

## **Implementing Severn Trent Water's People Plan to become the best in Great Britain at managing reservoir safety**

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**SYNOPSIS.** Reservoirs provide a vital service in storing the country's water, but the consequences of failure are truly terrifying. Managing reservoir safety remains a major business risk for all owners. Great Britain has an excellent record of reservoir safety, with no deaths following dam failure since the introduction in 1930 of reservoir safety regulations that sought to embed learning and lower risk. However, the unprecedented flooding of the summer of 2007 brought reservoirs into sharp focus and has led to regulatory change that will have a major impact on all dam owners.

For Severn Trent Water, one of Great Britain's leading water companies, the devastating floods severely tested our reservoirs, challenging our resilience and exposing vulnerability. We recognise that reservoir safety is one of the biggest business risks we face and is one that we manage vigorously. This paper details the strategic development and implementation of Severn Trent Water's *People Plan*, to achieve our aim "*to be recognised as the best in Great Britain at managing reservoir safety*". It describes the identification, assessment and management of business risks; the delivery and application of a new visual management system for dams and reservoirs; the integral and essential role of employee engagement; the application of knowledge management; embedding lessons learned; and our proactive response to the major changes in legislation.

### **INTRODUCTION**

Severn Trent Water (STW) is one of the largest water companies in England and Wales, providing water supply and waste water treatment services for over seven million customers. Our administrative boundaries are defined by the fluvial catchments of the Rivers Severn and Trent, and we effectively manage the water cycle in central England. A fascinating diversity of over 700 dams and reservoirs, constructed over the last 170 years, form a key component of our strategic infrastructure and include the iconic Howden and Derwent Reservoirs and Lake Vyrnwy. Of our reservoirs, 58 retain more than 25,000m<sup>3</sup> of water above natural ground level and are regulated

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by the Reservoirs Act 1975 (the Act). The average age of these Large Raised Reservoirs (LRRs) is 77 years, compared with 115 years nationally. The majority of the LRRs are impounding reservoirs (37 No.). The remainder of our LRR portfolio comprise non-impounding and service reservoirs.

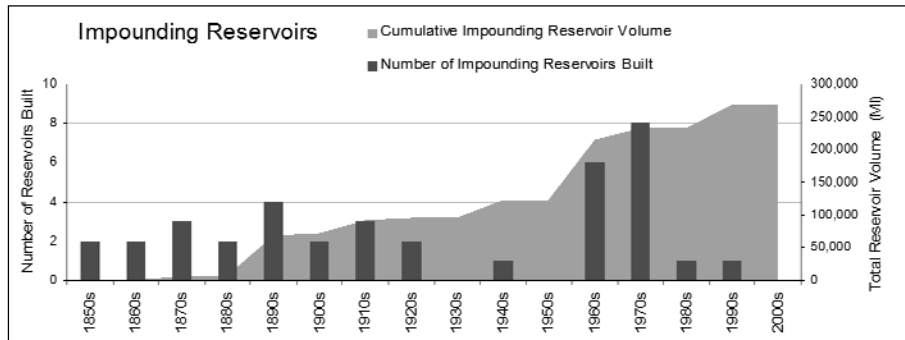


Figure 1. Capacity of reservoirs compared with construction date.

For STW, the 2007 floods impacted on key infrastructure, challenging our resilience and exposing vulnerability. While severely tested, our reservoirs performed satisfactorily. We are not complacent and recognise that reservoir failure is one of our largest corporate risks. In pursuit of our company goal to “*be the best water and waste company in the UK*”, we are striving “*to be recognised as the best in Great Britain at managing reservoir safety*”. Critical to this strategic direction is “*having the right skills to deliver*”. Implementing our newly developed **People Plan** underpins this goal. This plan is a comprehensive and targeted programme that resources our approach to risk analysis and management, our proactive response to regulatory change and our overarching commitment to communication and training across the organisation by transferring knowledge to effectively manage one of our largest business risks.

### RESERVOIR LEGISLATION

The Act provides the legal framework that seeks to assure the safety of the 1.2m people living within the flood path of the 2,100 LRRs in England and Wales. This framework is unique when compared internationally as the regulator is not required to impart any engineering judgment whatsoever (Hope 2006) and is designed to be self-regulating. The owner is required to appoint a Supervising Engineer (SE) “at all times” and an independent Inspecting Engineer (IE) for periodic inspections, at least every 10 years, for reservoirs in service. Where the IE believes the reservoir to be unsafe, prescribed safety works must be implemented in a timely manner. Ultimately, the reservoir owner is responsible for the safety of the reservoir. Understandably, society demands high environmental and safety standards. STW seeks to meet legal requirements without constant regulatory supervision or the threat of enforcement action.

