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REPORT DETAILS

Title:	**Feasibility Study Report**
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Client:	***Singapore Cooperation Enterprise***
Client Contact:	Mr. Melvin Lim (Senior Manager, International Partnership)

Synopsis: Feasibility Study Report (Project Deliverable No. 1) aims to develop feasibility and concept design for treatment options and configurations for Recycled Water Treatment Plant. It includes introduction and application of advanced recycled water treatment technology, advantages, disadvantages, preliminary sizing and costing implications. A high level and broad qualitative study of product recycled water is also carried out along with strategic discussion on the project delivery model.

REVISION / CHECKING HISTORY

Revision Number	**Date**	**Reviewed By**	**Approved For Issue**	**Distribution – Number Of Copies**		
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Preface

The NITI Aayog has entered into a partnership with Temasek Foundation (TF), Singapore and Singapore Cooperation Enterprise (SCE), to facilitate the sharing of Singapore's experience in Water Recycling and Reuse under "Urban Management (Water Recycling and Reuse) Program in India – Phase 2 Collaboration with NITI Aayog" Program. As such, Singapore Cooperation Enterprise signed a Grant Agreement with the NITI Aayog. The programme will receive funding support from Temasek Foundation and will also be co-funded by the NITI Aayog.

The Singapore Cooperation Enterprise (SCE) is the lead agency that will aggregate a team of Singapore's water experts from the Public Utilities Board (PUB) as well as private sector water company JACOBS to jointly develop with the NITI Aayog, a water recycle and reuse strategy, concept plan, feasibility study, preliminary design, and Model Document to implement a Pilot Recycled Water Treatment Plant, over a series of capacity building workshops for the partnering Indian States officials.

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Executive Summary

Water is among primary element for sustaining human life. Secure water supply and safe used water (wastewater) management provides a social, environmental and economic advantage to a city's communities and proactive businesses. As a city's water demand grows, resilient and efficient water and used water systems become crucial for continued growth, liveability and sustainability.

Ballari city is located 275 Km north of Bengaluru and has a population of about 4.1 lakhs as per 2011 census. The city is well known for its apparel cluster and has rich deposits of iron ore (1,032 MT). The city is also known for its dry weather and consecutive drought events, which had a debilitating effect on water availability for the city. In the period between 2001 to 2015, Ballari has witnessed 9 drought years[1].

Ballari receives its drinking water supply from the River Tungabhadra via two irrigation canals – Low Level Canal (LLC) and High Level Canal (HLC). Collectively, water through these two canals is supplied for 6 to 9 months. Water through these canals is also stored in an Impounding Reservoir (IR), to cater for water needs during remaining 3 to 6 months of non-supply period of HLC and LLC. Water is treated at two Water Treatment Plants (WTP) – Moka WTP (10 MLD) and Allipura WTP (40 MLD), and is supplied to the city via series of elevated Overhead Tanks (OHT). Water losses (physical and commercial) are reported at 50%, and a given water service zone in Ballari receives water once in five (05) days.

City's underground used water network has been developed in stages over last four decades. Ballari city's used water collection and conveyance system is divided in to four (04) zones. There are two Used Water Treatment Plant (UWTP) - 30 MLD capacity Ananthpur Road UWTP (receiving used water from Zone 3 and 4), and 15 MLD capacity Cowl Bazaar UWTP (receiving used water zone 1 and 2). Another 12 MLD capacity UWTP is under construction (Sequential Batch Reactor technology), and will receive used water from zones 1 and 2, which are currently undergoing construction of additional used water network to connect the newly formed and unconnected layouts.

Surface water is scarce in Ballari, and industries are typically dependent on groundwater for their water needs which is already over-exploited. Water has a high economic impact on Ballari's industrial area development. Ballari has more than 25 sponge iron units. Large industries include a thermal power plant and steel plant, along with two proposed steel plants. Karnataka Industrial Area Development Board (KIADB) has developed three industrial areas – Mundaragi (Phase I to IV), Sanklapura (Phase I, II) and Ananthpur Road Industrial Area, spread over 522 acres, which would need water for their sustainable development.

Existing urgent need of water to support industrial development is a major driver to develop alternate sources, such as recycled water, for Ballari. For last few years, Ballari Municipal Corporation has started selling secondary treated used water to industries and have list of identified industries that are potential customers.

This Feasibility Design Report (FDR) covers following aspects:

- Strategic goals, objectives and key challenges of implementing a viable water recycle and reuse scheme,

[1] Source: Proposal for Pilot Project Reuse of Recycled Water in Karnataka, Urban Development Department, Government of Karnataka.

- Applicable international and Singapore's reuse quality standards for various applications of recycled water,
- Applicable recycled water treatment and end use guidelines, influent and effluent water quality monitoring requirements, and target recycled water standards to produce water for indirect potable reuse,
- Introduction and application of advanced recycled water treatment technologies, identification and evaluation of various options for recycled water treatment, review of their advantages and disadvantages, etc.

Treatment process options

As shown in the Table ES 1 below, at present the two UWTP at Ballari are not meeting the CPCB treated effluent water quality standards (Table ES 2).

Table ES 1: Water quality results for existing UWTPs at Ballari

SI No	Sample details	Date of sampling	Parameter	Prescribed standard	Result of analysis	
					Eastern outlet	Western outlet
1	30 MLD UWTP	23rd May, 2018	BOD (mg/L)	10	92	158
			COD (mg/L)	50	264	325
			Suspended solids (mg/L)	30	60	40
2	15 MLD UWTP	23rd May, 2018	BOD (mg/L)	10	44	83
			COD (mg/L)	50	183	237
			Suspended solids (mg/L)	30	40	60

Table ES 2: CPCB treated effluent discharge guidelines

Parameter	Unit	CPCB (2015)
pH	-	6.5 – 9.0
Biochemical Oxygen Demand (BOD_5)	mg/L	10
Chemical Oxygen Demand	mg/L	50
Total Suspended Solids	mg/L	20
Ammonium	mg/L	5
Total Kjeldahl Nitrogen	mg/L	10 (As TN)
Faecal Coliforms	MPN/100mL	100

*Note: Total Phosphorus (TP) is not stated. Discharge of treated used water to inland waterways or lakes with elevated TP can lead to water body eutrophication (nutrient enrichment) and algal blooms and excessive nuisance aquatic weed growths.

With used water most of the total phosphorus is in the PO43+ form. The rest, about 15% is in the form of poly P. Thus PO_4^{3+} is nearly the same as total P.

The commonly adopted standard in India for the PO_4^{3+} as P, is taken as less than or equal to 2 mg/L. In Australia, the concentration of total Phosphorus (as P) to prevent eutrophication of lakes is taken as less than 0.1 mg/L.

This note recommends a concentration of up to 1 mg/l for total Phosphorus (as P).

In order for the treated effluent comply with CPCB standards, and is fit as feed for producing recycled water for non-potable purposes, treatment process options that are technically and operationally proven, will be considered for this project, owing to following factors:

- Land availability,
- Capital cost,
- Operation and maintenance with OPEX,
- Energy consumption,
- Reliability, redundancy, robustness and resilience of the treatment process,
- Product water quality targets for indirect potable reuse including industrial reuse.

The two such potential treatment trains are Biological Nutrient Recovery with side stream de-ammonification (if land is not a constraint)

Figure ES 1, and Moving Bed Bio Reactor with side stream de-ammonification (if land is a constraint) Figure ES 2.

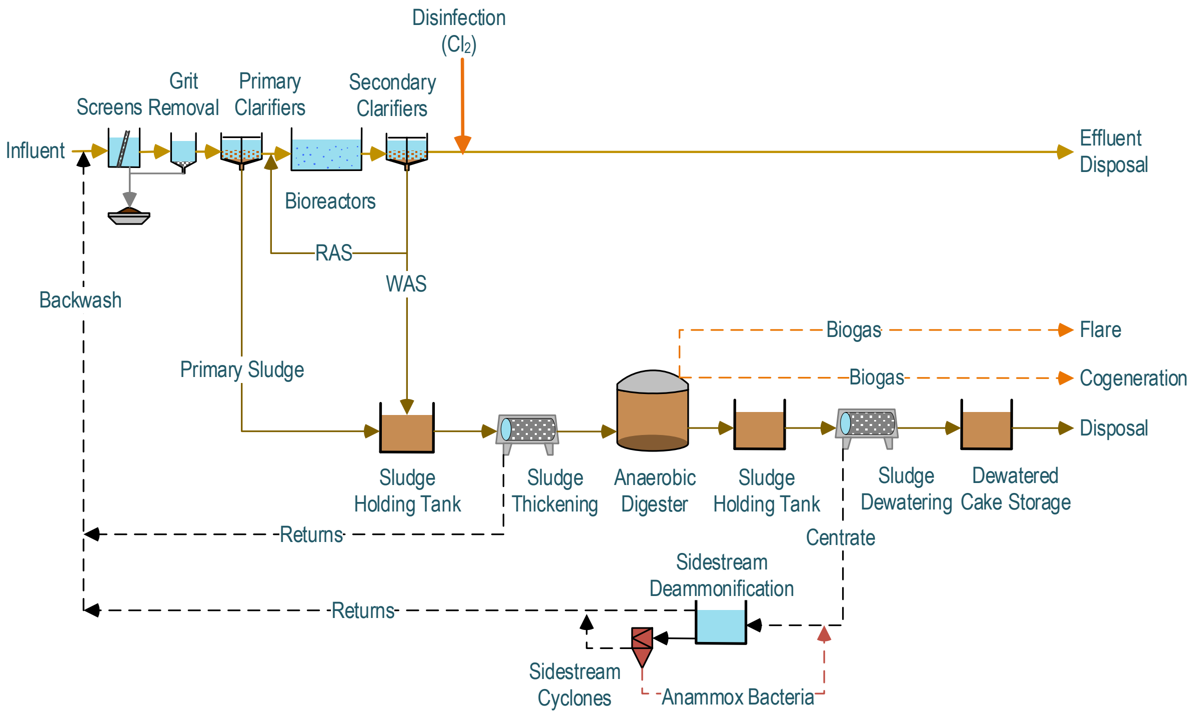


Figure ES 1: BNR with side stream deammonification and sludge management

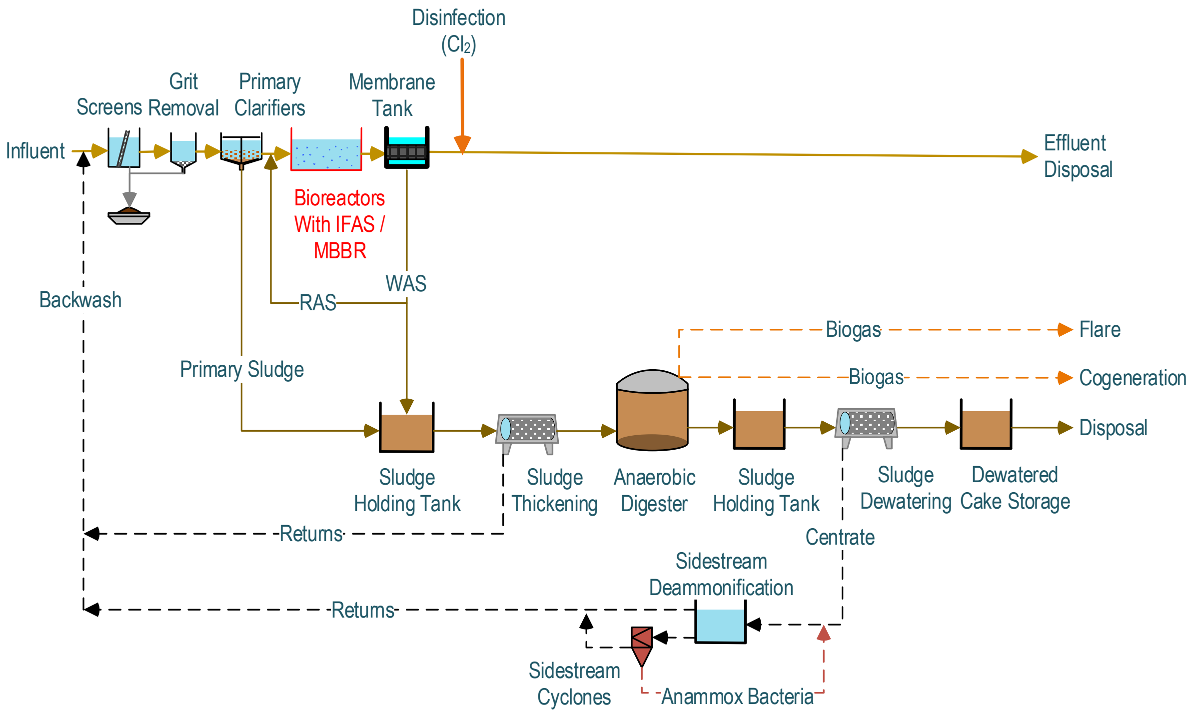


Figure ES 2: MBBR treatment with side stream deammonification and sludge management

Treatment scheme option development

As part of feasibility, following options were identified.

Proposed option by Karnataka Urban Water Supply and Drainage Board (KUWS&DB)

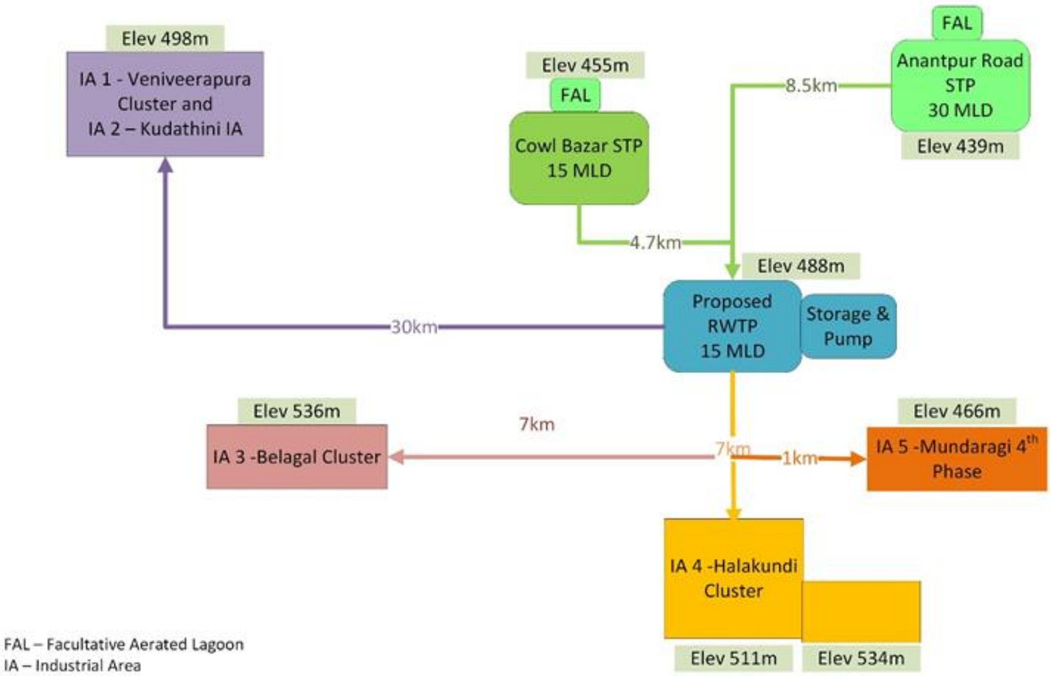


Figure ES 3: Proposed scheme by KUWS&DB for proposed ARWTP at Ballari

The pilot project proposed by KUWS & DB intends to convey secondary treated effluent from two existing used water treatment plants to recycled water treatment plant (RWTP), and further supply recycled water to industrial areas. The schematic in

Figure ES 3 presents the proposed recycled water supply scheme.

Identified options as part of Feasibility Study (Option 1a) – Upgrade 30 MLD Ananthpur Road UWTP, standalone ARWTP

Option 1a recommends upgrading the existing 30 MLD Ananthpur UWTP so that the treated effluent meets CPCB requirements, and construct a new ARWTP close to Mundaragi 4th Phase Industrial area (at the same location identified under KUWS&DB proposal).

Proposed Option 1a is shown in Figure ES 4.

