DISRUPTORS AND MEGATRENDS; IDENTIFYING EXTERNAL FACTORS FOR THE MELBOURNE SEWERAGE STRATEGY 2018

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ABSTRACT

The Melbourne Sewerage Strategy is a 50 year strategy for sewerage management in Melbourne. Identification of potential disruptors that could significantly alter the wastewater system is an important input to the strategy. To develop this input, consideration was given to global 'megatrends' such as climate change, resource scarcity, new technologies and rising inequity. The project scanned futures from a range of sectors including: urban water, cities, agriculture, energy, transport and communications. Innovative thinking was stimulated through futures methods. During two workshops industry practitioners identified novel factors, prioritised disruptors and assessed their possible manifestation as risks or opportunities for the system.

INTRODUCTION

The Melbourne water utilities' Sewerage Strategy for 2018 (the Strategy) considers the development of Melbourne's wastewater system over the coming 50 years, including its continuing and changing roles in the region. One of several work packages undertaken to provide input to the strategy was to identify the potential factors in the external environment that are likely to cause disruption or require changes to the current approach to providing sewerage services.

The Institute for Sustainable Futures (ISF), part of the University of Technology Sydney, partnered with the project steering group to facilitate a series of discussions to identify and prioritise potential external factors affecting the sewerage system. The study aimed to cast a wide net in exploring potentially significant influences on the Melbourne sewerage system in the future and to consider how they could specifically affect Melbourne's sewerage system, either positively or negatively.

In recent years, there has been much interest in identifying the global forces of change that will impact the way we live in the future. Key influences have been grouped together as Megatrends that may drive major change in the future. These Megatrends could have far-reaching effects upon societies, industries, economies and the environment.

The influences, which make up Megatrends, can also be described as 'disruptors' or 'external factors'. Disruptors are commonly characterised as being either 'trends' or 'shocks', with trends indicating a gradual change over time, while shocks are likely to occur suddenly and unpredictably.

The first step in this study was a targeted review of the literature to reveal major trends and potential disruptors that might be expected to affect the future in coming decades. Reports by CSIRO (2016), the OECD and Danish Agency for Science, Technology and Innovation organisation (2016), KPMG (2014), EY (2015) and PwC (2016) each present different sets of global Megatrends made up of potentially significant influences. From these various predictions of major global drives of future change, seven Megatrends with the potential to significantly impact the water industry were synthesised.

The Megatrends formed the basis for a Horizon scan of potential influences on the water industry and associated sectors. This collation of existing knowledge was then built on through futures methods not usually applied in the water industry.

The project included two workshops with water industry practitioners and stakeholders. In the first, participants identified future influences that may create significant changes (or require significant changes to be made) specific to the Melbourne sewerage system. This draws on the group's extensive knowledge of the local context. With input from stakeholders from outside the water sector, the group also considered a range of possible futures in other sectors that could become significant for the sewerage system over the next 50 years.

A synthesis process with the outputs from the first workshop established a set of 12 key disruptors. In the second workshop the 12 disruptors were assessed for their potential to create either risks

and/or opportunities for the sewerage system and were prioritised for their impact on the sewerage system.

MELBOURNE SEWERAGE STRATEGY

Water for Victoria (DELWP, 2016) outlines the water management opportunities and challenges facing Victoria over the coming decades. Action 5.4 outlines actions to make the most of our investment in wastewater. A key action under 5.4 is the development of a long-term bulk sewerage strategy by Melbourne Water, considering climate change and population growth scenarios.

The purpose of the Strategy is to provide an overarching vision and direction for sewerage management in greater Melbourne over the next 50 years, and has been undertaken as a collaborative industry project, with Melbourne Water, Yarra Valley Water, City West Water, South East Water and Western Water.

The Strategy's vision is "Creating a resilient, adaptable system that supports healthy, thriving communities and a liveable, flourishing environment". In developing the Strategy it is important to consider the way that the sewerage system will support Melbourne in the future. Identifying and exploring potential disruptors can help ensure the system continues to be resilient.

