WATER MINING: PLANNING AND IMPLEMENTATION ISSUES FOR A SUCCESSFUL PROJECT

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Contents

Summary

Water Mining involves extracting valuable water from the underground sewerage network, by treating raw sewage to very high standards. It can provide on-site recycled water for irrigation of public space, as well as for industrial or other non-potable uses. There are several advantages associated with adopting innovative concepts such like

water mining, when compared with conventional approaches. Water mining allows the flexibility of extracting water directly from a sewer practically anywhere, and to treat it closer to the site of its intended use.

These schemes provide opportunities for local community to be involved in managing their local water cycle. By treating additional sewage from the network, water mining facilities provide a volume stripping advantage, which can delay the need for expansion of the central sewage treatment plant and network, thereby significantly reducing a water utility's costs.

By virtue of being small in size, water mining facilities capture and reuse water within a local sewer catchment as opposed to the whole city. Water mining therefore ensures the equity, when it comes to the community's 'right to reclaimed water'.

A methodical approach to planning is important in developing a successful water mining project. Feasibility study for a water mining project must investigate and address issues such as demand/supply balance, raw sewage quality, and reclaimed water quality objectives.

The proponents should identify suitable locations close to sewerage network as well as intended point of use. Securing reclaimed water users is also critical to the success of a water mining project, one that could well be the difference between a proposed project being considered feasible or otherwise.

A variety of processes are available to treat sewage to the specified water quality targets with minimal plant footprint requirements. This chapter discusses the planning aspects of a successful water mining project.

1. Water Mining: An Introduction

The term mining in its broadest context describes the extraction of any substance of value (solid, liquid or gas) from the earth. The process of extracting valuable water from the underground sewerage network, by treating raw sewage to very high standards is called Water Mining.

It is a relatively new term, which is often used interchangeably with Sewer Mining. However, given the 'substance of value' being mined in this process is water and not sewer, describing it as sewer mining is rather ambiguous, and carries a negative connotation.

The Australian Capital Territory Electricity and Water (ACTEW), a progressive utility company in Australia is credited to have coined the term "water mining". According to Butler & McCormick (1996), ACTEW used it to describe the process of extracting raw sewage from a sewer and treating it to suitable standards for use as irrigation water for public open space.

Water mining, however can, not only provide on-site recycled water for irrigation of public space, it can also be used for industrial or other non-potable uses.

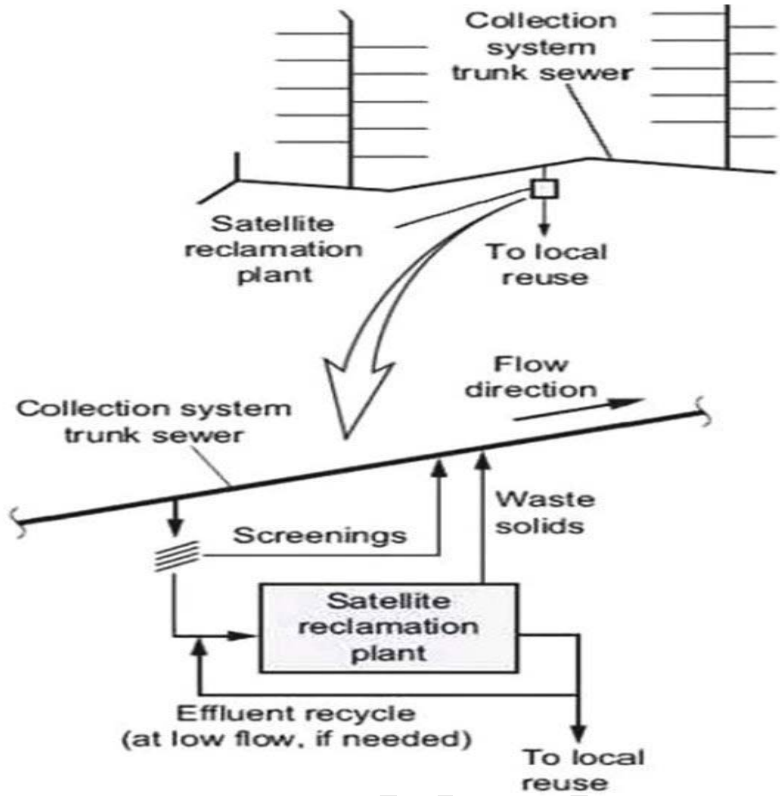


Figure 1: Schematic Illustration of Water Mining Facility

Water Mining operates independently from the conventional centralised sewer treatment facility. A small-scale treatment plant simply taps into a sewer main and extracts the effluent, processing it to a suitable standard.