## RAISING THE BAR OF RESERVOIR MANAGEMENT

Full compliance with the Act establishes a minimum safety standard only. Furthermore, a totally reactive situation arises when an owner waits for a statutory inspection to discover that essential safety works are required to render a reservoir safe. As part of our proactive strategy to safely manage our reservoirs we have instigated a pre-statutory inspection process and commissioned a complete Portfolio Risk Assessment (PRA) review.

### “Pre-inspection” process

The periodic S10 inspection is an independent audit of the safety of the dam, its infrastructure and management. We commission pre-statutory inspections two years before the statutory requirement, to highlight potential safety issues in order to proactively address them. The same level of scrutiny and appraisal is sought from the IE without the depth of reporting. This early review is demonstrably cost-effective and provides a window of opportunity to fully appraise options ahead of any legal driver. Inspections also provide training for aspiring SEs and an opportunity to mine the tacit knowledge of the IE. This enables us to learn of the good practice of others to further appraise how we can progress from being “good to great” in our role.

### Portfolio Risk Assessment

Leading owners employ varying PRA processes to quantify physical uncertainties, and structure risk management processes in order to focus and prioritise resources to further reduce risk to tolerable levels. We jointly developed a PRA process, which is qualitative in approach (Chesterton *et al* 2012). In the first phase we reviewed all reservoirs subject to the Act and apportioned a risk ranking. This was used to prioritise our current five-year capital investment programme AMP 5 (2010-15) and highlight generic groupings of studies that would normally be called for as a result of a statutory inspection. By grouping these studies we have attracted procurement economies and work load efficiencies. We have established our planned needs for AMP 6, developing evidence for the financial regulator, Ofwat. This has also left a transparent, auditable trail of decision making.

During the next phase of the process we reviewed key non-statutory structures. Appropriate risk controls were instigated and reinforced. Our strategic approach was endorsed by the Review Panel (Section 5.0 below).

### Extending asset life – Capital Maintenance

Whilst our asset owner, Operations, addresses normal maintenance works such as routine vegetation management, our Capital Maintenance programme addresses and counters the degradation of component parts of our ageing assets. This investment programme includes major construction

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works, e.g. spillway modifications, and resolves operating shortcomings to safely extend the asset life of these complex structures. This approach avoids a progressive and ultimately major degradation of the asset.

### Improving our resilience - Emergency exercises

We hold annual in-house exercises to test our on-site plans, reinforce roles and provide learning for those responding to and managing extreme events and incidents. We work closely with “blue light” services (leads for off-site response), and recently participated in a national government flooding exercise, **Exercise Watermark**, which centred on a multiple dam failure.

### Industry engagement

Our annual meeting with the regulator helps determine how else we can cost effectively meet expectations, beyond full compliance with the Act. We work closely with other leading owners e.g. Scottish and Southern Energy recently participated in our annual training forum and Tasmanian Hydro attended a knowledge sharing exchange into dam safety and application of Portfolio Risk Assessment techniques. We also actively participate in national and international Research and Development (R&D) projects, serving on working parties and industry review groups. We use this learning to further inform our strategic approach and structure our training forums.

## MANAGING RISK – OUR APPROACH

### Structure of Approach

STW is split into three operating areas with an SE located in area. All supervision is carried out in-house. This strategy provides SEs with the opportunity to acquire an in-depth knowledge and history of the structures they are responsible for. It encourages a productive working relationship with both operations management and maintenance staff across the area and assures a minimum response time in the event of an incident.