METHODOLOGY/ PROCESS

The study progressed with the following steps:

1) Collation of global megatrends and a horizon scan of futures for urban water and related sectors. This involved expert interviews and a review of literature on global futures and futures thinking for urban water and related sectors, including: cities, energy, materials, communications and digital technologies, food systems, artificial intelligence and robotics, medical, infectious diseases and pharmaceuticals. The document review also considered previous work on urban water futures include recent reports by ISF (Mukheibir and Howe, 2015, and Turner and White, 2017)

2) First workshop, with water industry practitioners and various external stakeholders, to review factors identified in the horizon scan and generate novel external factors through futures methods, including adapting the futures triangle described by Inayatullah (2008). The method considered the:
    - "pull" of the future, with drivers based on seven identified megatrends,
    - "push" of the present, reflecting on new approaches currently being trialed in the water industry
    - "weights" of the past, focused around the existing centralised systems and assocated practices

3) Second workshop, with a focus on water industry practitioners from across the water authorities, to assess how 12 key external factors (synthesised after workshop 1) could influence the sewerage system. This included conducting an assessment of risks and opportunities for the three identified system domains, the:
    i. physical infrastructure system
    ii. institutions or 'governance' that manage the system
    iii. customers of the system

Groups thinking from the perspective of each of the three system domains were asked to prioritise which disruptors they saw as being the most critical to explore and understand in the next five years, through posing the question: "*which disruptors would you prioritise spending on?*". The three groups were also asked to: "*identify the disruptor that in your view is unlikely but would cause the most chaos if it eventuated*" - i.e. nominate a 'dark horse'. These were not necessarily considered priority risks now but have the potential to become major agents of change further into the future.

TWELVE KEY POTENTIAL DISRUTORS

The set of 12 key potential disruptors for the Melbourne sewerage system were synthesised from the results of the Horizon scan (including the global megatrends) and the outcomes of the first practitioner workshop. All 12 disruptors are illustrated in an infographic, Figure 1 (at end of the paper). The anticipated linkages between disruptors and which domains might be most impacted are also illustrated in the figure. A short description of each of the 12 disruptors and follows, together with a summary of how the disruptor may have a significant influence the sewerage system.

Circular Economy

In the future, linear models of sanitation may be replaced by circular models where 'waste' as a concept does not exist, but rather is seen as a resource to be recovered.

Potential influence on sewerage system:

- The shift from a linear to a closed-loop system will require re-visioning products and business models with potential for new service offering from utilities
- Trade waste revolution; waste becomes resources for recovery
- New revenue streams to improve utility economic resilience including:
    - Energy generated from organic waste and sludge
    - Energy captured from heat in sewers

    - Global shortage makes Phosphorus recover technologies and urine separation viable
- Drives collaboration and partnership with other sectors
- Utilities may need to deal with low-grade sewage effluent after valuable resources are stripped out up-stream.

Cyber-attack
With an increased reliance on automation and remote operations of infrastructure, wastewater infrastructure is at risk of cyber-attacks, which could have environment and public health impacts. Cyber-hacking could also see customer data put at risk, especially with additional information being collected through digital metering.

Potential influence on sewerage system:
- Cyber-attacks on the system could see sewer pumps and treatment facilities targeted, causing sewage overflows threatening human health and ecosystems
- Ransoms issued to avoid threats of sabotage and disruption
- Corrupted data leads to poor planning or operational decisions
- Cyber-hacking could see customer data and information deleted, corrupted, or used for nefarious purposes, such as published in the public domain
- Customers could be misled to deposit bill payments into incorrect accounts
- With the roll out of digital metering, large volumes of customer data will be collected, which could be vulnerable. Digital meters used for customer feedback may become avenues for cyber phishing
- Public confidence in utilities damaged due to data breaches.

New sewer and treatment technologies
Technological (hardware) advances may change the way sewers are planned, where treatment facilities are located and how wastewater is reused.