Sludge or any other process residues such as filter backwash water, and plant wash-down water are returned to the sewer and treated in the usual manner at the central sewage treatment plant (Phillips, 2008). Figure 1 describes the typical set-up of a water mining scheme.

The concept of water mining has been around for well over four decades, dating back to the implementation of Whittier Narrows Water Reclamation Plant in Los Angeles County in the 1960s (Asano, 2007).

In the United States, water mining schemes are commonly described as Satellite Treatment Systems, referring to their outpost location away from the central sewage treatment plant. The location of water mining facilities closer to the point of water use has also been highlighted in some literature, giving water mining schemes the title of Point-of-sale Reuse.

2. Advantages of Water Mining

There are several advantages associated with moving away from conventional centralised sewer management systems and adopting innovative concepts such like water mining. Some of these include:

2.1 Transportation Costs Advantage

Sewer systems are designed to convey projected peak flows; consequently a response to the increasing urbanisation process has been a progressive increase in the size of interceptor sewers and tunnels.

Larger interceptor sewers and tunnels simply result in hauling larger volumes of water over significant distances to the centralised sewage treatment facilities, with major cost implications.

According to Andoh (2004), municipal wastewater is typically composed of more than 99% water and only less than 1% solids. Increasing the dry solids content of wastewater from 1% to 2% therefore effectively reduces the quantity of water that has to be conveyed by half, providing scope for major cost savings.

Water mining schemes by virtue of extracting valuable water out of the sewage stream, assist in reducing the volume of water needed to be transported to centralised facilities.

	Transmission Infrastructure, as % of Total Asset Value	Transportation Costs, as % of Industry Costs	Production Costs, as % of Industry Costs
Water	70	21	31
Electricity	50	8	50
Gas	60	14	40

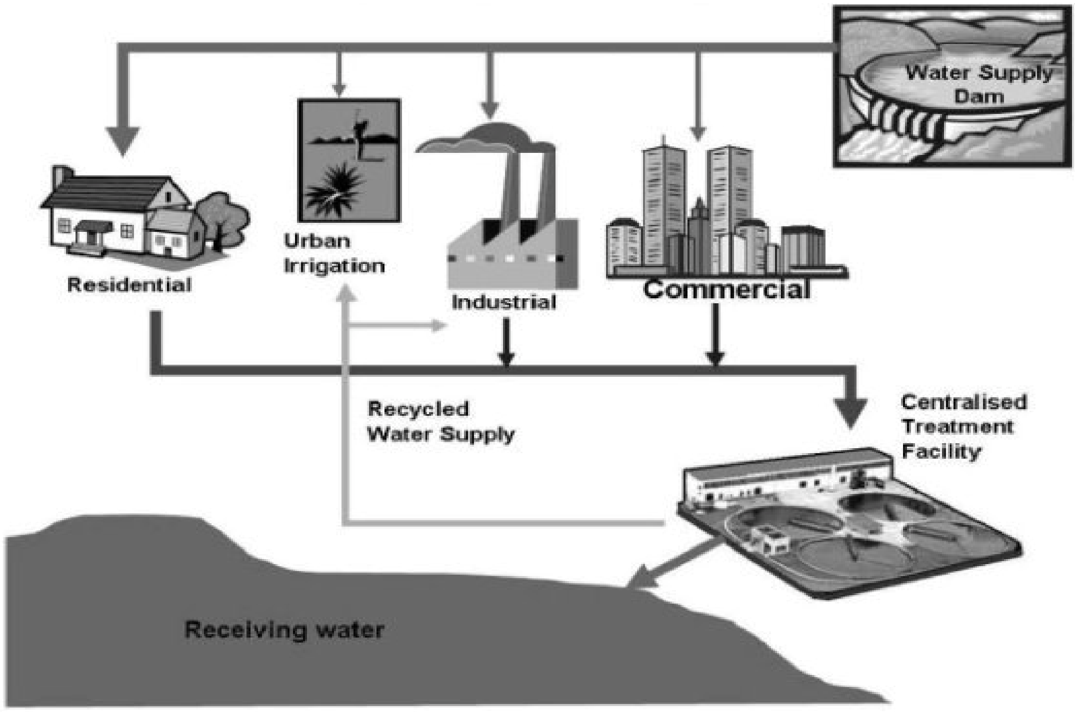
Table 1: Comparison of Transportation & Production Costs in the Utility Sector