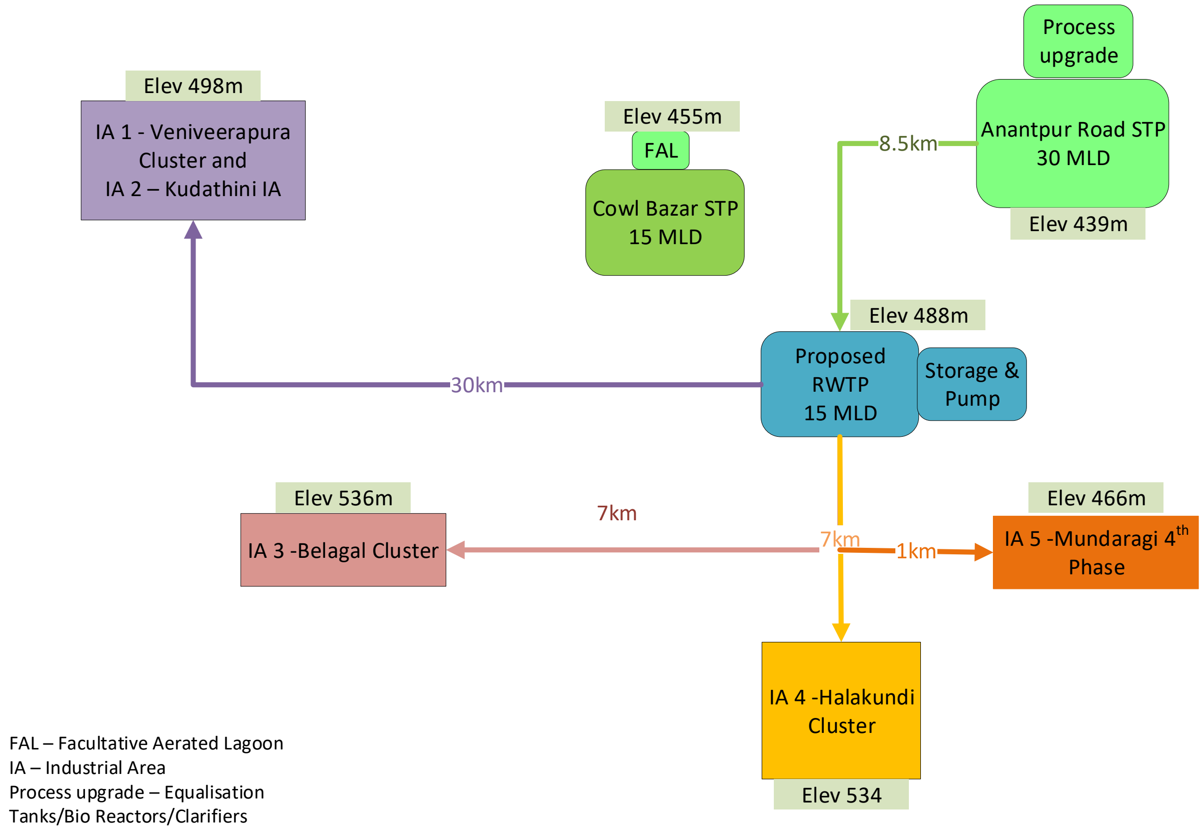


Figure ES 4: Option 1a - Upgrade 30 MLD Ananthpur UWTP and standalone ARWTP

The challenges and opportunities associated with Option 1a are shown in Table ES 3.

Table ES 3: Challenges and opportunities - Option 1a

Challenges	Opportunities
• Upfront capital cost investments, • O&M costs at two locations, • May require an external O&M contractor, • Less reliable RWTP influent quality, plant operation, and hence recycled water quality	• CPCB compliant treated secondary effluent, • Minimize UWTP modifications, • Separate delivery models possible for RWTP

Identified options as part of Feasibility Study (Option 1b) – Upgrade 30 MLD Ananthpur Road UWTP, co-locate ARWTP

Option 1b recommends upgrading the existing 30 MLD Ananthpur UWTP so that the treated effluent meets CPCB requirements, and co-locate ARWTP at 30 MLD Ananthpur UWTP site.

Proposed Option 1b is shown in Figure ES 5.

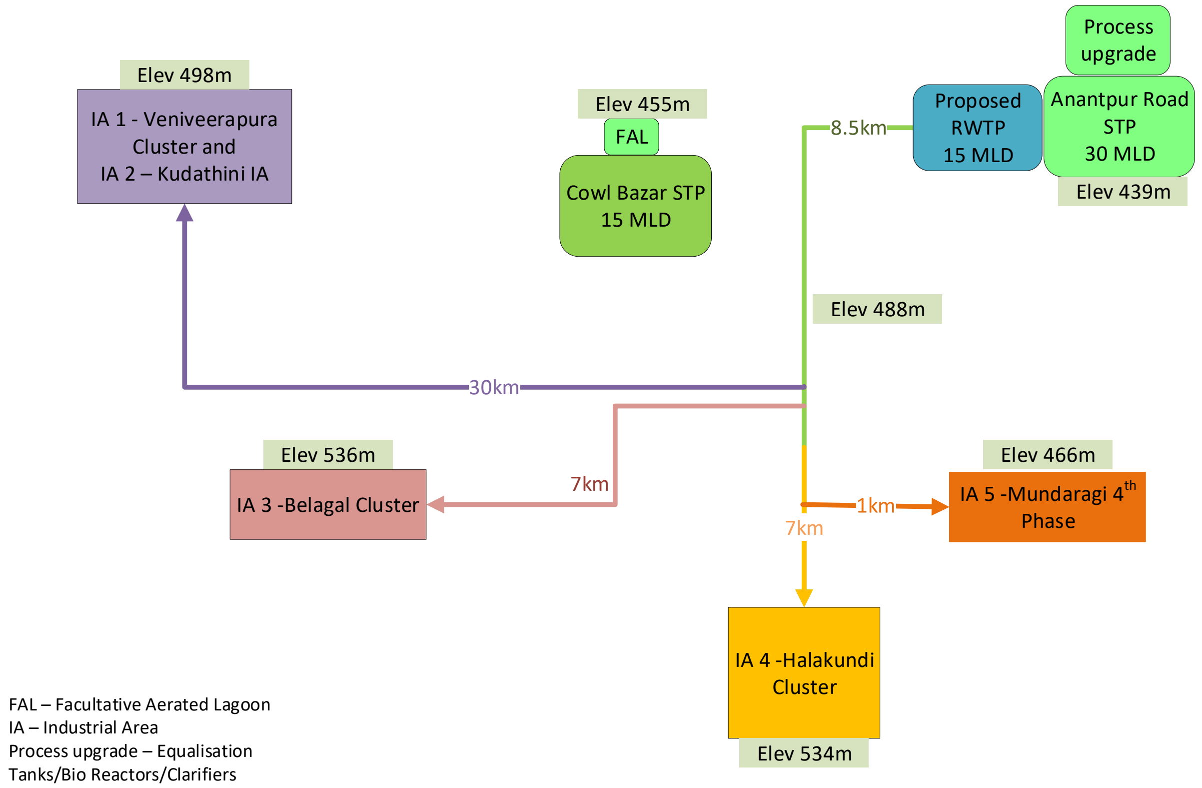


Figure ES 5: Option 1b - Upgrade 30 MLD Ananthpur UWTP and co-locate ARWTP at 30 MLD UWTP site

The challenges and opportunities associated with Option 1b are shown in Table ES 4.

Table ES 4: Challenges and opportunities - Option 1b

Challenges	Opportunities
• May require an external O&M contractor, • Operation of integrated treatment process	• Relatively lower land and capital costs, • Lower O&M costs due to co-location, • CPCB compliant treated effluent, • More reliable RWTP influent quality and plant operation, superior quality recycled water production,

Identified options as part of Feasibility Study (Option 2) – Construct new 30 MLD Ananthpur Road UWTP, standalone ARWTP

Option 2 recommends constructing new 30 MLD Ananthpur UWTP. The ARWTP will be located close to Mundaragi 4th Phase Industrial area (at the same location identified under KUWS&DB proposal).

Proposed Option 2 is shown in Figure ES 6.

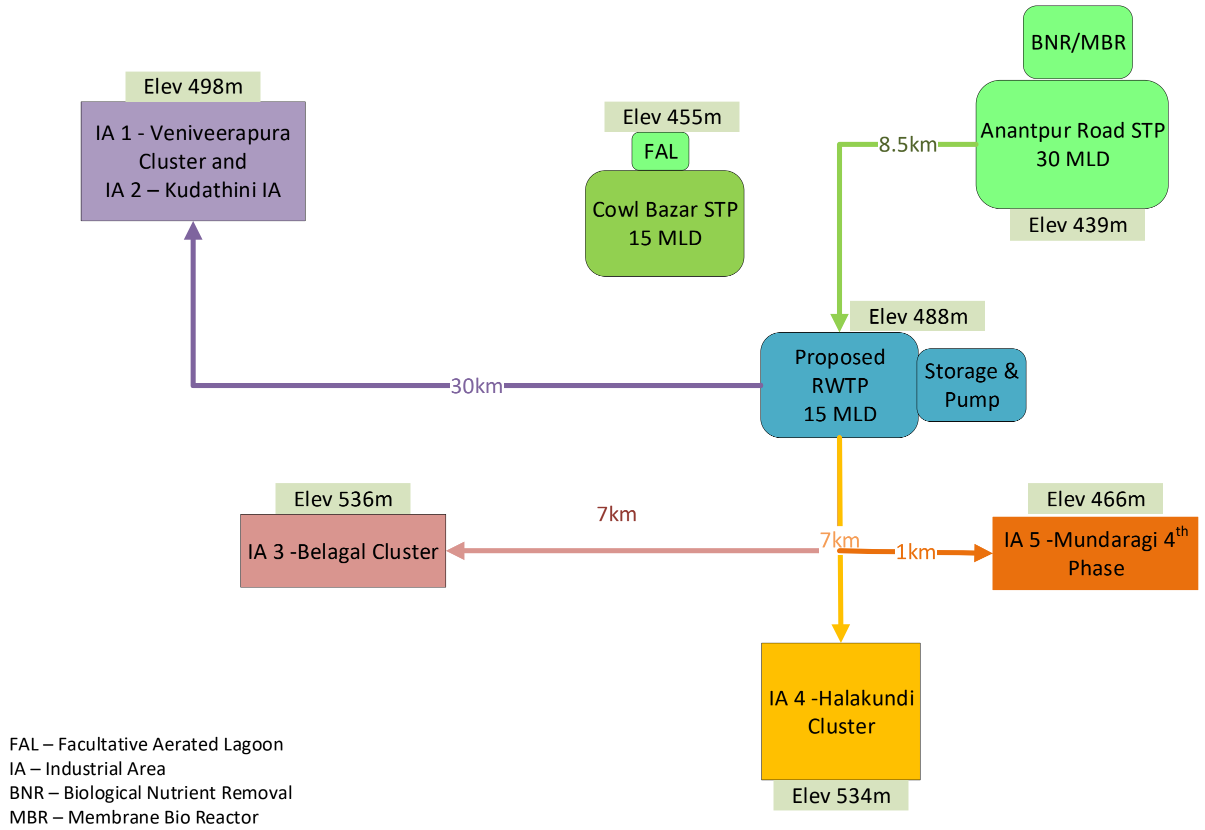


Figure ES 6: Option 2 - Construct new 30 MLD Ananthpur UWTP and standalone ARWTP

The challenges and opportunities associated with Option 2 are shown in Table ES 6.

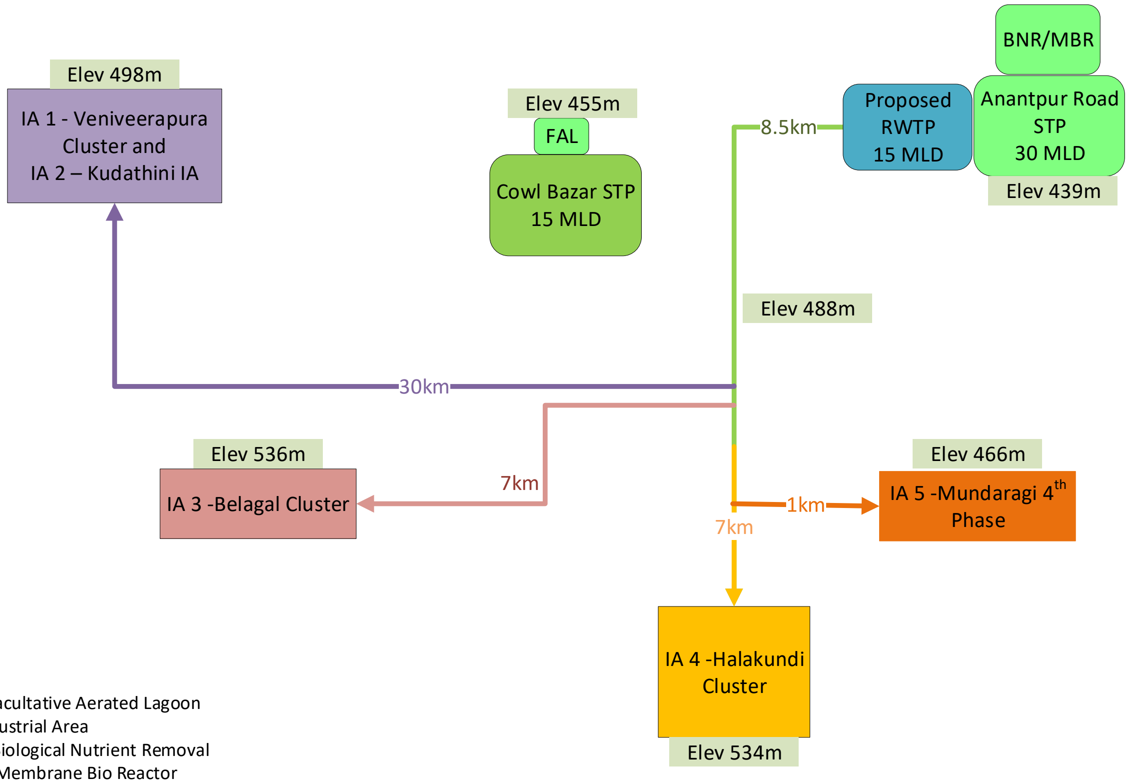
Table ES 5: Challenges and opportunities - Option 2

Challenges	Opportunities
• Upfront higher capital cost investments, • O&M costs at two locations, • May require an external O&M contractor,	• Leveraging latest treatment technology, • Surpassing CPCB treated secondary effluent, • High quality recycled water production, • Higher industrial uptake leading to improved revenue generation through proper pricing.

Identified options as part of Feasibility Study (Option 3) – Construct new 30 MLD Ananthpur Road UWTP, co-locate ARWTP

Option 3 recommends new construction of 30 MLD Ananthpur UWTP, and co-locate ARWTP at 30 MLD Ananthpur UWTP site.

Proposed Option 3 is shown in Figure ES 7.



FAL – Facultative Aerated Lagoon
IA – Industrial Area
BNR – Biological Nutrient Removal
MBR – Membrane Bio Reactor

Figure ES 7: Option 3: Construct new 30 MLD Ananthpur UWTP and co-locate ARWTP

The challenges and opportunities associated with Option 3 are shown in Table ES 6.

Table ES 6: Challenges and opportunities – Option 3

Challenges	Opportunities
• Upfront higher capital cost investments, • O&M costs at two locations, • May require an external O&M contractor,	• Leveraging latest treatment technology, • Surpassing CPCB treated secondary effluent, • High quality recycled water production, • Higher industrial uptake leading to improved revenue generation through proper pricing.

Proposed Advanced Recycled Water Treatment Plant

In order for producing high quality recycled water, two treatment options are considered

- Desalting option: requiring membrane-based treatment which will entail salt management,
- Non desalting option: a non-membrane based option

These options are shown in **Figure ES 8** and **Figure ES 9** respectively.

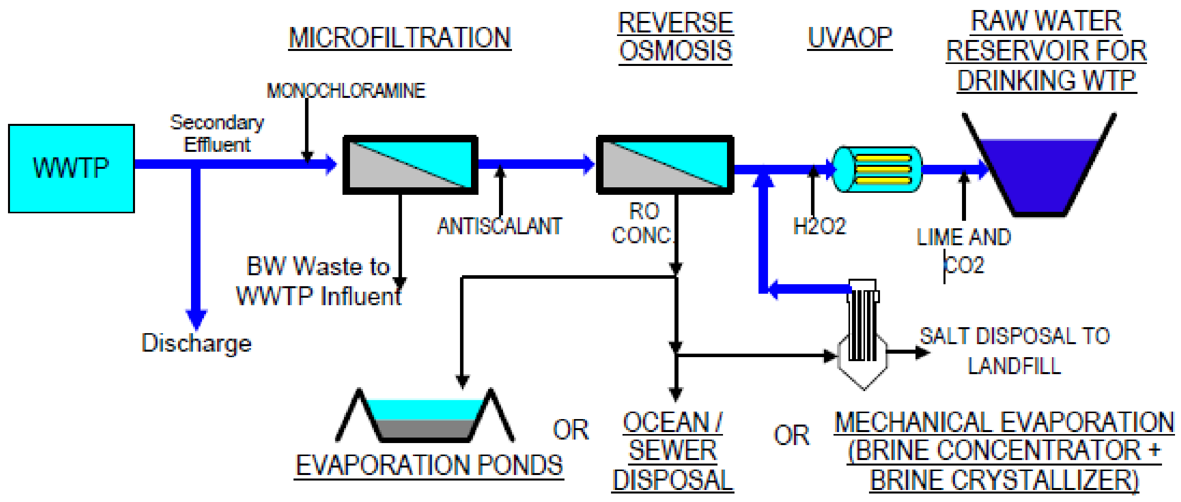


Figure ES 8: Membrane based recycled water treatment

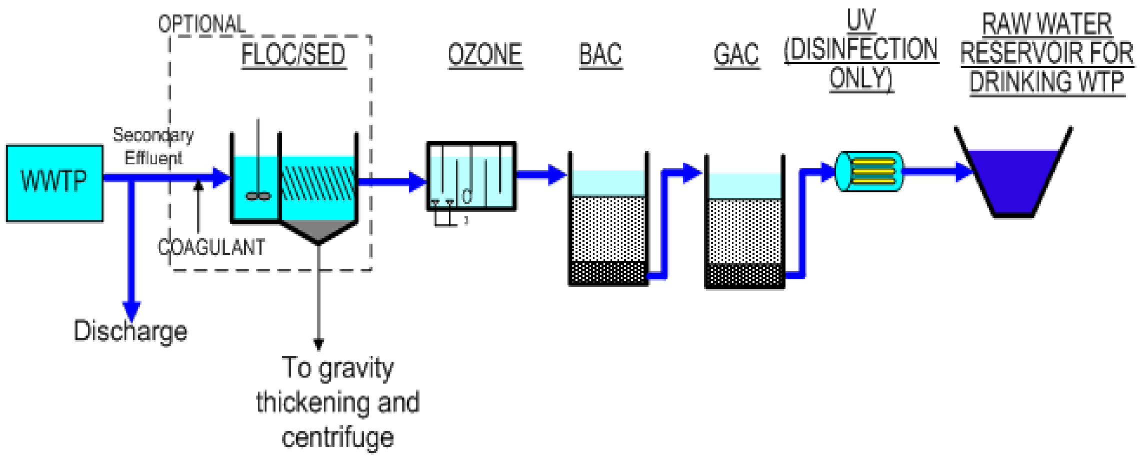


Figure ES 9: Non-membrane based recycled water treatment

The advantage and disadvantages of membrane versus non-membrane option are presented in Table ES 7 below.