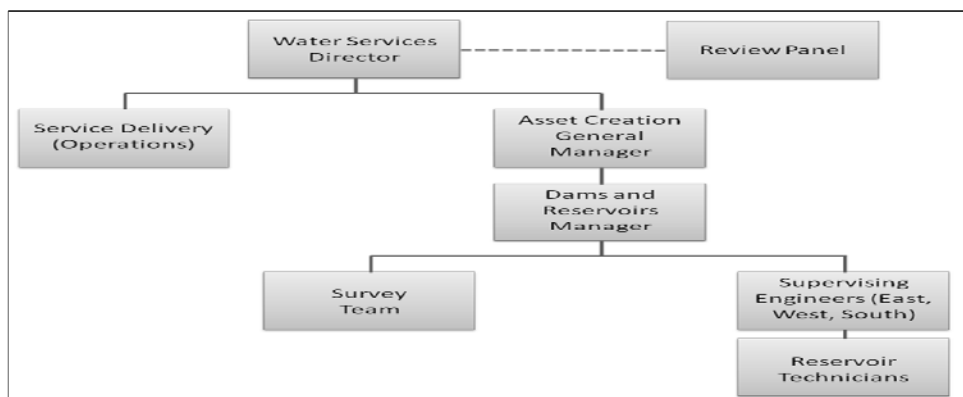


Figure 2. The Reservoir Safety Team structure and operating hierarchy

A Reservoir Technician (ResTech) supports each SE. They carry out quarterly site reviews, which include reading and servicing monitoring equipment such as piezometers, and witnessing the scheduled operation of “designated valves”. Crucially, they maintain a rapport with operations staff and ensure that maintenance works, prescribed by the SE and detailed in the Action Plan (a targeted list of actions with prescribed timescales) are progressing. With their comprehensive knowledge, they provide assured continuity when a change of SE takes place. Pride in accuracy and completeness of records is engendered by providing clear accountability.

The Lead Surveyor and his team conduct regular monitoring surveys of over 110 structures. Outputs for the SE to review include spreadsheet derived linear and vector graphs through to colour height banding plots of crests and embankments and isopachyte maps which highlight height changes in areas over time. In applying our key enablers (Figure 3) survey equipment and software has been updated to achieve seamless operation from field to office.

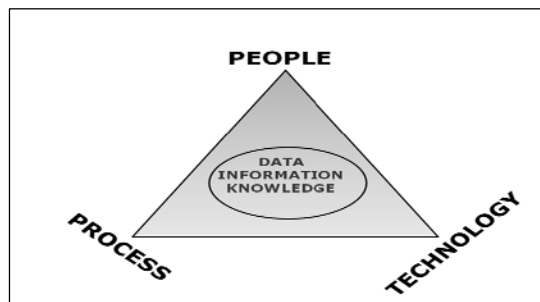


Figure 3. Key enablers to achieving our goal

A useful reminder of the value of regular monitoring is illustrated by the startling settlement recorded by Wessex Water and the need for immediate intervention at its reservoir at Sutton Bingham (Charles *et al* 2011).

As a team we also fulfil the role of “Expert Client”. We define capital solutions and manage implementation in collaboration with our supply chain (consultants and contractors), optimising the provision and operation of assets over their entire life cycle by balancing cost, risk and performance. We are responsible for managing the delivery of a £70m AMP 5 programme of works, which includes all planned changes to our reservoirs.

We readily apply our knowledge and learning from previous incidents. The Ogston incident (Hughes *et al* 2004) provides an excellent illustration currently applicable during our extensive programme of valve refurbishment and replacement. A decade ago, following a value engineering exercise, an inappropriate, cheaper valve was installed at Ogston Reservoir. During first operation this butterfly valve slammed shut leading to the catastrophic failure of the complex arrangement of drawoff pipe work in the valve tower.

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### People Plan

We used a “transformation map” (a process to identify the steps to achieve a vision) to develop our team strategy, define goals and crucially develop our ***People Plan***. This overarching plan includes a Capacity Plan, developed from a competency matrix, a work programmes, resource needs and workforce planning through to a Succession Plan that factors in team demographics and projected impacts of business change. Development plans for team members are derived from the ***People Plan***, with specialist training led by Review Panel members, leading IEs and key industry suppliers.

Recognising it can take an experienced chartered engineer three to five years to qualify as a SE a programme of training four in-house engineers is underway. A further three ResTechs are also being trained. Trainees are appointed to fulfil surrogate roles on non-statutory structures (SRRs and sludge lagoons) in order to develop their understanding and provide practical experience. Qualified SEs and ResTechs are appointed as mentors to support and appraise trainees, with progress regularly reviewed at the Comm Cell.

In strategically aligning the team to achieve value for money, sustainability, safety and reliability, we are investing in their development. Our well-trained staff have a clear understanding of their roles and responsibilities, and are empowered with the authority to do their job. Career development and job fulfilment is achieved by entrusting the team with joint responsibility for both reservoir safety management and capital programme delivery (the latter also assures a targeted recovery of 40% of costs).