In a comparative study of the three utility sectors, Marsden (2005), concluded that gas and electricity are expensive to produce, but relatively inexpensive to transport. Bulk water and wastewater services on the other hand, are relatively less expensive to produce than to transport.

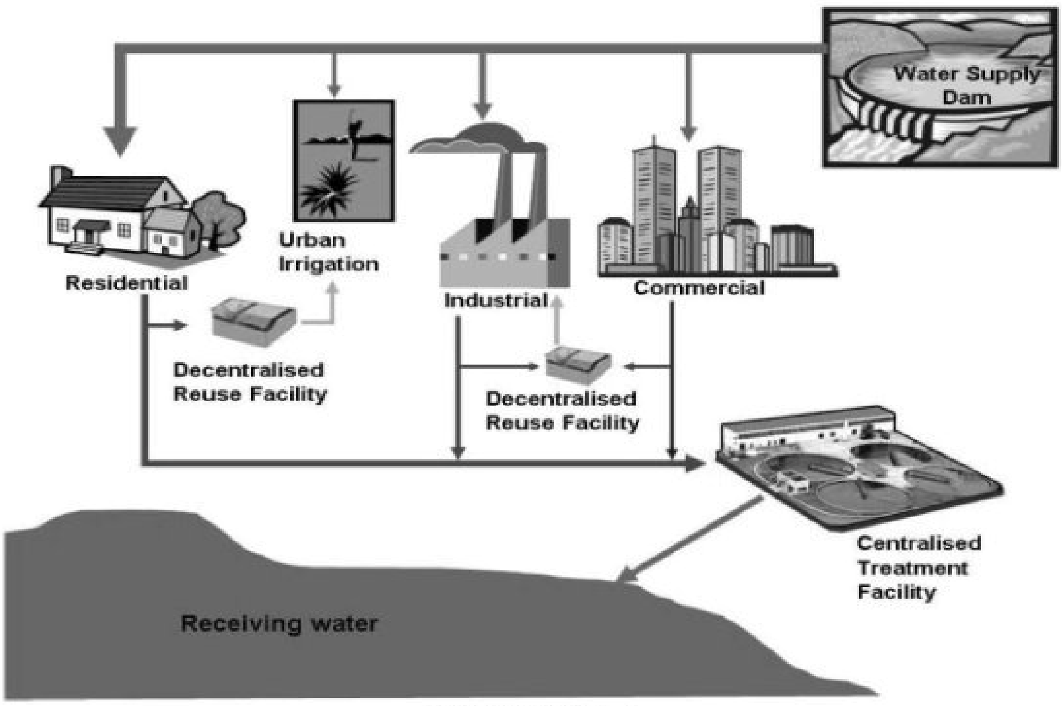
Table 1 below shows that the transportation costs in the water and wastewater sector comprise 21% of total cost compared with only 8% and 14% for electricity and gas respectively,(Marsden, 2005).

Transportation costs are also an issue when considering the supply network for treated water. One of the major difficulties in introducing water recycling in urban areas with centralised wastewater systems is the issue of long distance transport of treated water.

Water mining allows the flexibility of extracting water directly from a sewer practically anywhere, and to treat it closer to the site of its intended use (Khan, 2007). It therefore eliminates the need to transport water over long distances from centralised treatment facilities at the end of the sewer network, to where it is needed (as outlined in Figure 2).



a) Centralised Reuse



b) Sewer Mining

Figure 2: Sewer Mining Vs Centralised Reuse (Adopted from Rimer et al, 2004. Figure1)

2.2 Treatment Advantage

According to Andoh (2004), in most centralized sewerage networks large organic solids are typically discharged in water closets (WCs), at the upper reaches of the system.