Table ES 7: Advantages and disadvantages of membrane v/s non-membrane treatment options

Technology	Advantages	Disadvantages
Membrane based treatment	• Good track record and public acceptance for drinking water reuse • Removes salt / TDS, TOC, Contaminants of Emerging Concern (CECs) • Integrity monitoring provide high level of process assurance	• High capital cost to construct • High O&M cost for power and chemicals • Brine management required • High environmental cost (greenhouse gas and other air emissions)
Non membrane based treatment	• Relatively lower capital cost to construct	• Lesser track record for successful operation

Technology	Advantages	Disadvantages
	• Relatively O&M cost for power and chemicals • Relatively low environmental cost (greenhouse gas and other air emissions) • Excellent CEC removal	• Does not remove TOC as efficiently as MF/RO/UVAOP train • Limited removal of nitrogen compounds • Requires monitoring of TOC and TDS • Disinfection byproducts

Project Delivery Options

An analysis of various PPP delivery models is presented for the project delivery of a non-drinking water reuse project at Ballari.

Cost Estimates

A preliminary cost estimate for the following treatment technologies was made:

- Conventional Treatment with UV Disinfection
- Conventional Treatment without UV Disinfection
- Membrane treatment with UV disinfection
- Membrane treatment without UV disinfection

It is prudent to note that the costing for conventional treatment is significantly lower than that of a membrane treatment in terms of capital costs, operating costs as well as cost estimate for power.

Recommendations

The following actions resulting from this Feasibility Study are recommended:

- It is recommended that the production of advanced treated recycled water is done without the generation of a salt or brine stream,
- It is recommended the product water be used for non-drinking purposes including supply to industrial and commercial establishments,
- It is recommended that a detailed risk assessment for the total scheme be carried out for the preferred process option once it is adopted,
- Conduct detailed used water sampling and analysis on the existing Cowl Bazaar (15 MLD) UWTP and Ananthpur Road (30 MLD) UWTP to develop the preferred treatment scheme for the proposed Advanced Recycled Water Treatment Plant,
- It is recommended that a public education outreach engagement and consultation programme be undertaken prior to tendering of this project,
- It is recommended the PPP project delivery model be adopted for the implementation of this project.

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List of Abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARWTP	Advanced Recycled Water Treatment Plant
BWSSB	Bangalore Water Supply and Sewerage Board
BMC	Ballari Municipal Corporation
BDL	Below Detection Limit
BNR	Biological Nutrient Removal
BOD_5	Biochemical Oxygen Demand
CAPEX	Capital expenditure
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPES	CH2M HILL's Parametric Cost Estimating System
CPHEEO	Central Public Health and Environmental Engineering Organization
DB	Design Build
DBB	Design Bid Build
DBFOT	Design Build Finance Operate & Transfer
DBO	Design Build Operate
DNA	Deoxyribonucleic acid
GoK	Government of Karnataka
HRT	Detention Time, Hours
INR	Indian Rupee(s)
KIADB	Karnataka Industrial Area Development Board
KSPCB	Karnataka State Pollution Control Board
KUWS&DB	Karnataka Urban Water Supply and Drainage Board
LSI	Langelier Saturation Index
MC	Maintenance Clean
MF	Microfiltration
MLD	Million Litres per Day
MLSS	Mixed Liquor Suspended Solids
MOC	Material of Construction
MPN	most probable number
NDWR	Non-Drinking Water Reuse

NITI	National Institution for Transforming India
NF	Nano-filtration
NPV	Net Present Value
NTU	Nephelometric Turbidity Unit
O&G	Oil and Grease
O&M	Operation and Maintenance
OPEX	Operational expenditure
P&ID	Process and Instrumentation Diagram(s)
PFD	Process Flow Diagram(s)
PPP	Public Private Partnership
PUB	Public Utilities Board
RCC	Reinforced Cement Concrete
RNA	Ribonucleic acid
RO	Reverse Osmosis
RWTP	Recycled Water Treatment PLant
SAMP	Sampling and Monitoring Program
SAR	Sodium Adsorption Ration
SCE	Singapore Cooperation Enterprise
SDI	Silt Density Index
STP	Sewage Treatment Plant
SWD	Side Water Depth
TDS	Total Dissolved Solids
TMP	Trans-Membrane Pressure
TSS	Total Suspended Solids
UF	Ultrafiltration
USD	United States Dollar(s)
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UWTP	Used Water Treatment Plant
VSS	Volatile Suspended Solids
WHO	World Health Organization
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant same as Sewage Treatment Plant or Used Water Treatment Plant

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1 Program background and introduction

India is experiencing rapid urbanisation. The urban population has gone up from 29 crore in 2001 to 37.7 crore in 2011, and the number of town and cities has also risen from 5,161 to 7,935 during this period. At present, there are more than 8,000 cities and towns in India. Due to rapid urbanisation, water demand in urban areas is increasing rapidly. The water situation in metropolitan cities is particularly exacerbating, where the people in such cities face acute water shortage during summers. Changing climate and its impact on temporal and spatial variability of rainfall, is a further deterrent to timely and sufficient availability of water resources.

Government is putting concerted efforts in implementing rainwater harnessing schemes for groundwater improvement, however, there is an urgent need for water portfolio diversification through introducing alternate sustainable water sources. The recycle and reuse of water presents itself as a potential solution for ensuring assured water supply in the Cities, on a sustainable basis. Recycling and reuse has been widely practised in Singapore, where every drop of water is recycled for reuse. Such an approach not only reduces pressure on other water sources, but also offers a sustainable solution for water resources management.

The National Water Policy (2012)[2] of the Government of India proposed radical changes to the existing water policy, encouraging water reuse. It has also been observed that water is recognised as an economic good, over and above the pre-emptive need, i.e. the basic minimum quantity of water for essential health and hygiene and sustenance of ecology that would promote maximisation of value of water and its conservation and efficient use.

To benefit from Singapore's experience in sustainable urban management, NITI Aayog partnered with Singapore Government under "Urban Management Program in Indian – Phase 1" Program, with an objective to build capacity of technical and management leaders from Indian public utilities in water, wastewater and solid waste management. As part of the capacity building programme, two sets of strategic baseline framework documents were developed for Water & Wastewater Management and Solid Waste Management, for participating Indian States. The framework included general guidelines to address challenges and opportunities associated with Water & Wastewater Management and Solid Waste Management, generic enough for participating states to apply based on context and requirements.

Subsequently, NITI Aayog and Singapore Government have extended their collaboration to further deep dive capacity building in recycle and reuse under "Urban Management (Water Recycling and Reuse) Program in India – Phase 2" Programme.

Singapore is a pioneer in urban water cycle management, and has successfully addressed water management challenges through technical ingenuity and strong public outreach efforts over the years. Singapore has set benchmark in successful implementation of large scale water recycling projects, public education and participation, management and quality control systems and Public Private Partnerships (PPP) investments. Public Utility Board (National Water Agency of Singapore) through its highly successful NEWater programme supplies top quality recycled water for industrial as well as for indirect potable reuse purposes. Singapore has successfully been able to transform their urban waterscape over the last four decades, and their learnings can be adopted and contextualised for Indian scenario.

[2] http://mowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf

1.1 Program objective

Under Phase 2 of this capacity building programme, following key objectives have been identified:

- Build capabilities of participants in recycling and reuse – infrastructure development, operation and management, Non Revenue Water management, and used water management,
- Develop concept and feasibility study, preliminary design, development of delivery options and model documents for implementing a pilot recycled water treatment plant with desired water quality and safety guidelines,
- Develop understanding of the benefits and challenges towards adopting integrated wastewater management based on Singapore's experience, along with lessons learnt from Singapore towards development of policy frameworks and actions required to implement a successful water recycling strategy,
- Other objectives of this project include:
  - Achieve an in-depth understanding of the benefits and challenges of sustainable integrated recycle water management,
  - Identify policy action required to implement recycle and reuse strategies, and
  - Build capabilities of key officials through sharing of Singapore's lessons and experience in project implementation, including introduction to Public Private Partnership (PPP) based project delivery model,
  - Developing recycled water as part of sustainable and diverse water portfolio.

Further, the proposal submitted by Urban Development Department, GoK, for Ballari City is selected as the "Pilot Recycled Water Treatment Plant" project. It is envisaged that a successful water recycle and reuse program will assist in reducing the stress on freshwater sources, like surface water or groundwater, to meet non-potable water demand of industries in Ballari.

1.2 Report objective

This report identifies the potential recycled water treatment technologies and treatment trains for non-drinking purposes water reuse project located in Ballari, based on the techno-economic evaluation. This Feasibility Study aims to become the foundation for a future reference design under forthcoming implementation phases.

1.3 Scope of works

Scope of work for the project includes:

- Capacity building in Recycled & Reuse Water, Non-Revenue Water (NRW) Management, and Used Water Treatment through the sharing of the Singapore Experience:
  - Application of recycled and reuse water for non-potable purposes,
  - Sharing non-revenue water management experience and lessons learned from Singapore,
  - Knowledge sharing on various used water treatment technologies, key process equipment, and process elements for recycled water treatment,
  - Overview of used water management in Singapore,
  - Development of feasibility study for recycled water treatment plant:
  - Sharing applicable international and Singapore's reuse quality standards for recycled water applications,
  - Identification of applicable recycled and reuse water treatment and end use guidelines for Indian context, influent and effluent water quality monitoring requirements, and target recycled water standards to produce water for indirect potable reuse,

  - Introduction and application of advanced recycled and reuse water treatment technologies, identification and evaluation of various options for recycled and reuse water treatment, and review of their advantages and disadvantages,
- Development of preliminary design report:
  - Identification of treatment plant design criteria, and development of preliminary design and configurations for pilot recycled water treatment plant,
  - Health and Environmental aspects of Water Reuse including human health effects and water quality monitoring protocol,
  - Sharing Singapore's experience in stakeholder engagement for public acceptance of recycled water utilisation in indirect potable reuse,
- Development of Delivery Options and Model Documents for Project Implementation for Water Recycling Scheme:
  - Equipment specifications,
  - Identification of risks and mitigation strategy for implementing the water recycling scheme,
  - Strategy for operation and maintenance, and
  - Project delivery model - Discussion of potential options for project delivery models and development of recommendations for contract types (such as EPC/ DB/PPP etc).

1.4 Project description

Following section presents a brief description about Ballari City as well as the proposed pilot project.

1.4.1 About Ballari city

Ballari city is located 275 Km north of Bengaluru at an elevation of 495 m and has a population of about 4.1 lakhs as per 2011 census, with approximately 82 km^2 of area within Ballari Municipal boundary. The city is well known for its apparel cluster and has rich deposits of iron ore (1,032 MT). Ballari has more than 25 sponge iron units. Large industries include a thermal power plant by KPTCL and Steel plant by Jindal South West (JSW Group). There are two proposed steel plants – by Arcellor Mittal and Uttam Galva. Karnataka Industrial Area Development Board (KIADB) has developed three industrial areas (IA) in the vicinity of Ballari city – Mundaragi (Phase I to IV), Sanklapura (Phase I, II) and Ananthpur Road IA, spread over 522 acres. KIADB is also developing a new industrial area in Kuduthini, 20 km to the West of Ballari city. Iron and Steel industry (with cogeneration power plant) and jeans washing units in Mundaragi Phase IV have large water demand.

The city is also known for its dry weather and consecutive drought events[3], which had a debilitating effect on water availability for the city.

1.4.2 Water and used water infrastructure in Ballari

Following section presents the water and used water infrastructure for Ballari City.

Water infrastructure

Ballari receives its drinking water supply from Tungabhadra River via two Canals – Low Level Canal (LLC) [supplying water to Ballari City for 6 to 9 months] and High Level Canal (HLC) [supplying water to Ballari City for 3 to 5 months].

[3] Source: Proposal for Pilot Project Reuse of Recycled Water in Karnataka, Urban Development Department, Government of Karnataka.

Water supply scheme through Tungabhadra River to Ballari City via LLC and HLC is shown in the Figure 1-1 below.

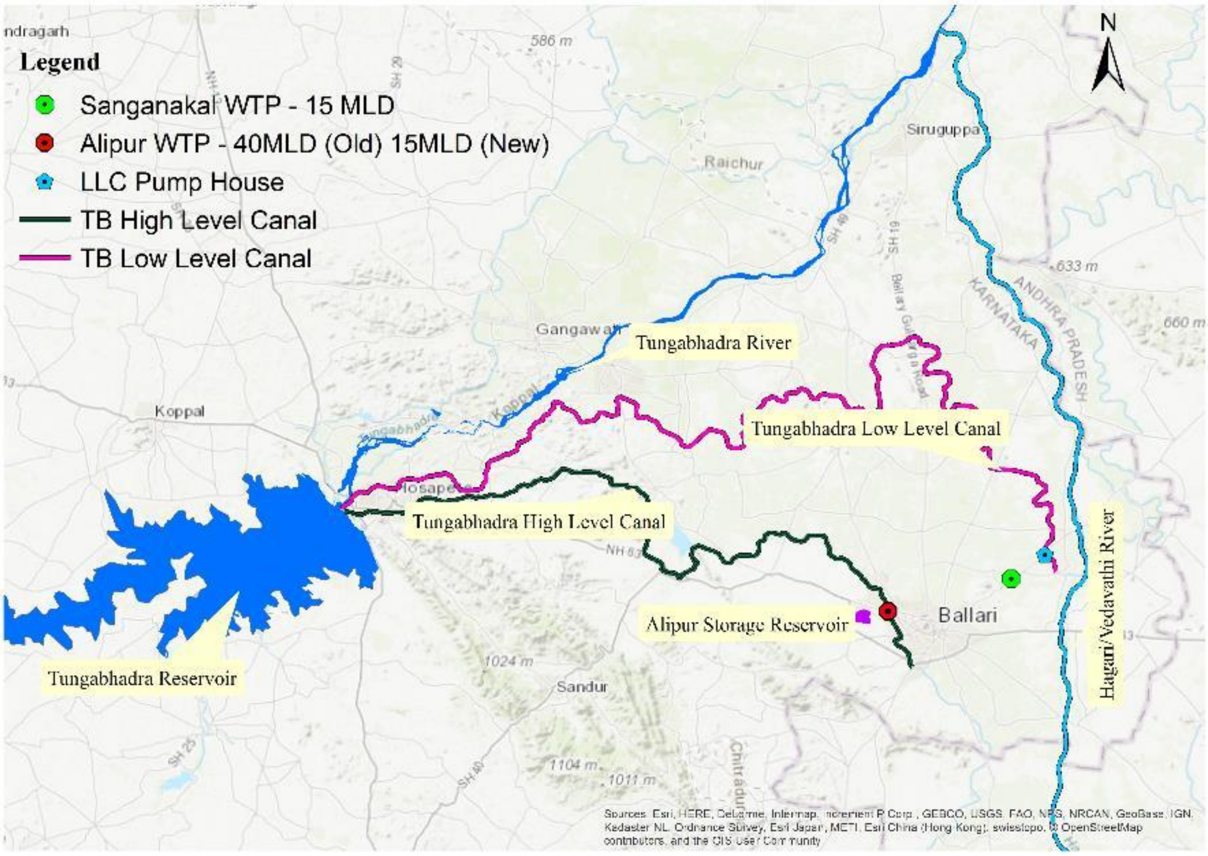

Figure 1-1: Ballari water supply scheme

Figure 1-2: Tungabhadra low level canal supplying drinking water to Ballari

Figure 1-2 above shows the Tungabhadra Low Level Canal. During the period of water supply in LLC, approximately 90 MLD of water is captured via an intake well from LLC, and is pumped through LLC Pump House to four (04) nos of WTPs. Figure 1-3 shows the intake well at LLC, and Figure 1-4 shows the LLC Pumphouse.

Figure 1-3: Intake well at LLC

Figure 1-4: LLC Pump house

Water from intake well is pumped to following WTPs:

- Allipura old WTP – 40 MLD [commissioned in 1975]
- Moka old WTP – 10 MLD [commissioned in 1992]
- Sangankal new WTP – 20 MLD
- Allipura new WTP – 15 MLD

Additional water from LLC is also stored in the Allipura Water Supply Impounding Reservoir of 12, 633 ML capacity, shown in Figure 1-5.