### Data storage

Access to explicit knowledge, namely our comprehensive bank of reports, analyses and routine data on our reservoirs is facilitated through our data storage system AQUIR. Parts of our ageing infrastructure date from early Victorian times where few or no records exist. This database is also crucial for emergency response; for example when a standby SE, perhaps not fully familiar with the site, may be required to lead in an emergency.

### Risk reduction

The singularly most important factor in reducing risk on these massive monoliths of locally won materials is regular, routine monitoring and surveillance. Of the many “near miss” incidents over the years, perhaps the most illustrative is Rivington (Charles *et al* 2011), where early detection of deterioration of the dam by an operator provided a crucial window within which to conduct an emergency draw down of the reservoir, avoiding catastrophic failure. We have risk assessed all our reservoirs, defined a frequency of monitoring, and our operations staff check key elements

defined in a checklist accordingly. Operational visits can range from weekly monitoring on concrete structures to tri-weekly monitoring for earth embankment dams. This critical link in the safety cycle is featured below.

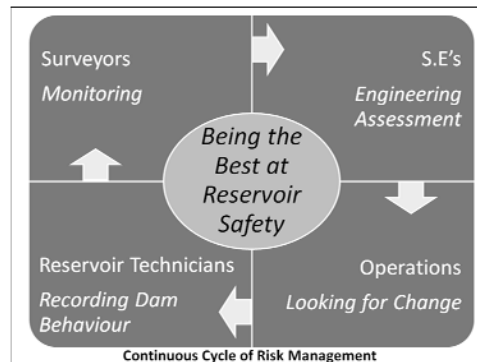


Figure 4. STW's Supervision and Surveillance Regime

### SAFER, BETTER, FASTER

In signalling its ambitious vision, STW created a methodology for continuous performance improvement by learning from a collaborative partnership, comprising an experienced consultant (Egremont) and effective practitioner (Unipart). **Safer, Better, Faster** draws together research outcomes, applied learning and NLP techniques together with tools for root cause analysis and problem solving supported by behavioural interventions. In striving to remove inefficiency, all processes continue to be reviewed. For example, a leaner process for presentation of survey results was developed which has also delivered improved repeatability in survey results.

The most common learning point following post-incident analysis and organisational change is the need to improve communication. STW analysed the challenges it needed to overcome to transform the organisation to achieve its ambitious goal. Key to delivery of the changes were behavioural expectations, and the Communication Cell (**Comm Cell**) was developed. This builds on the compelling evidence that to improve effectiveness and productivity employee engagement through providing opportunity for employee voice, reinforcing strategic narrative and values has to be part of the routine way of working.

### COMMUNICATION IS KEY

Comm cells are a form of visual management and are displayed throughout the workplace. They are used by all functions of the business, at all levels. They provide the focus for regular and penetrating analysis of both individual and team progress and performance. In providing this overt visual representation, they also provide the opportunity to shape our organisational culture, reinforcing values while enabling teams to drive continuous and permanent improvement. Ideas and lessons are shared across the business and embedded into our standards. As a team we have

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established two Comm Cells. The Reservoir Safety Comm Cell comprises 25 sheets that include:

- Skills Matrix – a running check on empanelment, first aid training etc.
- Safety Review – a check on health and safety issues, review of undesired circumstances, and embedding learning from near miss and accidents.
- Annual SE inspection tracker – collating progress of survey, monitoring and reporting for all 58 reservoirs subject to the Act and a further 62 structures (including major aqueducts and waste water structures).
- Audit Tracker\* – highlighting progress of the annual, independent audit of 10% of SE statements and resolution of issues raised.
- Progress on resolution of maintenance and improvement items required by the SE and detailed in the Action Plan Tracker\*\* (resolution of these items also form performance measures for the asset owner).
- Capacity Planning – monitoring training for aspiring SEs and ResTechs.
- Operations Up-skilling – progress on training and re-qualification. Development of new training materials, e-learning and assessments.
- Emergency Planning – upgrading of Emergency Plans, organisation of and participation in both LRF and in-house led exercises.
- Problem Solving – root cause analysis, a summary of three Cs (Cause, Concern, Countermeasure) and seven Ss (a seven step process designed for solving more complex problems) and embedding lessons learned.

\*Rigorous cross checks are conducted on reports, statements and surveys to avoid mistakes and complacency. Monitoring results are scrutinised. Randomly selected structures are re-surveyed. Our culture of continual improvement by applying Kaizen principles is reinforced by team feedback.

\*\*Our Codified Procedures prescribe the way in which asset owners manage and resource reservoir operation and maintenance, e.g. routine surveillance.