These solids get degraded into smaller sized particles with age and transport through the sewerage network. This process is further assisted by ancillary components such as pumping stations that create high turbulence and shear. Consequently, wastewater at the end of an extensive sewerage network has a higher proportion of smaller sized solids, when compared with wastewater at the top end of the system.

Particle Size (microns)	Order of Size	Time Required to Settle (Inert sediments, sg = 2.65)	Time Required to Settle (Organic solids, sg = 1.2)
10000	Gravel	0.4 seconds	1.2 seconds
1000	Coarse Sand	3 seconds	9 seconds
100	Fine Sand	34 seconds	5 minutes
10	Silt	56 minutes	8 hours
1	Bacteria	4 days	32 days
0.1	Colloidal	1 year	9 years
0.01	Colloidal	> 50 years	> 50 years
0.001	Colloidal	> 50 years	> 50 years

Table 2: Settling times for various solids

As outlines in Table 2, larger organic solids found at the top end of the collection system can settle rapidly and can therefore be easily removed using sedimentation process, (Andoh, 2004). The earlier this separation is implemented in the sewerage system, the easier it is to achieve water quality benefits. Water mining facilities located in the upper reaches of sewer network provide an ideal opportunity to gain from this treatment advantage.

2.3 Security and Disaster Recovery Advantage

Given the heightened terrorism awareness in today's world, it is now well recognized that centralised water infrastructure including sewerage systems can become potential targets for terrorist activities. According to Gikas and Tchobanogloukas (2007), damage to centralised sewage treatment facilities whether caused by terrorism or by natural disasters, such as earthquakes or floods, has the potential to cause severe public health and environment impacts.

Security and disaster recovery of a centralised sewage system can be optimised by incorporating a number of water mining facilities throughout the network, thereby reducing the impact associated with such unforeseen events. A catastrophic failure of a local water mining facility would not cause the whole system to shut down; similarly failure in the central treatment facility could fall-back on the cumulatively capacity of the water mining facilities operating within the network.

2.4 Community Engagement Advantage

Sewage treatment plants in the large-scale centralised schemes often tend to be located "out-of-sight" at the end of the network, consequently providing very little scope for stakeholder involvement. Andoh (2004) suggested that centralised schemes therefore result in "an out-of-sight-out-of-mind type mentality, with no communal sense of duty of care".

Localised water mining schemes however provide opportunities for local community to be involved in managing their local water cycle. Water mining therefore raises community awareness, which in turn results in increased capacity for further beneficial reuse of the produced water in the local area.

2.5 Environmental Advantage

Water mining facilities are by design compact operations. Their small size, self containment and virtual absence of sewage odours, makes them easy to build and operate in urban environments. Furthermore, given the small size water mining schemes involve low energy usage.

Major river systems around the world are suffering over-extraction to meet increased water demand, and the need to provide environmental-flows to revive our rivers is more critical now then ever before. Water mining provides a new, reliable supply of water that can help reduce our reliance on over-stressed river systems. The reliability of water mining as a source of water becomes even more noteworthy when considering climate change induced changes to global water cycles, with potentially longer droughts. The use of reclaimed water from water mining could help to offset water shortages, and provide vital irrigation water for maintaining urban landscapes.