Figure 1-5: Allipura Impounding Water Supply Reservoir

All the four WTPs use conventional treatment, and the treated water is weekly checked from various location around Ballari City for drinking water quality compliance.

Typically, drinking water is supplied once in every five (05) days to each water service area.

Used water collection and treatment infrastructure

The underground used water collection and conveyance system for Ballari City has been developed over the period of last three decades, and currently has approximately 475 km of underground used water collection and conveyance network. The city is divided in to four (04) used water zones, namely Zone 1, 2, 3, and 4.

Used water collected from these zones is transported to following two Used Water Treatment Plants (UWTP), which are based on Facultative Aerated Lagoon technology for treating the used water:

- Ananthpur Road UWTP – 30 MLD Capacity (average inflow 20 MLD, from Zones 3 and 4), [Figure

1-6]

- Cowl Bazaar UWTP – 15 MLD Capacity (average inflow 9 MLD, from Zones 1 and 2) [Figure 1-8]

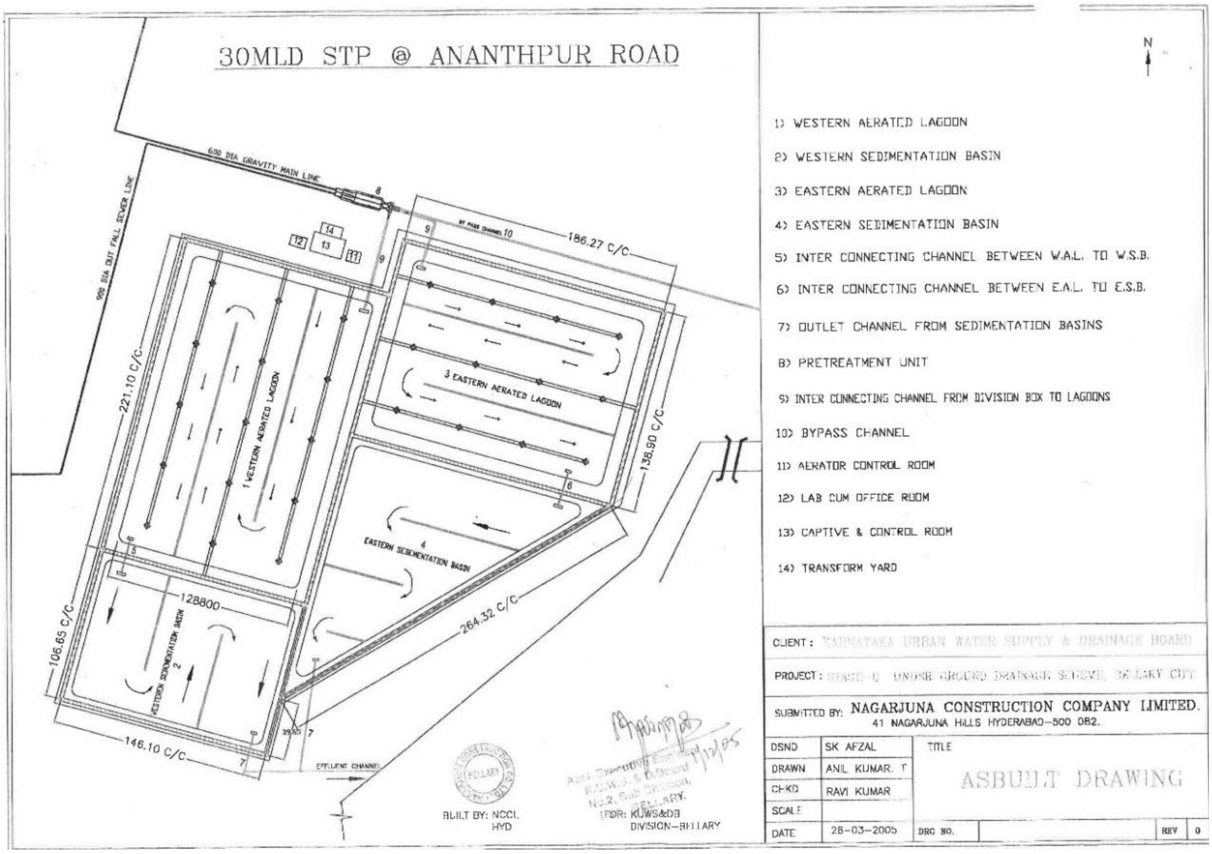

Figure 1-6: 30 MLD capacity Ananthpur Road UWTP Layout

Figure 1-7: Aerial image of 30 MLD capacity Ananthpur Road UWTP

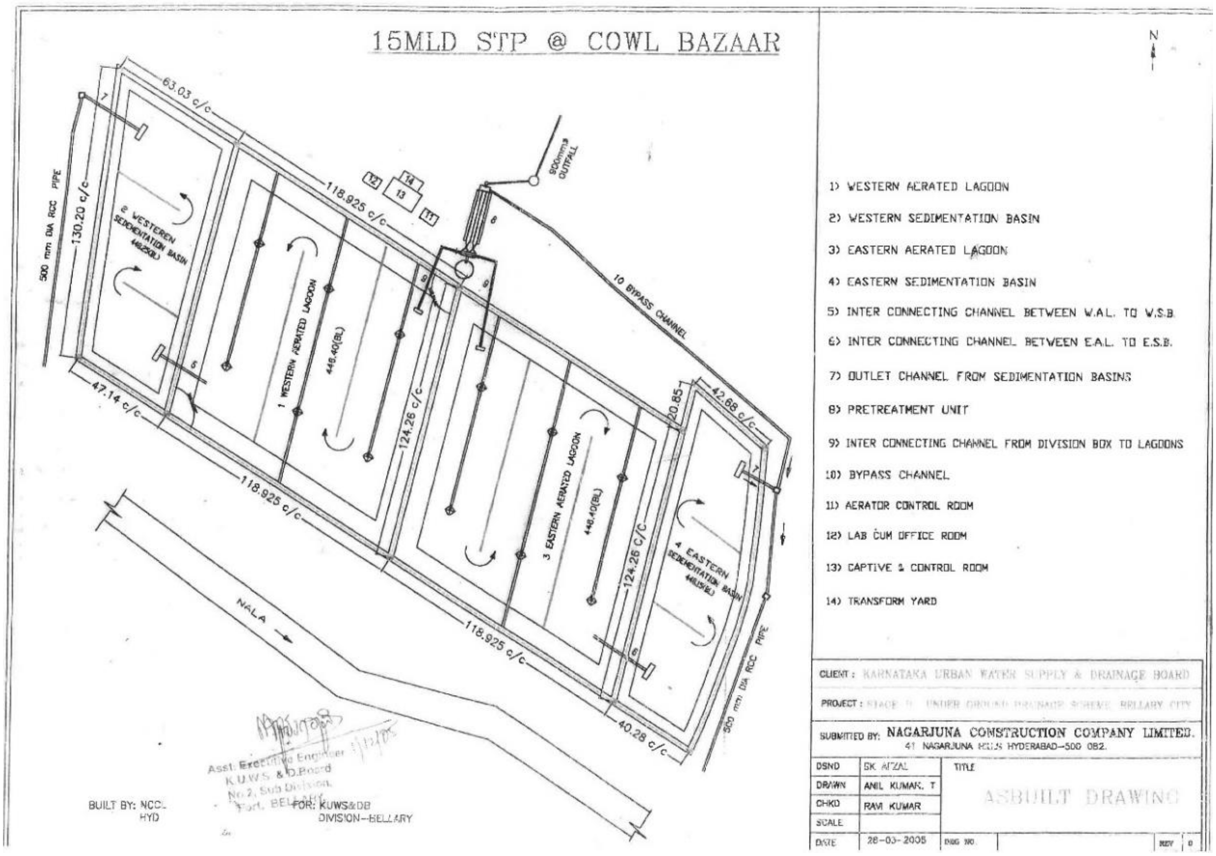

Figure 1-8: 15 MLD capacity Cowl Bazaar UWTP Layout

Figure 1-9: Aerial image of 15 MLD capacity Cowl Bazaar UWTP

Figure 1-10: 30 MLD capacity Ananthpur Road UWTP

Figure 1-11: 15 MLD capacity Cowl Bazaar UWTP

As per the water quality analysis performed for BOD, COD and Suspended Solids concentration in treated effluent from 30 MLD and 15 MLD UWTPs, the sample failed on all the three parameters. During discussion with Ballari Municipal officials, it was informed that the municipality is exploring the opportunity to upgrade/replace the existing UWTP for a better and technologically advanced treatment plant. Part of the used water currently being treated at the UWTPs, is supplied to industries, and remaining is discharged in the drain which runs through Ananthpur UWTP to Cowl Bazaar UWTP and meeting with Hagari River, which is a tributary to Tungabhadra River (Figure 1-12).

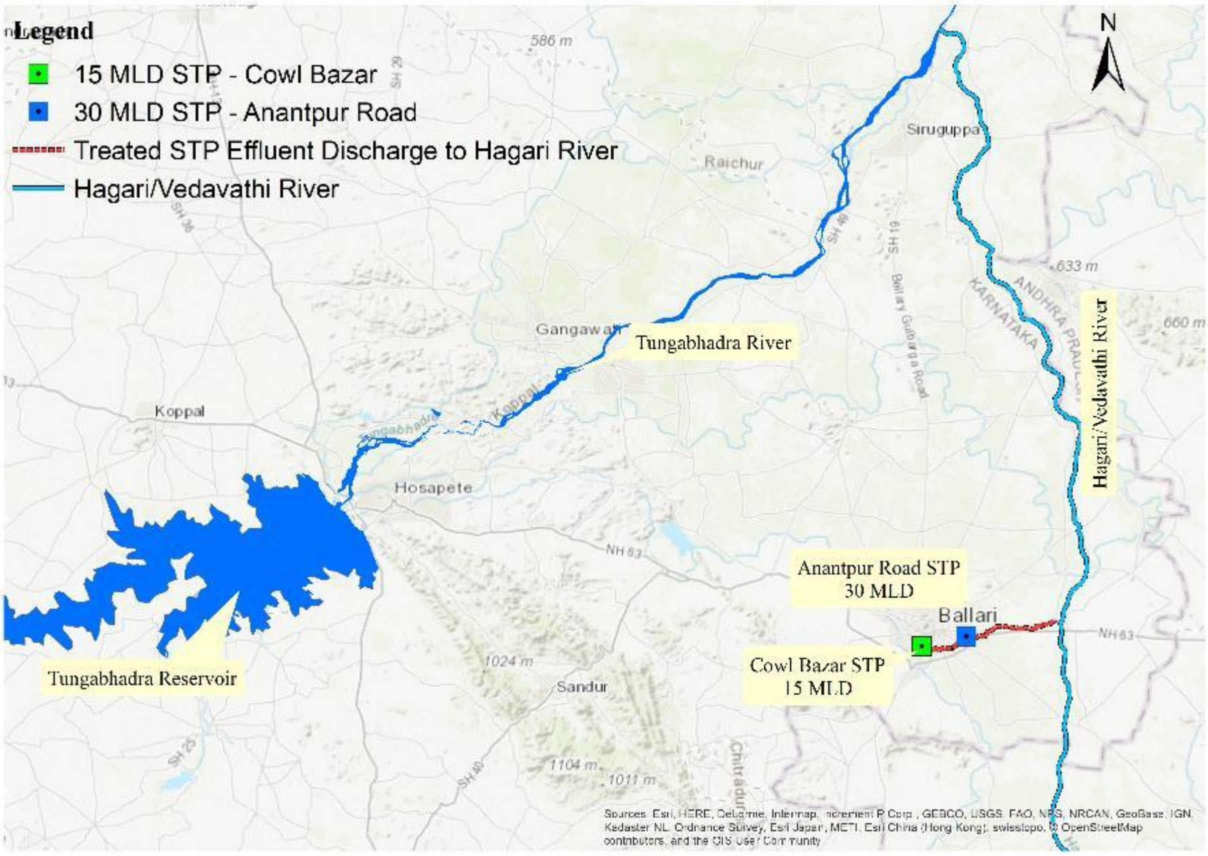

Figure 1-12: Used water treatment plants and existing scheme for disposing treated effluent

Existing Treatment Train Process Description for 30 MLD Ananthpur and 15 MLD Cowl Bazaar UWTP

Both, the 30 MLD Ananthpur UWTP and 15 MLD Cowl Bazaar UWTP use Facultative Aerated Lagoon for used water treatment. The treatment process train is shown the below.

Process units – 15 MLD Cowl Bazaar

Following presents the unit dimension of 15 MLD Cowl Bazaar UWTP.

15 MLD Capacity	
Location	Cowl Bazaar
Primary Treatment	
Inlet chamber	Type: RCC
	Size (all dimensions in m): 2.10 x 4.40 x 0.65
	Penstock gates: 2 numbers
Spin chamber	Type: Automatic
	Automatic Motor Capacity: 1.5 HP
Grit chamber	Type: RCC
	Length: 18.00 m

15 MLD Capacity	
	Width: 1.60 m
	Depth: 1.87 m + 0.5 m (free board)
Division box	Type: RCC
	Size: 0.80m x 6.20m x 0.80m + 0.50m (free board)
	Penstock gates: 2 numbers
Inlet channel type	Mechanical
	Length: 40.50 m
	Width: 0.75
	Depth: 1.5 m
Secondary Treatment Plant:	
Aerated lagoon details	Number of ponds: 2 (east / west)
	Measurement –Eastern: 119.00m x 124.00m x 3.50m +0.50m (free board)
	Measurement –Western: 119.00m x 124.00m x 3.50m +0.50m (free board)
	Number of aerators: 15 HP – 12 numbers
Sedimentation Basin Details	Number of Sedimentation Ponds: Eastern
	Measurement – Eastern 40.00m x 124.00m x 1.75m + 0.60m free board
	Measurement – Western 47.00m x 130.00 x 1.65m + 0.60m free board
Outlet channel details:	Type: Machinery/Mechanical
	135m x 0.75m x 0.95m + 0.5m free board

Process units – 30 MLD Ananthpur

30 MLD Capacity	
Location	Ananthpur Road
Primary Treatment	
Inlet chamber	Type: RCC
	Size: 4.45m x 4.80m x 0.55m
	MLD: 2.35 FB
	Penstock gates: 2 numbers
Spin chamber	Type: Automatic
	Automatic Motor Capacity: 1.5 HP
Grit chamber	Type: RCC
	Length: 18.00m
	Width: 3.00m
	Depth: 1.87m + 0.5 MFB

30 MLD Capacity	
Division box	Type: RCC
	Size: 1.60m x 6.20m x 0.80m + 0.50m (free board)
	Penstock gates: 2 numbers
Inlet channel type	Mechanical
	Length: 80 m
	Width: 1.2 m
	Depth: 1.45 m + 0.6m (free board)
Secondary Treatment Plant:	
Aerated lagoon details	Number of ponds: 2 (east / west)
	Measurement –Eastern: 140.00m x 186.00m x 3.5m +0.5m (free board)
	Measurement –Western: 221.00m x 128.80 x 3.5m +0.5m (free board)
Number of aerators	12.5 HP – 15 numbers (western)
	15 HP – 12 HP (eastern)
Sedimentation Basin Details	Number of Sedimentation Ponds: 2 (east / west)
	Measurement – Eastern 69, 192 m^2+ 0.60 FB
	Measurement – Pond 2: 221.00m x 128.80m x 1.65m + 0.60m (free board)
Outlet channel details:	Type: Machinery/Mechanical
	126m x 0.75m x 1.15m

1.4.3 Current utilisation of secondary treated used water

For Ananthpur UWTP, Ballari Municipal Corporation has got in to a contract with Janaki Corporation Limited for purchasing a minimum binding quantity of 3 MLD of treated effluent at Rs. 4.01 per kL. In case if Janaki Corporation uses more than 3 MLD of treated effluent, a cost of Rs. 4.01 per kL is levied. The cost of infrastructure for transporting the treated water from Ananthpur UWTP to Janaki Corporation premises, including pump house and pipelines, is borne by the Janaki Corporation.

Figure 1-13: Pump infrastructure supplying treated used water from Ananthpur UWTP to Janaki Corporation

Figure 1-14: Discussion with Ballari Municipal Officers at inlet to Janaki Corporation

1.4.4 Pumping Infrastructure

Once the treated used water from Ananthpur UWTP reaches Janaki Corporation, this water is again treated at the UWTP installed within Janaki Corporation premises.

The treated water at Janaki Corporation UWTP is used for following purposes:

- As feed water to boilers for steam production,
- Steam condensation and recirculation for cooling tower at power plants,
- For heat exchange in pellet and sponge iron plants,
- Irrigation and construction works.

The existing treatment process at Janaki Mills 5 MLD UWTP is shown in below.