Potential influence on sewerage system:
- Alternative servicing can be more efficient than conventional systems
- Potential for lower impacts on the environment and for increased recycling
- Small package sewage treatment plants can be distributed across the network making water recycling common in new precincts
- Pressure/vacuum sewers avoid overflow and reduce volumes from rain events. They have reduced pipe size and can be run inside old gravity sewers
- Technological advances result in:
    - Reduced sludge production and easier resource recovery
    - Bioengineering to digest plastic waste and kill pathogens
    - Community acceptance of potable reuse.

Erosion of social cohesion
Rapid changes in the makeup of society in Australia's mega cities may see an erosion of social cohesion with increased inequity and more individualism. Accepted cultural norms of providing for the public good and egalitarianism may be lost, thereby undermining "postage stamp pricing" and the cross-subsidisation of new centralised infrastructure.

Potential influence on sewerage system:
- "Each person for themselves" attitude results in a misuse of sewerage services with disposal of dangerous or damaging materials
- This attitude also leads to funding being limited for the 'public good' services of the sewerage system (protecting public health and the environment)
- Wealthy customers could choose to abandon the centralised system and look after their own services with private operators. This maybe because better services are offered by the private sector or escalating capital and maintenance costs of the centralised system drive customers to alternatives
- Postage stamp pricing comes under pressure if wealthy customers are no longer willing to subsidise poorer customers or existing users will not pay for growth in greenfield areas
- "Fake news" or social media drives issues that unfairly target utilities, impact reputations and distort decision making.

Internet of Things
The Internet of Things will integrate smart metering, sensors and monitoring to derive big data and provide further automation and insights for operators and customers via digital communication.

Potential influence on sewerage system:
- Digital communications become embedded in all aspects of daily life, including utility services
- Proliferations of monitoring, with sensors and real-time testing across the system
- Optimisation of networks with monitoring and data analytics
- Potential reduction in costs through big data and machine learning
- Automation of asset management and operations leads to fewer failures or overflows
- Decision-making become opaque as more decisions left to artificial intelligence
- Data systems become critical but are vulnerable to misuse or data corruption
- Risks to individual's privacy exist with large scale data collection across system.

Changed ownership models
While not on the current agenda, a conceivable disruption could be a change in ownership model for water utilities. This would see new owners (either private corporations, collectives or individuals) owning all or parts of the sewerage system, makes regulating efficient servicing outcomes challenging.

Potential influence on sewerage system:
- Government decides to privatise existing sewerage system or part thereof
- Private sector services areas of new growth
- Risk that privatised utilities run existing assets to failure to minimise costs, creating more failures and poor environmental and public health outcomes
- Pressure on bills as costs rise to meet private sector rates of return
- Increasing bills or poor service drives richer customers to implement their own private sewerage services.
- Only the poor are left on the existing system
- The cost of existing centralised assets in terms of debt servicing and maintenance becomes more difficult to manage as customers are lost
- Equity in levels of service strained
- 'Retailer or supplier of last resort' provisions become a concern for remaining public utilities
- The Melbourne Sewerage Strategy of the future is framed as a 'statement of opportunities' for private sector investment

New microbial diseases
Anti-microbial resistant and new pathogens may emerge, creating public health risks from 'superbugs' and pandemics

Potential influence on sewerage system:
- International travel facilitates the transport and introduction of new diseases
- Climate change may give rise to new infectious diseases
- Recycled water systems need additional barriers to counter new health risks. Risks limit potential recycling options
- There are implications for closed-loop systems where wastewater is used for irrigating and fertilising food crops.
- Water utilities need to manage vulnerabilities to bio-terrorism
- Increased costs for more monitoring and treatment.

Climate change
Increased frequency and severity of extreme events that disrupt services and impact public health and the environment. Trends of increasing temperature, decreased rainfall and rising sea level also place pressure on sewerage systems.