Intense debate, penetrating reviews and contrasting appropriate humour are a regular feature at our Comm Cell assuring full engagement. Performance is summarised on a Balanced Score Card, informing group key performance indicators and establishing next steps for continuous improvement. This is a further illustration of employee engagement with each team member fully aware their contribution toward our goal of “being the best”.





Figure 5. A typical Comms Cell in progress with team members motivated by the ability to drive progress and improve efficiency by eliminating waste.

#### OPERATOR TRAINING AND DEVELOPMENT

While the industry has developed sophisticated processes for risk management, it is crucial to ensure that established controls are regularly maintained by properly trained operators. The interrelationship between components of risk management and assessment (Bowles 1999) has been adapted to emphasise human interaction and dependency at every stage.



Figure 6. Risk management process underpinned throughout by people

Formal procedures, known as “Codified Procedures”, establish the formal requirements for management and supervision of STW reservoirs by our Operations teams. To support this crucial role, we have established an assessed training programme for operational functions employing reservoirs: water production (raw water impounding), water distribution (service reservoirs) and waste water (flood attenuation and waste/sludge storage). This aligns with our newly installed financial and workforce planning software (SAP). Training for operators working in this discretionary effort zone is delivered by a SE, supported by an Operators’ Handbook and planned e-learning package. Examples of failure modes are illustrated, together with diagrams and photos detailing what to look for. If a reminder were required, (Shannon 2010), cites numerous examples of dam failure, vividly demonstrating that the initial signs/triggers are most frequently detected by those with day-to-day operational responsibility.

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Where operating roles have been outsourced or contracted in, we also provide surveillance training. This has already paid dividends, with seepage detected by a ground works contractor working in woodland some distance from an earth embankment dam. Continued vigilance is the key to effectively managing these assets into the future, appreciating that they are often working well beyond their original design life.

We are also acutely aware that ownership and responsibility cannot be established by formal procedures and training alone. In seeking to establish further ownership by our operating teams we recently held a joint workshop where we each explored what we knew and essentially did not know about our reservoir infrastructure. Differing perspectives highlighted gaps in the management of our critical infrastructure which were actioned accordingly.

### EXTERNAL ASSESSMENT - RESERVOIR REVIEW PANEL

Following failure of Carsington Reservoir during construction in 1984, a government inquiry recommended establishing a reservoir Review Panel. The panel's role was to advise on all aspects of the reconstruction of the dam. STW has retained the panel to provide expert advice and independent oversight of reservoir safety for all its reservoirs. The panel currently comprises two eminent dam engineers who report directly to the Director of Water Services, providing an essential strand of corporate governance.

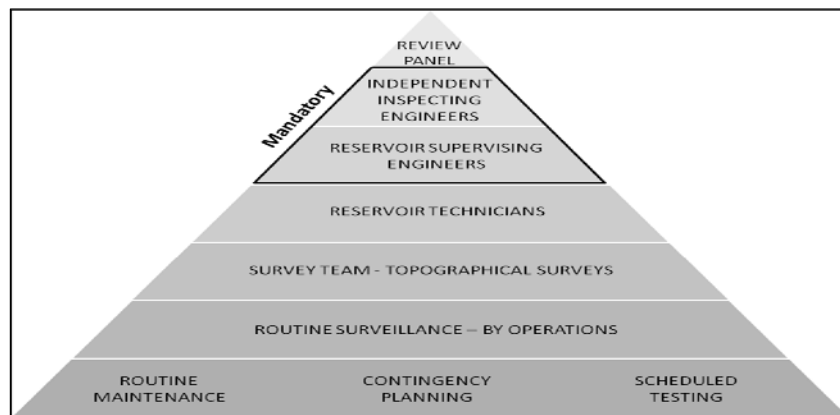


Figure 7. Hierarchy of Inspection Regime and Management

In a recent report, the panel stated that it was impressed with the standard of management of STW's reservoirs and considered that our strategy to manage forthcoming legislative changes had been appropriately designed with timely implementation. Retention of this expert panel is an illustration of our ambition to lead in our field and further achieve investor confidence.

### LEARNING FROM EXPERIENCE

Prominent failures focus attention on lessons learned. The challenge is to embed the learning to avoid repetition of the incident. For Ameren, the owner and operators of Taum Sauk reservoir, Missouri, USA, the impact of

the incident went far beyond dam re-construction, litigation etc. Following investigation, the regulator FERC viewed operating practices to be “beyond imprudent”, verging on “reckless”, requiring Ameren to produce a Dam Safety Plan. Extending beyond the definition of roles and responsibilities, this strategic document defines Quality Assurance (QA) processes and crucially behavioural expectations through employee engagement.