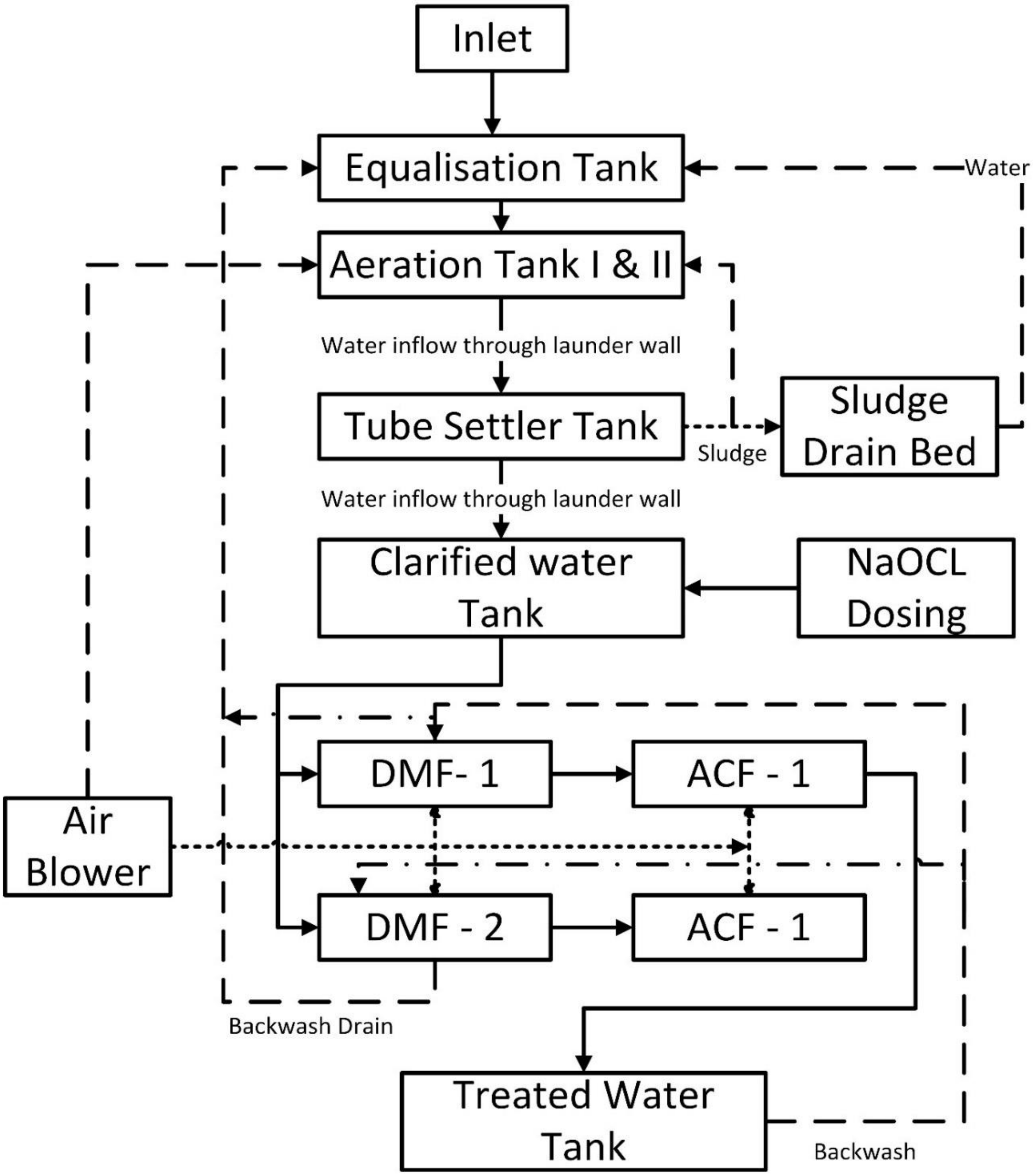

Figure 1-15: Existing treatment process ta Janaki Mill UWTP

1.4.5 Proposed pilot project and identified beneficiaries

In Ballari, sponge iron clusters are located in Belagal, Halakundi, and Veniveerapura. Sponge iron industries use water for the cooling towers and power plants. During water demand survey, 19 sponge iron units have expressed interest in using treated wastewater. Of these, only one unit has a cogeneration power plant. Remaining industries have not invested in a co-generation power plant due to water shortages. At present, all the industrial units use water from private bore wells and purchase water tankers that are sourced through groundwater. Jeans washing cluster in Mundaragi Phase IV industrial area has 53 jeans washing units. These industrial units require about 100,000 litres water per day, and receive their water through private water tankers (Sourced through groundwater from nearby villages). About 25 of these units have an ETP within premises, but none of these ETPs are operational. Upcoming industrial projects such as the Kuduthini Industrial Area and Uttam Galva Steel Plant will significantly add to the future demand of water. The estimated water demand in Kuduthini industrial area is about 07 MLD, while that of steel plants such as Uttam Galva is about another 07 MLD, totalling it to close to 15 MLD.

The water demand of existing sponge units in Ballari is presented in Table 1-1.

Table 1-1: List of iron sponge units in Ballari and their water demand

Name of the sponge iron unit	Water demand (MLD)
Mahamanav Ispat	0.125
Sapthagiri Sponge	0.05
Bhuwalka Steel	0.2
Suvan Steel	0.2
Pragati Ferro Steel	0.2
Hindustan Metals	0.25
Sree Giritej Iron and Steel	0.05
Jairaj Ispat	0.3
Balaji Premium Steel	0.25
Bellary Ispat	0.25
Yeshashvi Steel	0.125
Rangineni Steel	0.1
Supra Steel	0.15
Sree Venkateshwara Sponge	0.15
Popuri Steel	0.1
VKRP	3
Rayen Steel	0.25
Agarwal Sponge and Energy	3
Pavman Ispat	0.075
Total	8.825

Source: Source: Proposal for Pilot Project Reuse of Recycled Water in Karnataka, Urban Development Department, Government of Karnataka.

The proposed project envisages to take secondary treated effluent from the Ananthpur Road UWTP and Cowl Bazaar UWTP, treat it further before supplying the tertiary treated water to sponge iron units in Halkundi, Belagal, Veniveerapura belt, jeans washing units in Mundaragi Phase IV, and to upcoming industries in Kuduthini industrial area. The design capacity of the proposed tertiary treatment plant is 15 MLD, expandable up to 25 MLD. Location for proposed recycled water treatment plant (RWTP) is identified at a 04 Acre plot located in Mundaragi Phase II Industrial Area.

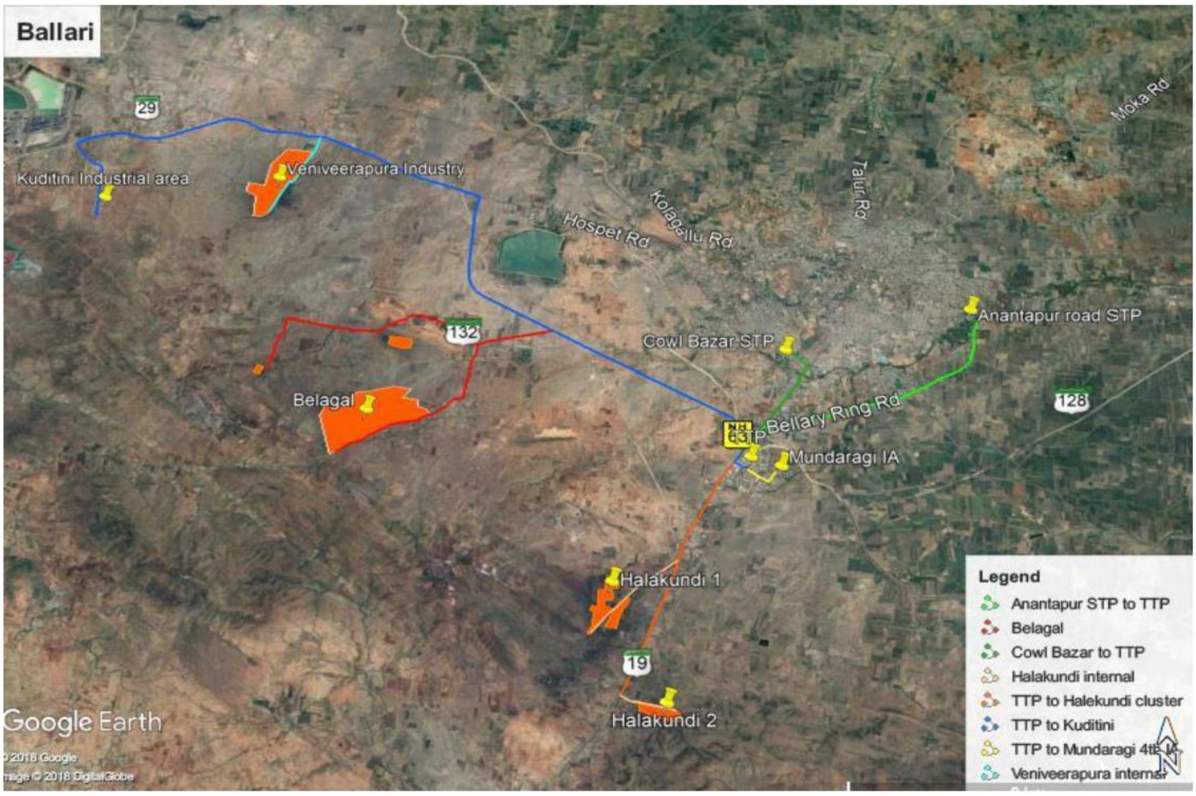

Figure 1-16: Proposed location of RWTP and potentially served Industrial Area

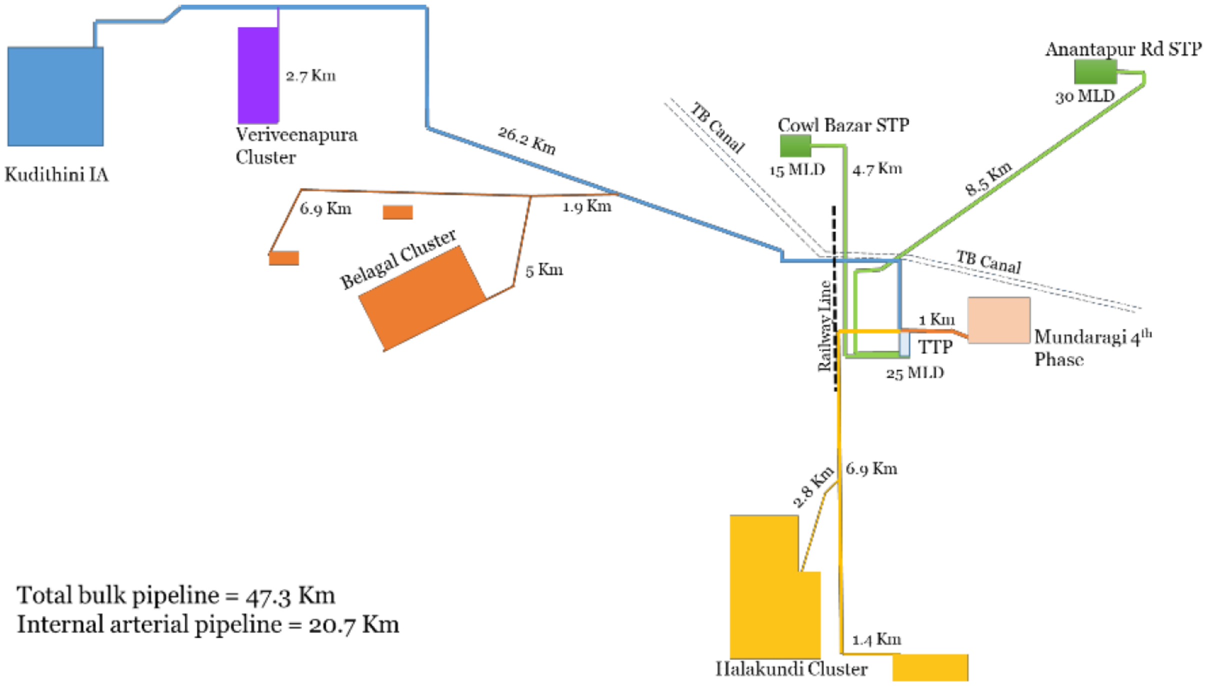

Figure 1-17: Schematic of proposed scheme

The recycled water will be pumped to industries over a distance of 47 kms via two separate pipelines – Southern pipeline from RWTP to Halakundi cluster, and Western pipeline from RWTP to Kuduthini Industrial Area via Belagal and Veniveerapura.

1.5 Report structure

An outline of each section of the report is summarised below:

- **Section 1 – Program background and introduction** provides an overview of the background, strategic planning and objectives for this project, a brief description of water and used water infrastructure status in the city as well as of proposed pilot project.
- **Section 2 – Basis of Design** outlines the key design basis including the relevant codes and standards, recycled water demand projections, wastewater characteristics and flows, water quality targets, existing treatment plant system and residual management.
- **Section 3 – Scheme option and feasibility development** presents the suit of treatment scheme and potential technologies that are considered feasible at the current stage of project.
- **Section 4 – Development of treatment options and feasibility** provides guidance on the treatment scheme options including salting and non-desalting treatment processes.
- **Section 5 – Product Water Integration** details the proposed options for the end uses of the product water.
- **Section 6 – Financial Assessment** details the estimates of capital and operational cost of the selected treatment schemes.
- **Section 7 – Project Delivery Options** details the various commercial options for project delivery.
- **Section 8 – Conclusions and Recommendations** prescribes the actions and steps important for the successful implementation of the project.

2 Basis of design

Following section presents the key aspects that will form the basis of design. It includes applicable policies, codes and standards for recycled water treatment and utilisation, availability, quality and existing treatment scheme of used water,

2.1 Policies, codes and standards for recycled water utilisation

Existing policies, codes and standards for recycled water treatment and utilisation are provided in this section.

2.1.1 Existing policy for reuse in India

Historically, India has limited national policy governing reuse of treated used water. The Environment (Protection) Rules 1986, developed under the Environment (Protection) Act 1906 (Government of India), specifies water quality standards for discharges, including use of treated water for irrigation. Regulation on the use of treated used water for other activities is absent from the document.

However, there has been a push for reuse in more recent years, on both regional and local (building or development level) scale. The National Urban Sanitation Policy 2008 endorses recycling and reuse but abstains from specifying obligations. The National Water Policy 2012 also encourages recycling and reuse of water after treatment but does not outline specific requirements.

More recently in April 2015, CPCB issued a directive to promote non-drinking reuse together with revised treated used water standards. The directive states that:

"secondary treated sewage should be mandatorily sold for use for non-potable purposes such as industrial process, railways & bus cleaning, flushing of toilets through dual piping, horticulture and irrigation."

"no potable water to be allowed for such [above] activities."

"dual piping system should be enforced in new housing construction for use of treated sewage for flushing purposes."

2.1.2 Central Pollution Control Board direction for treatment and utilisation of treated used water

The Central Board in its 168th meeting held on 27.03.2015 resolved to notify the standards for treated used water. These standards for discharge of treated used water from UWTPs have also been endorsed in the Minister's Conference held during April 6-7, 2015 and 59th Conference of Chairman and Member Secretaries of Pollution Control Boards and Pollution Control Committees held on April 8, 2015, and are presented below in Table 2-1.

Table 2-1: CPCB standards for discharge of treated used water

Sl No.	Parameters	Parameters Limit (Standards for New STPs Design after Notification date)*
1	pH	6.5 – 9.0
2	BOD (mg/L)	Not more than 10
3	COD (mg/L)	Not more than 50
4	TSS (mg/L)	Not more than 20

Sl No.	Parameters	Parameters Limit (Standards for New STPs Design after Notification date)*
5	NH_4- N (mg/L)	Not more than 5
6	N- total (mg/L)	Not more than 10
7	Fecal Coliform (MPN/100 ml)	Less than 100
Note: These standards will be applicable for discharge in water resources as well as for land disposal. The standards for Fecal Coliform may not be applied for use of treated sewage in industrial purposes. *Achievements of Standards for existing STPs within 5 years from the date of notification.		

2.1.3 Urban Waste Water Reuse Policy of Government of Karnataka (GoK)

The Government of Karnataka (GoK) approved the Urban Waste Water Reuse Policy in the year 2017 with an overall goal to establish an enabling environment for the reuse of municipal wastewater to maximise efficient resource use, protect the environment, address water scarcity, and enhance economic output. This policy focuses on the reuse of treated wastewater and the associated implications on sustainable sanitation and water resources availability, and considers integrated approach to urban water management emphasising on circular water economy.

This policy envisages to achieve the vision of accelerated adoption of circular economy across major towns and cities of Karnataka with respect to wastewater treatment and reuse through the targets listed below:

- By 2020, 10 major cities[4] have adopted wastewater reuse principles and developed firm plans, to be increased to [100% of all major cities/towns by 2030].
- By 2020, 20% of all secondary treated wastewater (STW) is targeted for reuse across the state, in accordance with regulatory standards; to be increased to 50% by 2030, subject to responsible ecological return flow provisions approved under Integrated Urban Water Management Plans[5].

This policy applies to all Class I and Class II urban centres in Karnataka and focuses largely on recycling after wastewater conveyance through sewer networks and treatment at sewage treatment plants. Separate guidance may be developed for smaller cities and towns that may have alternative wastewater conveyance and treatment systems in place (ex: faecal sludge management systems).

This policy has suggested minimum water quality criteria for reuse of treated wastewater for the following broad sectors as shown in Table 2-2.

A detailed note on Waste Water Reuse Policy of Government Karnataka in presented in **Appendix A**.

Table 2-2: Suggested minimum water quality criteria for different sectors

Suggested minimum water quality criteria for agriculture reuse		
Parameter	Unit	Value
Intestinal nematodes	No./liter	<1

[4] Class I and II cities, corresponding presently to 67 cities and town in Karnataka
[5] This provision accounts for the hydrological principle of return flows, whereby users of treated wastewaters are themselves new generators of wastewater; and whereby net withdrawal of the urban hydrological cycle is limited to evapotranspiration, embedded water in products, and/or lost return flows.

