG stores, hire, lay down area provision, etc).

Where a **permanent mains power supply is not viable**, provisions for a reliable alternative source of **permanent on-site power generation** (e.g. diesel generator) should be provided. In addition, **emergency power back-up connections** shall be provided, should the on-site generation fail.

The power requirements for the siphon should be determined through design, with assessment of the risk that temporary power could be sourced should the mains supply go offline. A testing regime for the primary and secondary power supplies should be documented through design and included on the regular testing regime by NWG Ops. Refer to NWG's Engineering Standard E0108 – *Diesel Powered Generators and Installations.*

4. PIPEWORK MATERIALS AND VALVES

4.1 Pipework Materials

It is recommended that the siphon pipework for both the above ground and below ground applications are constructed from either **steel, ductile iron**, **or HDPE**. A technical appraisal of pipework materials should be undertaken and presented to the QCE for discussion and agreement as part of the design.

Submerged fixings should be stainless steel with suitable prevention of corrosion for dissimilar metals.

4.2 Valving and Arrangement

For a typical preferred vacuum primed siphon, this would comprise of the following arrangement:

- A screened open-ended inlet with a solid top.
- An isolation guard valve at the crest of the dam, preferably located immediately upstream of the water-tight element.
- A means of discharging the siphon flows, either into an intermediate terminal discharge chamber or stilling basin or spillway chute. Flows shall be controlled via a submerged discharge valve, **or** an in-line valve immediately upstream of the chamber, **or** a terminal discharge valve at the end of the siphon.
- Priming connections (e.g. valves to aid air evacuation, connections to supply mains to aid filling downstream legs, etc).
- An air release/management system at the crest.

It is recommended that all **gate valves on the siphon are designed for dams**, reservoirs, or hydropower use and **hydraulic checks shall be undertaken in design** to ensure all valves can withstand the predicted flow velocities through the siphon(s). Valve suppliers should be engaged in the early stages of design and preferred valves agreed with the key project stakeholders.

While it is not recommended due to confined space, for valves that will be buried, the controls shall be housed within a suitably sized chamber (where possible, pending site conditions) to enable access to the asset and maintenance and provisions for future removal.

Access covers shall be **lockable**, and any security systems should comply with NWG Engineering Standard E0121 – *Specification for Security Systems* and agreed on a site-by-site basis with NWG Ops, NWG Business Continuity, and the asset owner.

4.3 DWI and Reg 31 Approved Materials

Where the reservoir provides raw water supply to a downstream treatment works, all pipework, valves, fittings and materials that are in contact with the body of water shall be **compliant** with the **Drinking Water Inspectorate (DWI) Approved & Considered Products**, as per Regulation 31 of The Water Supply (Water Quality) Regulations 2016. The design team shall document materials to be used on a register to assess and confirm that all materials proposed to be used are Reg 31 approved and NWG Water Quality should be engaged during the early stages of design. If any proposed materials are not Reg 31 compliant, a risk assessment shall be undertaken with NWG and formal confirmation received from NWG Water Quality before construction commences. Any required water quality sampling/testing required shall be determined as part of the early design phases and agreed with NWG.

5. CONSTRUCTION AND COMMISSIONING

5.1 Construction / Temporary Works

Many of NWG's reservoirs are used for potable water supply and as such, a key task during design is to give due consideration of the **temporary works** required along with proposed water management of the reservoir through construction. During the early stages of a project (e.g. **Concept phase**), the temporary works and a method of construction shall be developed in liaison with NWG Water Supply, NWG Ops, NWG Engineering, Early Contractor Engagement (ECE), NWG Framework Contractor, Environmental team, QCE, SupE and any other key stakeholders (e.g. NWG Recreation, angling/sailing clubs, etc).

Throughout construction, it is recommended that the contractor provides emergency contacts should issues arise during construction, with 24/7 availability.

A **water management and co-ordination plan** with due consideration for the data collection, construction and commissioning phases should be developed with key stakeholders to consider reservoir safety, flood management, water quality (e.g. sediment disturbance from construction activities), environmental, recreational impact, wider works in the reservoir catchment amongst other matters. This shall be developed through Concept, Definition and Design & Construct (D&C) phases with agreement from key stakeholders at key gateways.

It is recommended that consideration be made on a site-by-site basis to assess whether an additional water management document is required to consider reservoir safety during the construction phase, including any actions to be taken to **ensure dam and reservoir safety through construction**. Key roles and responsibilities should be made clear in the document.

The existing On-Site Emergency Plan (OSP) for the reservoir should also be updated to include any changes to the asset that would affect the OSP.

5.2 Airtightness and Pipes and Valves, Testing, and Commissioning

With preference for a vacuum primed system, high construction quality is required to ensure the pipework is airtight. Consideration for **testing of the siphon** and upfront agreement for testing methods with the key stakeholders (including QCE, NWG PE, contractor etc) should be obtained during design development.

Positive pressure testing of the siphon pipework should be undertaken in line with *CESWI* and NWG's Engineering Standard E0101 – *Eng Spec for Civil Engineering Work,* with the System Test Pressure (STP) calculated as per the guidance in *BS EN 805*. In addition, consideration should be made to develop and define a method of testing the vacuum (i.e. ability of the siphon to not draw air into the system).

One such method could be priming the siphon to an agreed pressure and monitoring pressure loss over a set period of time with no discharge. The testing and commissioning regime should be agreed with NWG Ops, QCE and the NWG Project Engineer, and clearly defined in the D&C contract documents.

A **Detailed Description of Operation** document shall be provided to provide in depth details to NWG Ops management, SupE and other key stakeholders on the design philosophy. In addition, a **Standard Operating Procedure (SOP)** document should be provided (with an on-site physical copy) to include a step-by-step guide to site operatives on how to prime and operate the siphon, depending on the starting condition (i.e. reservoir water level), including any other relevant operational tasks such as oil replacement, greasing, monitoring of drainage flows, etc. It is recommended that **visible depth gauges** are installed on the upstream embankment to assist operatives in identifying water levels and the corresponding priming method.

As a standard, *C813* should be followed with regard to design of the siphon system so that it can be primed and operational within one hour of an operative arriving to site for regular testing or in an emergency scenario.

6. OTHER GUIDANCE

For additional information and detail regarding siphon design, please refer to *C813 Siphons in Dams*. The above recommendations are not exhaustive, and other aspects of design should be considered in detail on a site-by-site basis when designing a new or retrospective siphon at any NWG reservoir site.

7. ACKNOWLEDGEMENTS

While the recommendations covered in this briefing note are NWG's preference for emergency drawdown siphon design, should the design team deviate away from the guidance above, an Engineering Deviation Request (EDR) would **not** be required. Design acceptance is to be achieved on a site-by-site basis with agreement from NWG and the QCE.

Any feedback on the briefing note should be directed to the NWG Engineering team via standards@nwl.co.uk.

Thank you to the following key stakeholders for engagement and feedback which helped guide this briefing note for NWG Engineering:

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