Potential influence on sewerage system:
- Increased damage to system and impacts on public and environmental health due to disasters
- Low lying areas become increasingly hard to service
- Hotter ambient temperatures can create problems with wastewater treatment, increase toxic gas production in sewers and eutrophication in waterbodies
- Relocation of sewerage infrastructure to avoid sea level rise and storm surges
- Design specification for sewage system must change to increase robustness to heat, storm, fire damage
- Higher demand for recycled water for heat mitigation and liveability
- Energy source for system moves towards carbon neutrality
- Opportunity for carbon sequestration in wetland and water bodies

Cascading systemic risk
A disruption event in a major infrastructure system, external to the wastewater system, could trigger a series of major disruption events across other infrastructure systems, and the wastewater system.

Potential influence on sewerage system:
- As mega cities develop, the risk of cascading failure grows i.e. an event in one major infrastructure/economic system acts triggers a series of failures across systems
- Infrastructure systems have tended to become more interdependent as technologies advance
- New vulnerabilities introduced unknowingly due to systems interdependence
- Systems optimised for least cost and efficiency, becomes brittle with a high risk of failure due to lack of redundancy
- Trigger events may be deliberate, as in a terrorist attack, the result of natural disasters or a failure of another infrastructure system (such as energy or water) or economic (banking, billing, financing) system
- Loss of staff experienced in system operations reduces capacity to handle crises.

Change in sewage composition
Changes in the behaviours of residents, their diet, household appliances and their water use, as well as the appearance of novel chemicals, will impact sewage characteristics that the wastewater system will need to manage.

Potential influence on sewerage system:
- Materials from households, include fibres from clothes, personal care products and pharmaceuticals are already a significant challenge for wastewater management
- Water efficiency has reduced wastewater volumes and is likely reduce further

- Shifts away from manufacturing reduce volumes of trade waste
- Increased insinkerator use introduces a new organic waste loads to sewers
- Changes may strain current treatment facilities and/or cause blockages in sewers networks
- Planning for treatment upgrades not timely if there is a poor understanding of changing waste-steams
- Introduction of novel material to waste steam may result in failure to protect environment or public health
- Additional organic load from food waste would provide utilities with the opportunity for biogas generation, and increases corrosion of sewers using current materials.
- Ownership of the sewage may become an issue if waste is viewed as a valuable resource.

Power shift to communities and customers
In the future, citizens may demand that decision-making shifts towards civic and local models of governance, in conjunction with customers being able to take greater control over the sewerage services they require.

Potential influence on sewerage system:
- Aging centralised asset base with escalating maintenance and renewal costs drives individuals and groups to localised alternatives (as has occurred in the energy sector with renewables)
- Customers expecting to be provided with personalised services
- Customers empowered by smart technologies to take control and responsibility for their use of water and sewerage services
- Community expectation of 'their' sewerage system are transformed to meeting aspirations for greening, sustainability and amenity (as well as public health)
- Private sector grows to meet new service demands, "cherry-picks" cheap sites to service and wealthy customers. Utilities left with stranded centralised assets
- Loss of cohesive approach sees the erosion of universal service obligations as well as public health and environmental objectives
- Private small systems fail and cause environmental and public health impacts. Water utilities are expected to be suppliers of last resort

Changes to urban form
Continued urban growth and densification will place increased demand on sewerage systems. Future drivers of the urban form are unclear as new transport systems will revolutionise mobility in cities.

Potential influence on sewerage system:
- Higher density makes use of existing system capacity - lower bills or improved service quality. More customers per hectare mean a lower average cost
- Opportunities for integrated water servicing in new areas
- Increased density means solid waste collection is difficult. This promotes food waste disposal to sewer as a solution which is good for energy generation but may exacerbate sewer corrosion.
- Sewer mining and alternative serving becomes viable in new precincts, further changing the sewage composition
- Location of agricultural land close to recycled water sources allows greater recycled water reuse in agriculture
- But sprawl (with Autonomous Vehicles) would increase average cost of servicing placing pressure on the cross subsidy to outer suburbs

RESULTS OF PRELIMINARY PRIORITISATION

In the second workshop the 12 disruptors were assessed for their potential to create both risks and opportunities for the sewerage system and those with the greatest potential impact on three domains were identified. The results of the preliminary prioritisation are summaries in table 1 below.