Faecal coliforms	MPN/100 ml	Nil (for crop eaten raw) & <230/100 ml (for crops eaten cooked or non-edible crops			
pH		6 – 9			
Source: Chapter 7, Part A of CPHEEO 2013 Manual on Sewerage and Sewage Treatment					
Typical water quality requirements for industrial reuse					
Constituent (mg/L)	Boiler Feed	Pulp and Paper	Textiles	Petroleum and Coal	Cooling Water*
Calcium	0.01 – 0.4	20	-	75	100
Iron	0.05 – 1.0	0.3 – 1.0	0.3 – 1.0	1	-
Manganese	0.01 – 0.3	0.05 – 0.5	0.01 – 0.05	-	-
Alkalinity as $CaCO_3$	40 – 350	100	-	125	-
Chloride	-	200 – 1000	-	300	100
TDS	200 – 700	-	100	1000	-
Hardness as $CaCO_3$	0.07 – 350	100	25	350	-
Ammonium - N	0.1	-	-	-	1 – 3
Phosphate – P	-	-	-	-	0.6
Silica	0.7 – 30	50	-	-	20
Colour (Hazen)	-	10 - 30	5	-	-
Calcium	0.01 – 0.4	20	-	75	100
Source: Guidance Note for Municipal Wastewater Reuse and Reclamation in India, JICA *2013 CPHEOO Manual (Part A Chapter 7) discusses cooling tower water and boiler water in some details*					

Suggested minimum water quality for environmental/recreational reuse		
Parameter	Unit	Value
BOD5		≤ 10
TSS	mg/L	<5
Faecal coliforms	MPN/100 ml	Nil
pH		6.5 – 8.3
Total Kjeldahl Nitrogen (as N)		<5 for impoundments, <10 for horticulture/golf course
Dissolved Phosphorous (as P)		1
Colour (Hazen)		Non-detect
Source: Chapter 7, Part A of the CPHEEO 2013 Manual on Sewerage and Sewage Treatment		

2.1.4 Recycled water transfer system

Currently, there are no Indian standards or codes exist for a recycled water transfer system. It is anticipated that the same codes as a water transfer/reticulation system can be applicable for a recycled water transfer system.

2.1.5 Residuals (bio-solids) management

Biosolids are produced during the treatment of used water. They contain organic matter and plant nutrients and hence provide a useful soil conditioner and medium grade fertiliser.

However, untreated used water sludge may also contain pathogens (capable of causing disease in humans and animals), microorganisms such as bacteria, viruses, helminths (parasitic worm-like invertebrates), protozoa (small single celled animals including amoebae, ciliates and flagellants) and fungi. These organisms must either be destroyed by treatment or managed through controls on recycling. In addition, biosolids may contain various levels of chemical contaminants including metals from domestic and industrial sources.

In recent years, new treatment methods and technologies have improved the quality of generated biosolids. At the same time, there is growing awareness of the value of this product and increasing demand for its use. Biosolids contain a wide range of essential nutrients that are beneficial for plant growth. These include nutrients, nitrogen and phosphorus, and the trace elements calcium, magnesium, potassium, sodium, manganese, copper, zinc, molybdenum, boron and others. However, it should also be noted that the trend towards improvement in treated used water quality by removal of nutrients via chemical means has the potential to adversely affect biosolids quality by increasing iron or aluminium and associated trace contaminant content.

In India, no guidelines currently exist for the management of biosolids. In several international countries, the USA and Australia for example, the first step in biosolids management is the classification of biosolids according to stabilisation status (including pathogen reduction, vector attraction controls and chemical contaminant levels). Typically, where a sludge or biosolids product does not meet a reuse classification and is to be disposed by landfill, it is classified according to leachate status.

Further safeguards are typically provided by:

- The regulatory pathway determining how the biosolids may be used, dependent on the biosolids classification,
- Limitations on biosolids application rates,
- Monitoring of soil contaminant levels before application,
- Ceiling concentrations for soil contaminant levels,
- Dilution by incorporation into soil, and
- Monitoring of groundwater before application.

Classification and use of biosolids

International guidelines on biosolids management require a level of biosolids treatment to reduce the concentrations of pathogens and contaminants depending on the proposed use of the resource. In Australia, the classification system contains seven categories of biosolids related to recycling or disposal:

- All land application uses, including residential,
- Agriculture - biosolids suitable for land used for the grazing of cattle, crops consumed raw, crops consumed cooked or processed,
- Institutional landscaping: recreational - biosolids suitable for urban land application (such as parks and racecourses),
- Institutional landscaping: non-recreational,
- Forestry, land rehabilitation,
- Municipal landfill, and
- Controlled landfill or thermal processing.

To achieve a classification, the biosolids should comply with:

- The specified stabilisation grade (which includes pathogen reduction and vector attraction controls), and

- Chemical contaminant level limits.

Biosolids disposal options

Since the method of biosolids treatment will be dictated by the chosen disposal route, the available biosolids disposal options will drive the overall biosolids management strategy. Biosolids disposal options are subject to the following considerations:

- Practicability and reliability,
- Security and sustainability,
- Environmental impact,
- Public acceptance,
- Timelines and,
- Economics.

The following final disposal options for treated biosolids were assessed, including:

- Landfill,
- Land application, e.g. agriculture, forestry, horticulture,
- Thermal oxidation with energy recovery (mono- or co-incineration),
- Combustion/ Co-processing (supplementary fuel/ raw material in industry),

The advantages and disadvantages of the most common biosolids disposal techniques are summarised in Table 2-3.

Table 2-3: Advantages and disadvantages of biosolids disposal techniques

Disposal Technique	Advantages	Disadvantages
Landfill	• Little monitoring required • Simple solution • Continuous outlet • Can generate energy from landfill gas	• Not environmentally sustainable • Requires good physical quality • Requires landfill capacity • Health and safety concerns
Land application • Agriculture • Forestry • Horticulture • Land reclamation	• Considered best practice environmental option • Low CAPEX and OPEX • Environmentally sustainable route • Benefits both biosolids producer and user	• Logistically and administratively complex • Requires strict monitoring and control • Requires additional biosolids treatment • Seasonal demand (storage implications)
Thermal oxidation with energy recovery (mono- or co-incineration)	• Largest volume reduction • Destruction of pathogens, toxic organic compounds • Uses calorific value of biosolids • Continuous outlet (no seasonal/ weather impacts)	• High CAPEX and OPEX • Nutrients not recycled • Complicated process – requires skilled operators • Residuals (air emissions and ash) require careful handling • Potential public aversion over health concerns

Combustion/ Co-processing (supplementary fuel/ raw material in industry)	• Complete destruction of biosolids • Uses calorific value of biosolids • Continuous outlet	• High CAPEX and OPEX* • Requires the appropriate industry to use the biosolids as a secondary fuel/ raw material.
*Achieving a biosolids product of sufficient quality for this use may require additional treatment (e.g. biosolids drying to achieve 90%DS), increasing both CAPEX and OPEX		

2.2 Used water quantity and quality assessment

This section presents the used water quantity and quality at Ananthpur and Cowl Bazaar UWTP.

2.2.1 Used water quantity assessment

Ballari City has two used water treatment plants – 30 MLD on Ananthpur Road and 15 MLD at Cowl Bazaar, with two wet wells at Raghavendra Colony and Mahalaxmi Timber that were commissioned in 2004. Another 6 wet wells (six different places in the city) were commissioned in 2012; one at Ballarappa Colony was commissioned in 2014; and two at Azad Nagar and Gonal were commissioned 2017.

On average, Ananthpur UWTP receives around 21 MLD of used water, whereas Cowl Bazaar UWTP receives 9 MLD of water.

2.2.2 Treated used water quality assessment

Both the UWTPs use facultative aerated lagoon (FAL) technology for used water treatment. The aeration is achieved using surface aerators, and aerated effluent is stored in sedimentation tanks, prior to disposal in open drain at downstream.

Following Table 2-4 presents the treated effluent water quality results, and results shows that the treated water did not comply with prescribed limits for BOD, COD and suspended solids.

During discussion with Ballari Municipal Corporation officials, it was learned that the aerators in the UWTPs have not been functioning and also the ponds have not been de-sludged. This could be a potential reason for high BOD, COD and SS in treated effluent.

Table 2-4: Water quality results for treated used water at 30 MLD and 15 MLD UWTPs

SI No	Sample details	Date of sampling	Parameter	Prescribed standard	Result of analysis	
					Eastern outlet	Western outlet
1	30 MLD UWTP	23rd May, 2018	BOD (mg/L)	10	92	158
			COD (mg/L)	50	264	325
			Suspended solids (mg/L)	30	60	40
2	15 MLD UWTP	23rd May, 2018	BOD (mg/L)	10	44	83
			COD (mg/L)	50	183	237
			Suspended solids (mg/L)	30	40	60

Source: Ballari Municipal Corporation

Table 2-5: Effluent discharge standards for sewage treatment plants

Parameter	Unit	Revised CPCB Discharge Standards (Discharge in Water Resources & Land Disposal) for New STPs*	Old CPCB Discharge Standards (Inland Surface Water)
pH	Units	6.5 – 9.0	5.5 – 9.0
BOD	mg/L	≤10	30
COD	mg/L	≤50	250
TSS	mg/L	≤20	100
NH_4 – N	mg/L	≤5	50
N – total	mg/L	≤10	
Faecal Coliform	MPN/100ml	<100	

Source: Directions under Section 18 (1) (b) of the Water (Prevention and Control of Pollution) Act, 1974 regarding treatment and utilization of sewage. Notification dated: 21 April, 2015.

One of the key objectives of CPCB to have these guidelines was to facilitate recycled water production and utilisation.

2.3 Wastewater flows

At present, the Ananthpur UWTP is receiving an average of 21 MLD of inflow and Cowl Bazaar UWTP is receiving 9 MLD of inflow.

2.4 Product recycled water quality guidelines – Indirect drinking reuse (IDR)

Recycled water utilisation for indirect reuse does technically entails to produce water that meets safe drinking water standards, however, it is a prudent approach to reduce public health risks. Recycled water treatment can be employed to provide multiple barriers for removal of pathogens and trace organic contaminants.

In India, and internationally there are no agreed guidelines or standards for IDR. As such an amalgam of WHO, USEPA, Australian Recycled Water Guidelines and Australian Water Quality Guidelines for Fresh and Marine Waters has been adopted in defining the target treated recycled water quality. Table 2-6 gives a summary of the water quality targets for recycled water.

Table 2-6: Treated Recycled Water Quality Targets (Adapted from WHO, USEPA, Australian Recycled Water Guidelines, California Recycled Water Standard & ANZECC Guidelines for Freshwater)

Parameters	Units	Adopted Value	Reason
Alkalinity (as $CaCO_3$)	mg/L	None	Not a health-based target
Aluminium	mg/L	None	Not a health-based target
Ammonia (as N)	mg/L	<1.0	Environmental objective
Bacteria	organism/100 mL	>8.1 log reduction	Pathogen log reduction target based on Campylobacter

Parameters	Units	Adopted Value	Reason
Escherichia Coli (E. coli)	cfu/100ml	<1.0	Health-based target
Boron	mg/L	2.4	Health-based target
Calcium	mg/L	None	Not a health-based target
Chloride	mg/L	None	Not a health-based target
Copper	mg/L	2	Health-based target
Fluoride	mg/L	1.5	Health-based target
Iron	mg/L	<0.3	For aesthetics & control of biofilm growth
Langelier Saturation Index (LSI)		None	Not a health-based target
Magnesium	mg/L	None	Not a health-based target
Manganese	mg/L	<0.1	For aesthetics & control of biofilms
Nitrate (as N)	mg/L	<10	Environmental target for control of nuisance plant growth; For irrigation
pH	mg/L	7.0 to 8.5	Corrosion control & environmental target
Total Phosphorus (as P)	mg/L	<0.2	Environmental target for control of nuisance plant growth
Potassium	mg/L	0.5 to 15	Health-based target
Protozoa	Log reduction	>8 log reduction	Pathogen log reduction target based on Cryptosporidium
SAR		None	Not a health-based target
Sodium	mg/L	None	Not a health-based target
Total Dissolved Solids (TDS)	mg/L	None <500	Not a health-based target for WHO or USEPA India drinking water guideline
Total Organic Carbon (TOC)	mg/L	<0.5	Control biofilm growths & absence of trace

Parameters	Units	Adopted Value	Reason
			organic compounds
Total Nitrogen	mg/L (N)	<10	Control biofilm growths & environmental target for control of nuisance plant growth
TSS	mg/L	See turbidity	
Turbidity	NTU	<0.3 prior to disinfection	WHO and USEPA pathogen control
Viruses	Log reduction	>9.5 log reduction	Pathogen log reduction target. Human health protection or drinking
Water Hardness (as CaCO3)	mg/L	None	Not a health-based target
Zinc	mg/L	None	Not a health-based target
Total Residual Chlorine	mg/L	<5	Health-based target
Total Trihalomethanes Ratio		<1.0	Health-based target
Barium	mg/L	<1.3	Health-based target

2.5 Environmental targets for recycled water utilisation

For recycled water, there is an absence of guidelines for designated of recycled water. Environmental water quality objectives for recycled water are shown in Table 2-6.

The State of Queensland in Australia has developed comprehensive water reuse guidelines (Queensland Government Environmental Protection Agency, 2005). The Queensland guidelines identify five levels of water quality for reuse applications varying from irrigation of non-food crops to applications involving potential for direct human contact. As with California regulations, emphasis is placed on microbiological characteristics and turbidity. Physical and chemical characteristics such as pH, free chlorine, total dissolved solids (TDS) and electrical conductivity (EC) are also included. While several technologies applicable for treating used water to reuse standards are described in the Queensland guidelines, the California standards do not specify prescriptions for specific processes trains or technologies required to produce treated effluent that satisfies the five levels of recycled water quality identified in the guidelines.

Table 2-7 summarizes the quality requirements for Class A+ recycled water which is the highest level and is considered suitable for “dual reticulation to households and industry for toilet flushing, garden irrigation, washing of cars, houses and hard surfaces and many industrial purposes (suitably determined in a case-by-case basis)”.

Table 2-8 summarizes the recommended water quality specifications for Classes A through D recycled water.

Table 2-9 summarizes typical recycle water uses and the corresponding recommended class of recycled water appropriate to each use.

Table 2-7: Recommended Water Quality Specifications for Queensland Class A+ Recycled Water (Queensland

Government Environmental Protection Agency, 2005)

Item	Requirement
Treatment Objective Starting with Raw Used Water (If measured from settled, primary screened sewage, a 0.5 log reduction credit can be applied for bacteria and protozoa and 0.1 log credit for viruses.)	Six log reductions of viruses (bacteriophage as indicator) Five log reductions of bacteria (E. Coli as indicator) Five log reductions of protozoan parasites (Clostridium perfringens as indicator) For irrigation applications, compliance with trigger values for irrigation waters in Chapter 4 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality
Microbiological Criteria	E. Coli <1 CFU per 100 mL (median); <10 CFU per 100 mL (95 %'ile) Clostridium perfringens <1 CFU per 100 mL (median); <10 CFU per 100 mL (95 %'ile) F-RNA bacteriophage <1 PFU per 100 mL (median); <10 PFU per 100 mL (95 %'ile) Somatic coliphage < 1 PFU per 100 mL (median); <10 PFU per 100 mL (95 %'ile)
Physical & Chemical Criteria	Turbidity <2 NTU (95 %'ile), 5 NTU (maximum) For dual reticulation systems, free chlorine residual 0.2 to 0.5 mg/L on delivery to customer. For other Class A+ uses, the need for a chlorine residual should be determined as part of 5-17 the risk assessment. pH 6.0 to 8.5 (if disinfection relies predominantly on chlorine, but not chlorine dioxide) or 6.0 to 9.2 if other disinfection systems are used. For sustainable irrigation, salinity should be kept as low as possible, e.g. if TDS >1,000 mg/L or EC >1,600 µS/cm, a salinity reduction program should be implemented. Any other physical or chemical criteria that the risk assessment phase of a Recycled Water Management Plan has identified as representing a risk to soil, crop or human health.