2.6 Volume Stripping Advantage

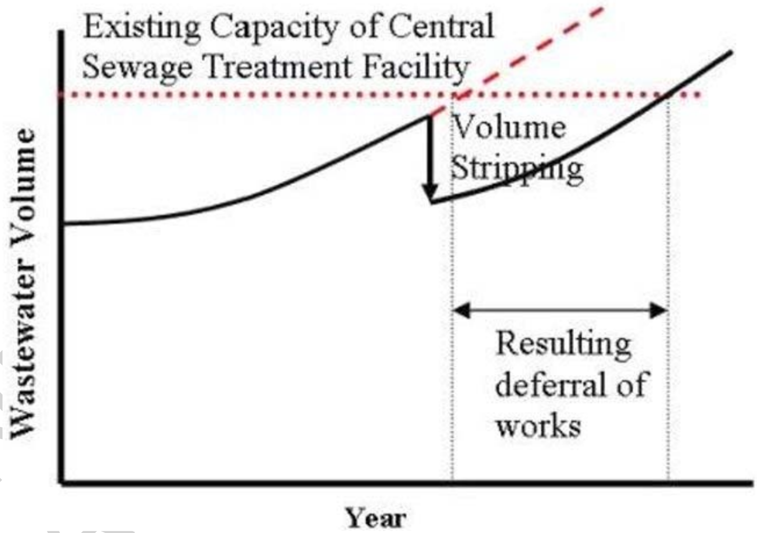


Figure 3: Volume Stripping Benefit of Water Mining Plants

Water mining facilities treat sewage to extract water for local reuse and in doing so; these facilities also take some of the load off the centralised treatment plant located at the end of the sewer network. The phenomenon can be described as Volume Stripping, when considering the volume of wastewater reaching the central facility.

Depending on the number and size of the water mining facilities, volume stripping can delay the need for expansion of the central plant. A well-planned and implemented water mining strategy is capable of quite significantly reducing a water utility's costs through avoiding or deferring the need for a major capital upgrade of the central treatment plant and associated network. This is illustrated in Figure 3 above.

According to Gikas and Tchobanogloukas (2007), benefits of avoiding or deferring expansion of existing system through volume stripping go beyond financial gains. For instance expansion of sewer networks invariably involves disruptions in the flow of traffic and other public activities, which is not viewed favorably by most municipal governments and the community.

2.7 Fit for Purpose Advantage

In 1958, the Economic and Social Council of the United Nations resolved that 'no higher quality water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade' (Cited in Okun, 200). Fifty years on, water mining now allows the water industry to take this major leap forward, by providing the opportunity to treat sewage to a standard that fits the purpose of its intended use. Water mining facilities can be tailored to the local users' requirements and thereby moving forward from the current "one size fits all" philosophy.

Based on the type and level treatment, water mining can be adapted to a wide range of community and industrial wastewater applications ranging from residential development projects to sports facilities and parks for a range of volumes. According to the US EPA (2004), water mining facilities could safely cater for various non-potable purposes including:

- Irrigation of public parks and recreation centres, including school yards and playing fields, and landscaped public areas.
- Irrigation of landscaped areas surrounding medium and high-density residential developments, general wash down, and other maintenance activities.
- Irrigation of landscaped areas surrounding commercial, office, and industrial developments.
- Irrigation of golf courses.
- Commercial uses such as vehicle washing facilities, laundry facilities, window washing, and mixing water for pesticides, herbicides, and liquid fertilizers.
- Ornamental landscape uses and decorative water features, such as public fountains, reflecting pools, and waterfalls.
- Dust control and concrete production for construction projects.
- Toilet and urinal flushing in commercial and industrial buildings.

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Bibliography

Anderson J., Adin A., Cook J., Davis C., Hultquist R., Jimenez-Cisneros B., Kennedy W., Sheikh B., and Van Der Merwe B. (2001), Climbing the Ladder: A step by step approach to International Guidelines for Water Recycling, Water Science and Technology, 43 (No) 1- 8. [This paper provides a global summary of treated water quality requirements, for water reuse.]

Andoh R. Y. (2004), Why Satellite Treatment Within Collection Systems Makes Sense, Proc. of Collection Systems 2004: Innovative Approaches to Collection Systems Management, August 8 –11, 2004, Milwaukee. [This paper highlights the wastewater treatment advantages of satellite systems.]

Butler R. and MacCormick T. (1996), Opportunities for decentralized treatment, sewer mining and effluent re-use, Desalination Journal, 106, 273-283. [This paper provides a summary of decentralized water reuse opportunities in urban water cycle context.]

Chanan A. and Ghetti I. (2006), Beverley Park Water Reclamation Project: Pioneering water reclamation in Sydney. Proceedings of IPWEA Conference, May 2006. [This paper provided a summary of Beverley Park Water Reclamation Project, Sydney's first water mining initiative.]

Davis C. K. (2006), Ethical Dilemmas in Water Recycling, World Water Congress, Beijing, September 2006, IWA Publishing. [The paper provides a commentary on challenges faced by water recycling initiatives.]

Enfinger, K.L. and Stevens, P.L. (2006). Sewer Sociology - The Days of Our (Sewer) Lives, Proceedings of the Water Environment Federation Technical Exhibition and Conference; Dallas, TX; Water Environment Federation: Alexandria, VA.