Table 1 Prioritised risks, opportunities and "Dark horses" across all disruptors

Disruptors	**Domains**		
	Physical infra.	Institutions Governance	Customers
Circular Economy		**Opp.**	
Cyber-attack			**Risk**
New sewer & treatment technologies	**Opp.**		
Erosion of social cohesion			
Internet of things			
Changed ownership models			
New microbial diseases			
Climate change	**Risk**		**Risk**
Cascading systemic risk			
Change in sewage composition			
Power shift – communities & customers	**Risk**	**Risk**	**Opp.**
Changes to urban form	**Opp.**		

In Table 1, the high potential impact risks are in red and opportunities are in purple. The possible 'dark horse' are also indicated.

The prioritisation process identified which disruptors workshop participants thought should be prepared for (as either risks or opportunities) in the next five years and which were possible dark horses. Interestingly, the prioritisation showed some differences in perceived risks and opportunities from the perspective of the three domains (the Physical Infrastructure; the Institutional and Governance; and the Customers).

The top disruptors to understand and explore further due to their potential to create risks were: *climate change*, *cyber-attack*, and a *power shift to communities and customers*. Each of these was ranked as a priority for at least one of the three domains. The greatest perceived opportunities, where anticipated future changes might be of benefit to the sewerage system were: *new wastewater technologies* and *changes to urban form*; a *move to circular economy models* (under resource scarcity) and; a *power shift to communities and customers*. Because the *Power shift* disruptor was ranked as both a significant opportunity and significant risk, six disruptors in total were rated as priorities. See Table 2 for and how they were assessed.

Table 2: Assessment of top six disruptors

Prioritised Disruptors	**Domains influenced and links identified**
Circular Economy	**Opportunity** in institutional domain and to lesser extent in customer domain. Links to both *New sewer and treatment technologies* and *Changes in sewage composition* disruptors
Cyber-attack	**Risk** across all domains but particularly to customers Is magnified by *Internet of things* disruptor
New sewer & treatment technologies	**Opportunity** in physical domain and dark horse from customer perspective. May facilitate *Changed ownership models, Circular Economy* and *Changes in sewage composition* disruptors
Climate change	**Risk** to both physical and customer domains. May exacerbate other disruptors including *Cascading systemic risk* and *New microbial diseases*
Power shift - communities & customers	**Opportunity** in customer domain **Risk** to both physical and institutional domains. May facilitate or exacerbate the *Erosion of social cohesion* disruptor
Changes to urban form	**Opportunity** in physical domain and a dark horse potentially impacting significantly on Institutions Governance aspects of the sewerage systems

CONCLUSION

The output of this study in the form of a prioritised list of potential disruptors, with both 'trends' and 'shocks' identified, provides a rich source of data for the development of future scenarios and for testing and guiding a strategy such as the Melbourne Sewerage Strategy.

The outputs of the study have been incorporated into scenarios that form plausible futures for the Strategy. Some of the 'shock' disruptors have also be utilised to test the outputs of the Strategy and the implementation plan to ensure the Sewerage system is sufficiently resilient and adaptable to cope with an uncertain future. The identification of disruptors will facilitate the development of adaptive pathways that aim to provide resilience to a wide variety of possible futures and a Strategy that ensures the goals for the sewerage system can be met in future.

By considering a wide variety of future potential events via the priority disruptors and future scenarios, the Melbourne Sewerage Strategy will ensure that Melbourne's sewerage system is prepared for a range of futures, and can continue to support healthy thriving communities and a liveable, flourishing environment.