Table 2-8: Recommended Water Quality Specifications for Queensland Class A through D Recycled Water (Queensland Government Environmental Protection Agency, 2005)

Class	E. Coli (median) CFU / 100 mL	BOD5 (median)	Turbidity (95 %'ile/ max) NTU	TSS (median) mg/L	TDS or EC (medians) mg/L or µS/cm	pH
A	<10	20	2/5	5	1,000 or 1,600	6.0 to 8.5
B	<100	20	-	30	1,000 or 1,600	6.0 to 8.5
C	<1,000	20	-	30	1,000 or 1,600	6.0 to 8.5
D	<10,000	20	-	-	1,000 or 1,600	6.0 to 8.5

Table 2-9: Recommended Recycled Water Classes for Various Uses (Queensland Government Environmental

Protection Agency, 2005)

Recycled Water Class	Recycled Water Use
A+	• Dual reticulation to households and industry for toilet flushing, garden irrigation, washing of cars, houses and hard surfaces and many industrial purposes (suitability determined on a case-by-case basis • Irrigation of field crops (fruits & vegetables), including root crops, eaten raw or with minimal processing • Retail nurseries irrigating ready to eat crops • Industrial uses such as open systems (potential for high human contact) such as a carwash or quarry where aerosol generation is constant • Fire fighting
A	• Above ground open space irrigation with uncontrolled public access of public open spaces and golf courses • Retail nurseries irrigating non-food crops • Various industrial open systems with potential for occasional human contact but with safeguards in place • Fountains and water features with no primary or secondary contact recreation
B	• Irrigating pasture/fodder for dairy animals without a withholding period Wash-down of hard surfaces in agricultural industries
C	• Irrigating pasture/fodder for dairy animals with a withholding period of 5 days • Irrigating pasture/fodder for non-dairy grazing animals except pigs with a withholding period of 4 hours • Irrigation of “no public access” areas • Various industrial closed systems with low potential for human contact • Water features for amenity purposes only and with controlled access • Natural or artificial wetlands
D	• Irrigation of non-food crops such as silviculture, turf, cotton, wholesale nurseries with controlled access and other safeguards to protect the health of workers or neighbours

2.6 Assumptions and limitations

There is very little precedence of advanced recycled water treatment plants -built for reuse applications in India. For this Feasibility Study, some key assumptions were made during the design and cost estimation phases. Such assumptions were based on similar overseas examples and experience acquired through delivering similar projects.

A project risk register needs to be compiled for this project and it is recommended that future project implementation stages for this project comprehensively review, evaluate and address each of the project risks identified for this project. The key areas of assumptions and limitations for the Feasibility Study are listed below:

- Limited water quality and quantity data. It is further assumed that RWTP will receive water quality that complies to CPCB – 2015 treated effluent standards,
- Planning level engineering design,
- Planning level cost estimates,
- Cost and available capacity of the power supply to the proposed site,
- Legal, land and property acquiring costs,

- Environmental, heritage and planning approvals for the proposed pipeline,
- No investigation of geotechnical aspects for the site or pipeline.

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3 Scheme options and feasibility development

This section presents options for recycled water supply schemes that are developed based on the analysis of existing water supply and used water management system in Ballari city and proposed pilot recycled water treatment plant for Ballari by KUWS & DB.

The following points summarise the existing water supply and used water management system of Ballari city.

Table 3-1: Summary of water supply and used water management system of Ballari City

Water supply system of Ballari – Summary
Sources • Tungabhadra Low Level Canal (LLC): 90 MLD water supply for 6-9 months and pumped to 4 WTPs o Additional water from LLC is stored in Allipura Impounding Reservoir o Total quantity: 90 MLD • Tungabhadra High Level Canal (HLC): water supply for 3-5 months
Water Treatment Plants (WTP) • 4 numbers – 85 MLD o Allipura Old WTP – 40 MLD (1975) o Moka Old WTP – 10 MLD (1992) o Sanganakal New WTP – 20 MLD o Allipura New WTP – 15 MLD • Drinking water is supplied once in 5 days to each service area
Used water management system of Ballari – Summary
• ~475 km of UGD network • Two used water treatment plants o Ananthpur Road UWTP – 30 MLD (average flow 21 MLD) o Cowl Bazaar UWTP – 15 MLD (average flow 9 MLD) o Facultative aerated lagoon (FAL) technology

Based on the understanding of existing water supply and used water management system, reuse and recycle scheme options were developed.

3.1 Reuse and recycle scheme options development process

Identification of end users and desired quality of tertiary treated water, and estimated demand for both current and future scenarios are necessary to establish the reuse goals for this pilot project. These have been identified and are as below.

- Types of major end users

Steel industry, sponge iron units, denim washing

- Estimated demand:

Current – 15 MLD
Future – 25 MLD

- Desired recycled water quality

Depends upon end use and industry types
E.g. boilers use water with low hardness

3.2 Proposed recycled water supply scheme (by KUWS & DB)

The pilot project proposed by KUWS & DB intends to convey secondary treated effluent from two existing used water treatment plants to recycled water treatment plant (RWTP), and further supply recycled water to industrial areas. The schematic in Figure 3-1 presents the proposed recycled water supply scheme.

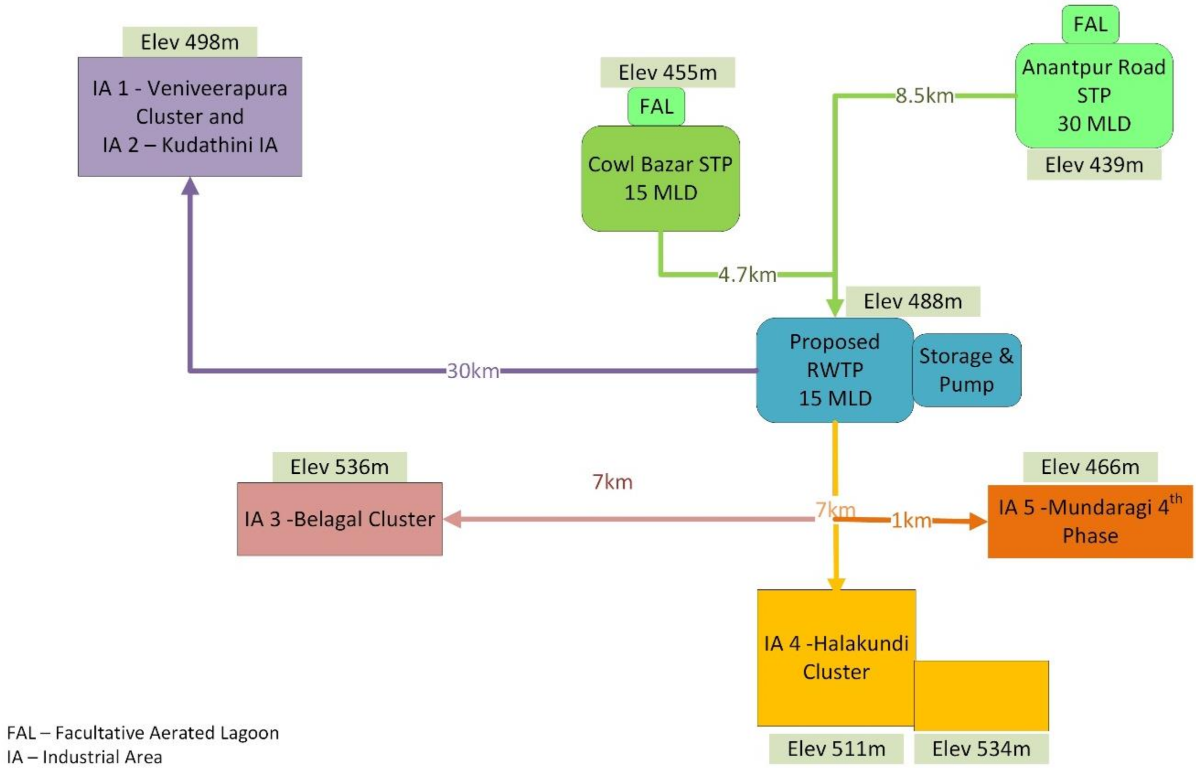


Figure 3-1: Schematic of proposed recycled water supply scheme (by KUWS & DB)

Figure 3-2 presents a bird's eye view of proposed recycled water supply scheme on terrain view of google earth with conveyance pipeline alignment and respective elevation to assess the pumping needs.

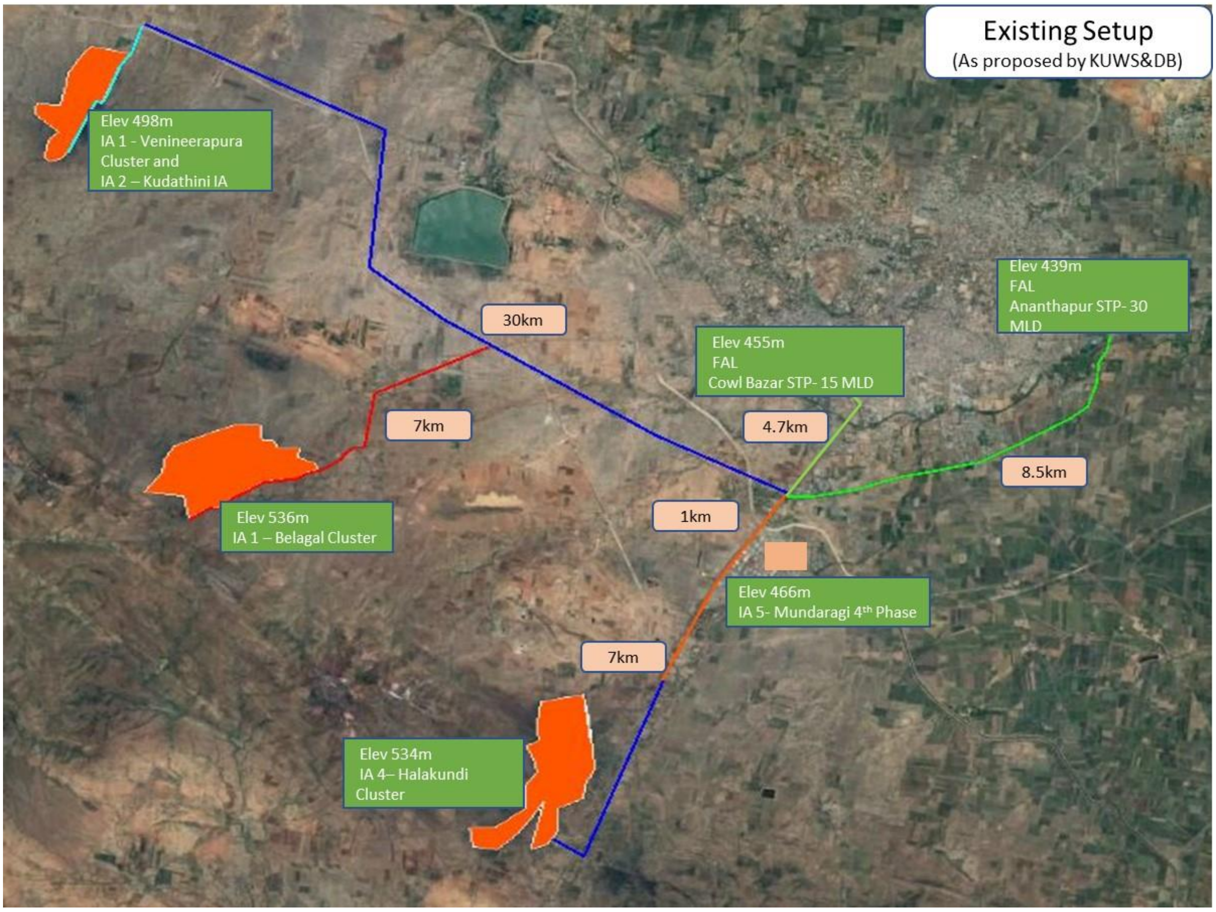


Figure 3-2: Bird's eye view of proposed recycled water supply scheme with pipeline alignment

Some of the challenges of this proposed pilot project are:

- The treated effluent quality in both UWTPs is non-compliant with CPCB standards,
- Treatment technology is very old (facultative aerated lagoon - FAL),
- Risk to operation of RWTP due to unreliable influent water quality,
- High operation and maintenance (O&M) cost for RWTP.

The biggest opportunity of this pilot project will be availability of tertiary treated recycled water for industries in this water scarce region.

3.3 Reuse and recycle scheme options

Following reuse and recycle scheme options are developed to meet the reuse goals.

Option 1: Upgrade treatment process (retrofit) at existing 30 MLD Ananthpur UWTP

a. Convey treated effluent from existing 30 MLD Ananthpur UWTP to new standalone ARWTP (at Mundaragi 4th Phase Industrial Area), treat and supply to industrial areas

b. Co-located ARWTP at existing Ananthpur UWTP location, treat and supply to industrial area

Option 2: Decommission existing 30 MLD Ananthpur UWTP and construct a new UWTP; convey treated effluent to new standalone ARWTP (at Mundaragi 4th Phase Industrial Area), treat and supply to industrial area

<u>Option 3:</u> Construct new UWTP+ARWTP at Ananthpur Road UWTP premises

The following sub-sections explain the options in detail.

3.3.1 Option 1: Upgrade treatment process (retrofit) existing 30 MLD Ananthpur UWTP

This option will have following features:

- Produces secondary treated effluent better than existing quality and meets CPCB standards,
- Utilises existing infrastructure with additional cost for reactors and clarifiers,
- Does not use multi-barrier treatment, unfit for human contact,
- Proper O&M is critical for this option as higher O&M cost for treatment plant at two locations.

Treatment units in this option are as in Figure 3-3.

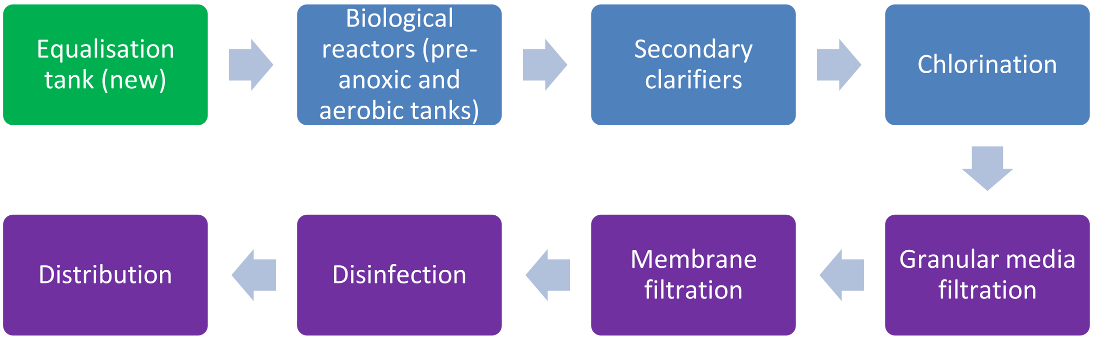


Figure 3-3: Treatment train for Option 1

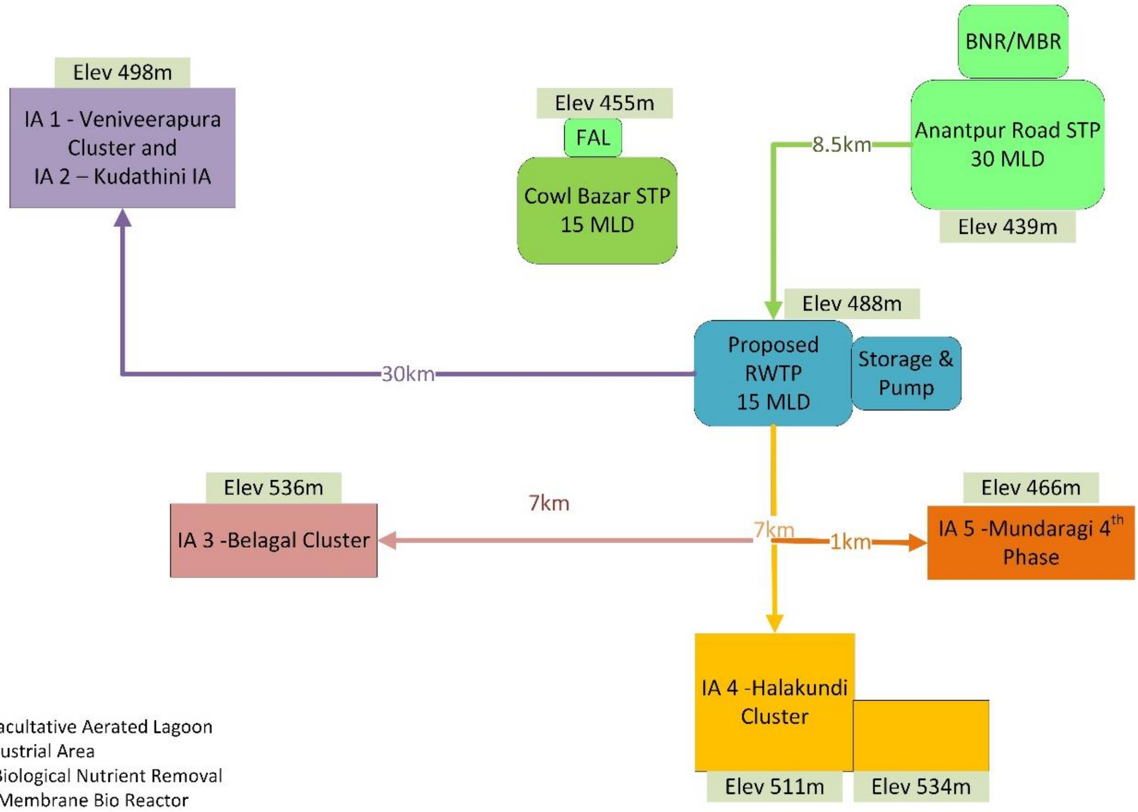
Option 1a: Upgrade existing treatment process, standalone RWTP

The challenges and opportunities for Option 1a are listed in the below.

Table 3-2: Challenges and opportunities - Option 1a

Challenges	Opportunities
• Upfront capital cost investments, • O&M costs at two locations, • May require an external O&M contractor, • Less reliable RWTP influent quality, plant operation, and hence recycled water quality	• CPCB compliant treated secondary effluent, • Minimize UWTP modifications • Separate delivery models possible for RWTP

The schematic and bird's eye view on terrain of Option 1a are presented in Figure 3-4 and Figure 3-5 respectively.