. [This paper highlights the uniqueness of a sewer system to its local catchment.]

Gikas P. and Tchobanoglous G. (2007), The role of satellite and decentralized strategies in water resources management. Journal of Environmental Management, page 1-9, August 2007. [This paper discusses the decentralized and satellite water reuse systems in detail.]

Hermanowicz S. W. and Asano T. (1999), 'Abel Wolman's "The Methabolism of Cities" Revisited: A Case for Water recycling and Reuse', Water Science and Technology, 40 (4-5) 29-36. [This paper discusses the opportunities for water reuse with global examples.]

Khan S. (2007), Water Recycling in Australia – A Blog site, http://waterrecycling.blogspot.com/2007/03/sewer-mining.html, Sunday 4, March 2007. [This blog site provides useful information on sewer mining, including case studies.]

Kogarah Municipal Council (2006), A HACCP Strategy for Beverley Park Water Reclamation Plant, Kogarah, New South Wales, (Unpublished). [This unpublished document provides an example of applying HACCP Principles to a water mining facility.]

Landcom (2006), Wastewater Reuse in the Urban Environment: Selection of Technologies, Dr Peter Holt and Emma James, February 2006. [This document contains a summary of various water reuse options available within an urban water cycle context.]

Leslie, G., Lozier, J. and Law I. (2003). Treatment Technologies to produce Class A water and beyond, Proc. Water Recycling Australia, 2nd National Conference, 1-3 September 2003, Brisbane, Australia. [This paper provides a summary of treatment options for water reuse.]

Logan I. (2008), Barriers and Drivers of New Public Private Infrastructure: Sewer mining – A Case Study, Proc 12th Annual Conference of the International Research Society for Public Management, Brisbane, 26–28 March 2008. [This paper provides a commentary on the institutional/legislative aspects of water mining.]

Marsden J., (2005), Third Party Access in Water and Sewerage Infrastructure: Implications for Australia, Proc. Water Recycling and Third Party Access Symposium, 14 December 2005, Marsden Jacob Associates, Melbourne. [This document provides a review of the proposed third party access to sewerage infrastructure in Australia, and its impact on urban water sector.]

Mills R. A., (2000), Planning and Analysis of Successful Water Reuse Projects: Case Studies in California, Proc of Wastewater Management for a Better Environment Conference, King Saud University, Abu Dhabi, United Arab Emirates. [Using case studies, this paper provides a good summary of planning aspects of reuse projects.]

Okun D. A. (2000), Water Reclamation and Unrestricted Non-potable Reuse: A New Tool in Urban Water Management, Annual Review of Public Health, Issue 21, pp 223-245. [This paper highlights the advantages of non-potable water reuse in urban context.]

Phillips S. (2008), Is there Gold in Sewer Mining? Waste Management & Environment, September 8, 2004. [This article provides a brief introduction to water mining.]

Rimer A. E., Sandino J. and Bosch R. T., (2004), Point of Sale Solutions, Water Environment and

Technology, January 2004, page 30. [This paper highlights the importance of decentralized reuse, by producing recycled water close to the point of sale.]

Robinson J. (2005), Cost Benefit Analysis of Effluent Reuse Schemes: Why Water Recycling Projects Fail to Pass the Test, The University of Queensland. [This paper provides a critique of traditional economic cost-benefit methods, and their failure to adequately recognise the benefits of water reuse projects.]

Schneider, P., Davison, A.D., Langdon, A., Freeman, G., Essery, C., Beatty, R. and Toop, P. (2003). Integrated Water Cycle Planning for NSW Towns. Water Science & Technology 47(7-8) 87-94. [This paper introduces the concept of HACCP into water cycle management & planning.]

US EPA (2002), Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008 February 2002**,** Office of Water, Office of Research and Development, U.S. Environmental Protection Agency. [This document provides guidelines for decentralised water reuse projects.]

US EPA (2004), Guidelines for Water Reuse, US EPA Municipal Support Division, Washington DC, September 2004. [This document is a comprehensive set of guidelines for all water reuse projects.]

White S. (1998). Wise Water Management: A Demand Management manual for Water Utilities. Water Services Association of Australia, Sydney Australia. [This document is a Manual for water utilities on demand management practices.]

Biographical Sketches

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