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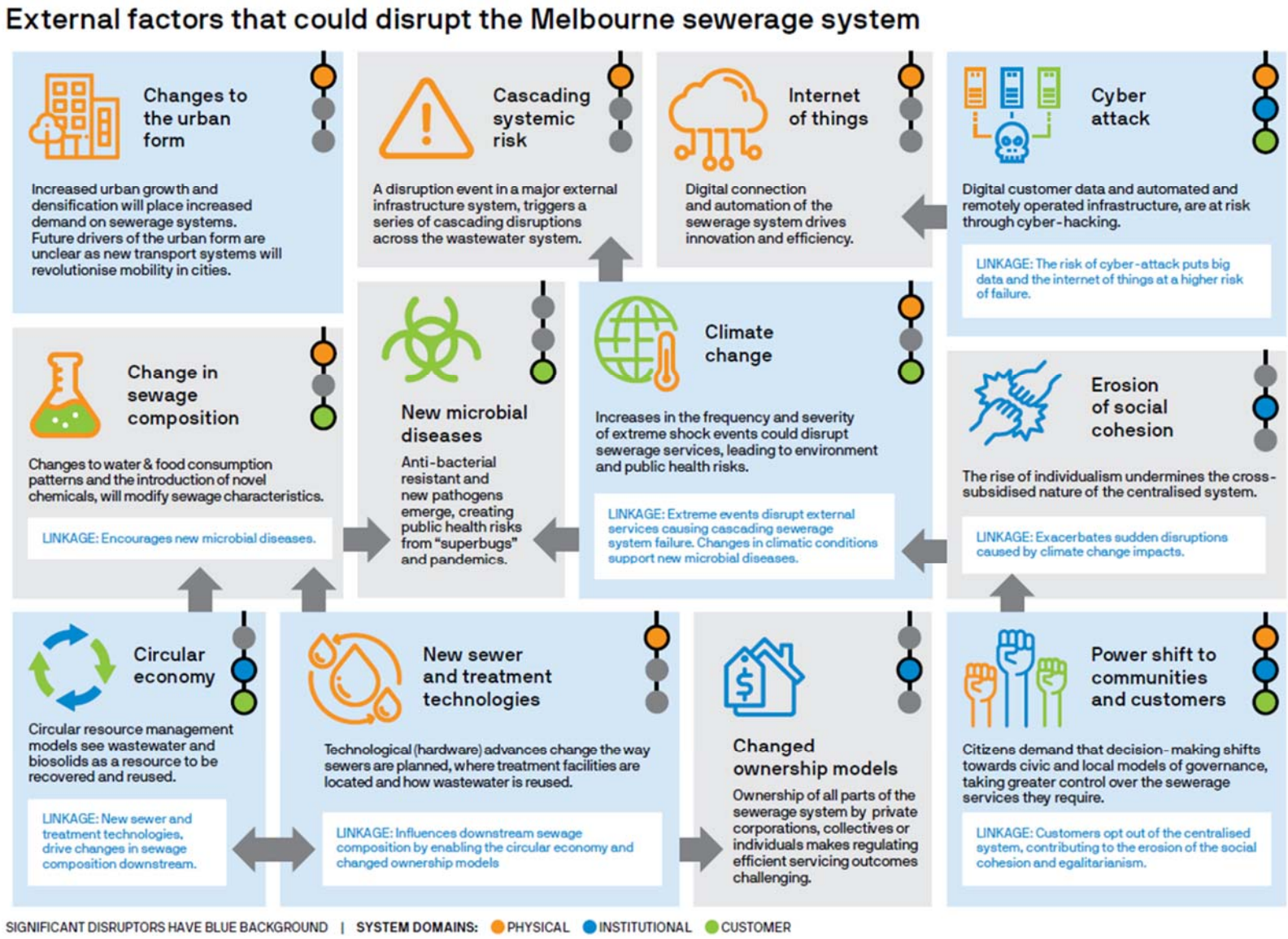

Figure 1 External factors that could disrupt the Melbourne sewerage system