Learning is continually refreshed and lessons learned applied via our operating procedures. For example, lessons from the Kolontar incident in October 2010, in Hungary, have been used to remind waste water managers of the potential vulnerability of sludge lagoons. This is further reinforced by the TVA Kingston Fly Ash Pond failure in 2008. We strive to ensure that those that operate and maintain reservoirs are ever vigilant illustrating what can go wrong by applying lessons learned from incidents. We firmly support the Environment Agency’s voluntary post-incident reporting process (Hope *et al* 2010).

#### RESPONDING TO REGULATORY CHANGE

Following amendment of the Act, a further 47 of our reservoirs are likely to be regulated. We have already commissioned a programme of inspection of these Small Raised Reservoirs (SRRs). Business plans have been developed to account for the additional workload and impact on resources. Where these structures have not been constructed or maintained in accordance with the rigours of the Act steps are being taken to upgrade them.

Ageing, elevated, sewage sludge lagoons, on occasion constructed from industrial waste, pose a significant risk as the tip failure at Deighton, Yorkshire in 1992 (Claydon *et al* 1997) proved. In learning from this incident, we are adopting a proactive approach to reduce the risk of failure of sludge lagoons by inspecting, surveying and assessing these non-engineered structures. While not subject to reservoir safety legislation, the catastrophic failure of a sludge lagoon would have a major impact on our reputation as well as attracting punitive remedial costs and litigation.

#### RESPONDING TO THE GROWING SKILLS SHORTAGE

The engineering industry as a whole has been confronted by a growing skills shortage, with the body of knowledge shrinking as experts retire. This decline has been mirrored in our industry, with a fall in the number of panel engineers (Hope 2006), contrasted by a projected increasing workload following regulatory change. The British Dam Society has developed curriculum-linked lesson plans and presentations for schools to help raise interest in dams at an early age. We too actively engage with universities, are re-establishing a graduate recruitment programme and have identified a development position in the Reservoirs Team. Engaging with students provides opportunity to understand the needs and expectations of different

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generations (Generation X, Y etc.) to better shape career opportunities. Our new mentoring programme assures the development of promising engineers.

### RETAINING KNOWLEDGE

#### Managing the impacts of constant change

Since the privatisation of water undertakings in England and Wales in 1989, the industry has been subject to five yearly programmes of investment and re-structuring. Through these many cycles of organisational change, knowledge can be lost. In the future, employees are likely to be more transitory as employment conditions change. As a learning organisation, we have sought to develop a strategy to transfer, retain and manage knowledge. This is particularly important when managing our ageing infrastructure.

#### Implementation of capital works

Standard design manuals housing best practice provide our benchmark for supply chain partners. Documents are controlled and accessible to all, incorporating a feedback route. Our governance process ensures that change management is overseen. Alerts termed “watch outs” are communicated via our bulletins (innovations and lessons learned) and reinforced via communities of practice using online forums. These are all held on our knowledge management hub. Lunch and learn sessions and more formal training is undertaken allowing tacit knowledge, rooted in individual’s experience, to be disseminated to new users.

#### Reservoir Safety

Explicit knowledge, all reservoir records and reports are held on our database (AQUIR). Learning is embedded through mandatory procedures and manuals, with bulletins issued to reinforce good practice, often by citing examples. Tacit knowledge, is captured as part of our training programmes, during inspections and reviews. As well as mentoring trainees, each qualified SE and ResTech is assigned a “buddy” within the team to further help knowledge transfer. Through peer review, this also provides an essential QA role. With set business outcomes formalised through annual objectives, regular appraisals provide the opportunity to review progress and provide direction. Full participation at the monthly Comm Cell provides a further opportunity for learning to be captured and refreshed, exploiting both explicit and tacit knowledge transfer. The SECI model provides a useful framework to understand the process behind the creation of new knowledge for workplace applications.

### CONCLUSION

As one of the country's leading reservoir owners, we remain resolute in our commitment to effectively manage the risks posed by these large, elevated bodies of water. Through providing employee voice and engagement,

reinforcing our strategic narrative and rigorously implementing our *People Plan* we will ensure that we are at the forefront of our industry.

#### ACKNOWLEDGEMENTS

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