FAL – Facultative Aerated Lagoon
IA – Industrial Area
BNR – Biological Nutrient Removal
MBR – Membrane Bio Reactor

Figure 3-4: Schematic for Option 1a

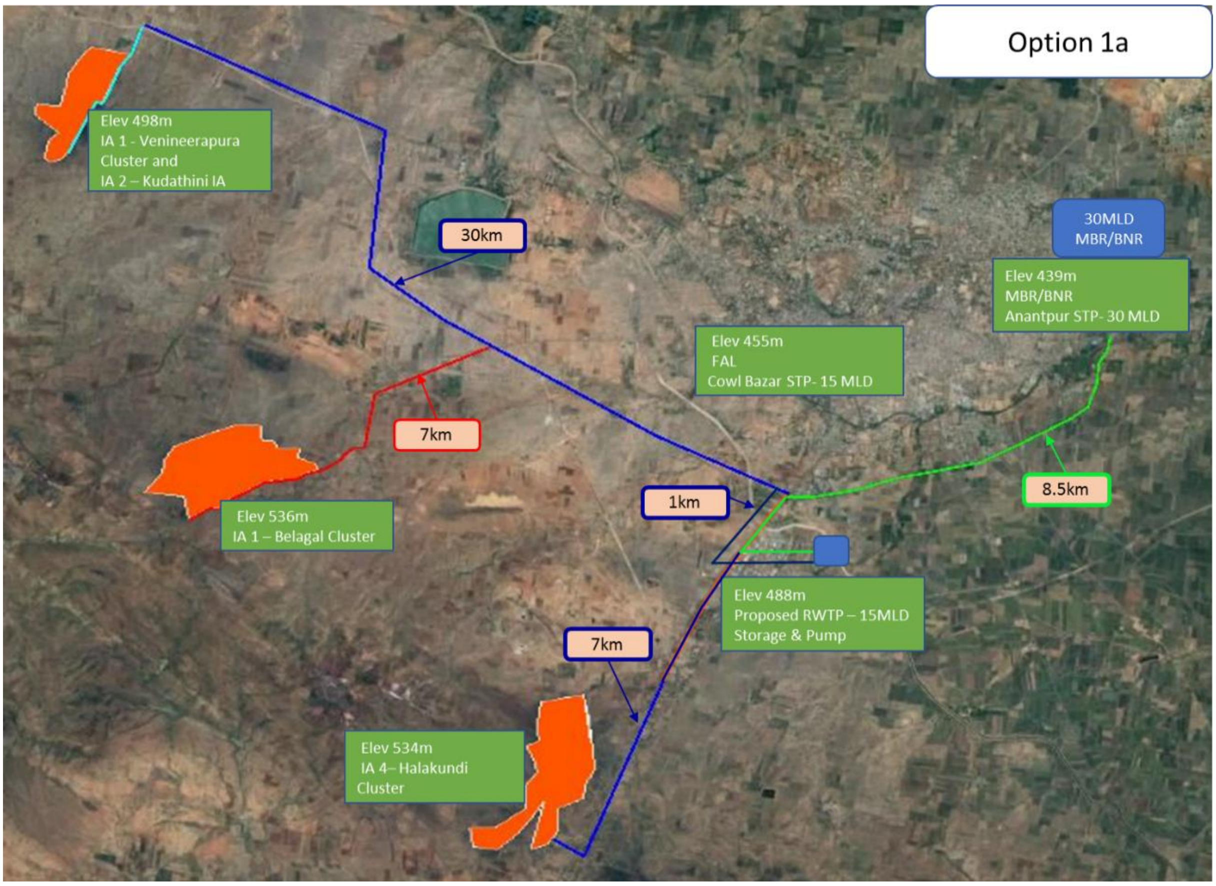


Figure 3-5: Aerial view of Option 1a

Option 1b: Upgrade existing treatment process, co-located RWTP at Ananthpur

Option 1b recommends upgrading the existing 30 MLD Ananthpur UWTP so that the treated effluent meets CPCB requirements, and co-locate ARWTP at 30 MLD Ananthpur UWTP site.

The challenges and opportunities associated with Option 1b are shown in Table 3-3.

Table 3-3: Challenges and opportunities - Option 1b

Challenges	Opportunities
• May require an external O&M contractor, • Operation of integrated treatment process	• Relatively lower land and capital costs, • Lower O&M costs due to co-location, • CPCB compliant treated effluent, • More reliable RWTP influent quality and plant operation, superior quality recycled water production,

The schematic and bird's eye view on terrain of Option 1b are presented in Figure 3-6 and Figure 3-7 respectively.

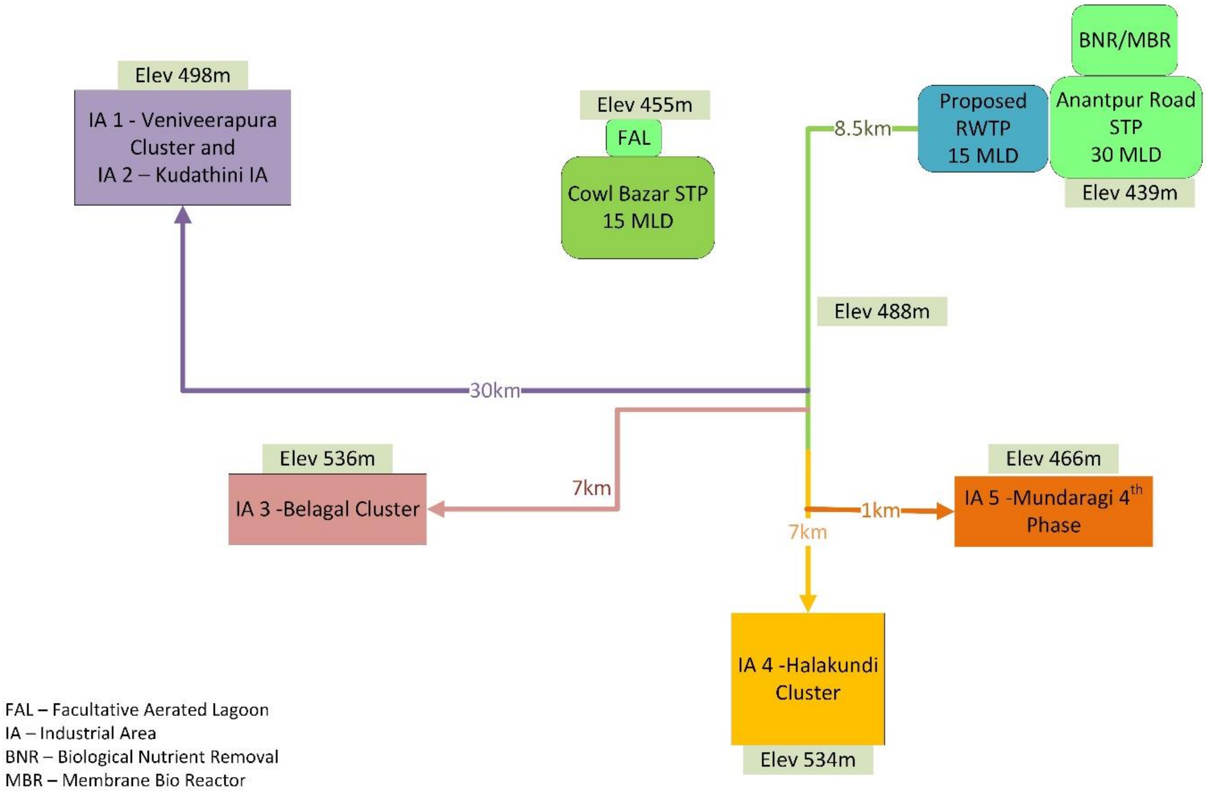


Figure 3-6: Schematic for Option 1b

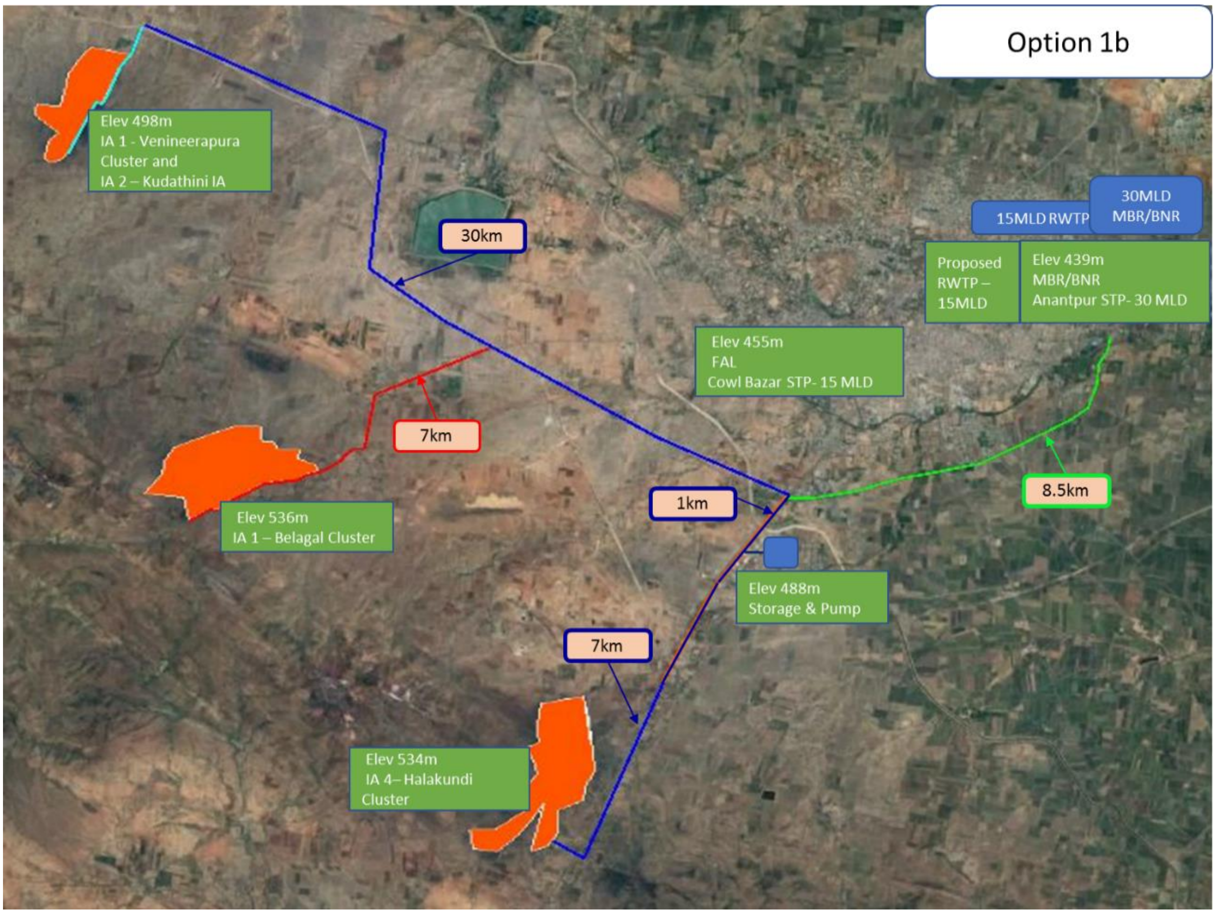


Figure 3-7: Aerial view of Option 1b

3.3.2 Option 2: Construct new UWTP and standalone RWTP

Option 2 recommends decommissioning the existing 30 MLD Ananthpur UWTP, and construct a new one of the same capacity. The ARWTP will be located close to Mundaragi 4th Phase Industrial area (at the same location identified under KUWS&DB proposal).

Option 2 will have following features:

- Produces high quality treated effluent and meets CPCB standards,
- Utilises existing land with additional cost for reactors and membrane,
  - Higher cost than Option 1
- Use multi-barrier treatment, and produce high quality recycled water,
- Proper O&M is critical for this option as higher O&M cost for treatment plant at two locations.

Treatment units in this option are as in Figure 3-8Figure 3-3.

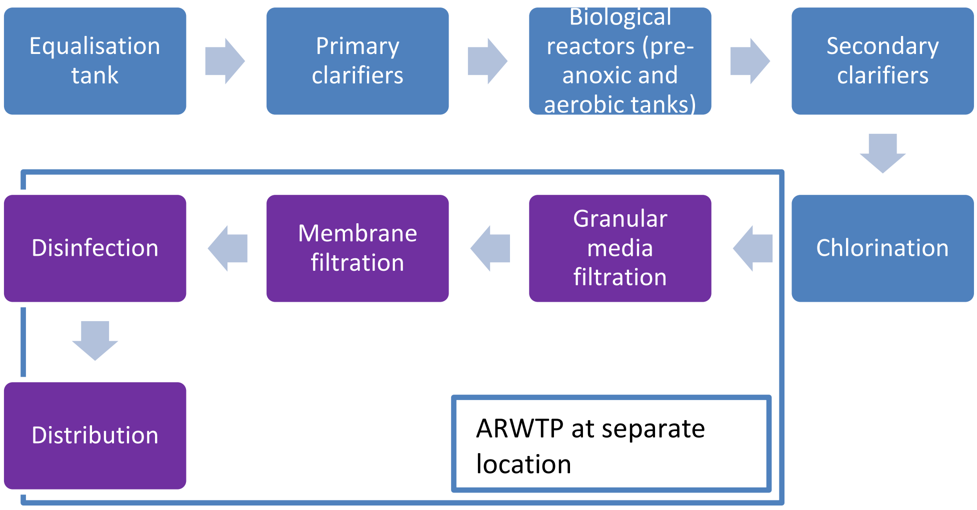


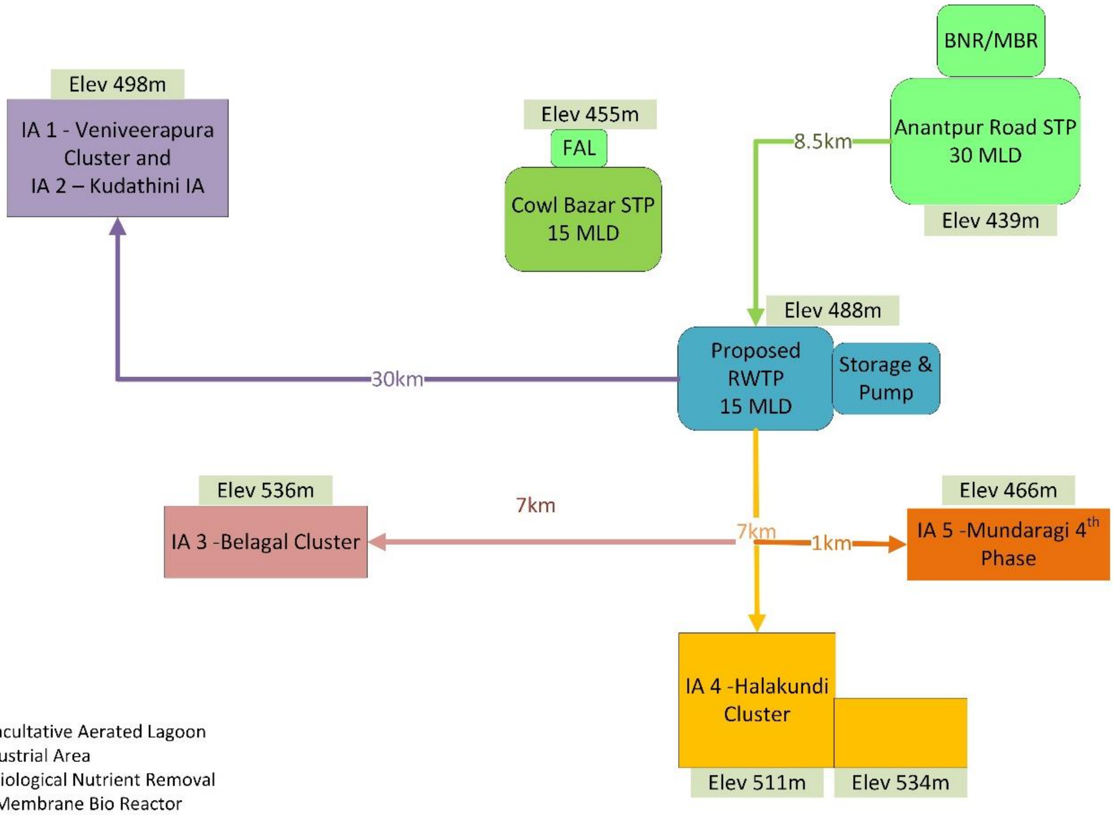
Figure 3-8: Treatment chain for Option 2

The challenges and opportunities for Option 2 are listed in the Table 3-4 below.

Table 3-4: Challenges and opportunities - Option 2

Challenges	Opportunities
• Upfront higher capital cost investments, • O&M costs at two locations, • May require an external O&M contractor,	• Leveraging latest treatment technology, • Surpassing CPCB treated secondary effluent, • High quality recycled water production, • Higher industrial uptake leading to improved revenue generation through proper pricing.

The schematic and bird's eye view on terrain of Option 2 are presented in Figure 3-9 and Figure 3-10 respectively.



FAL – Facultative Aerated Lagoon
IA – Industrial Area
BNR – Biological Nutrient Removal
MBR – Membrane Bio Reactor

Figure 3-9: Schematic for Option 2

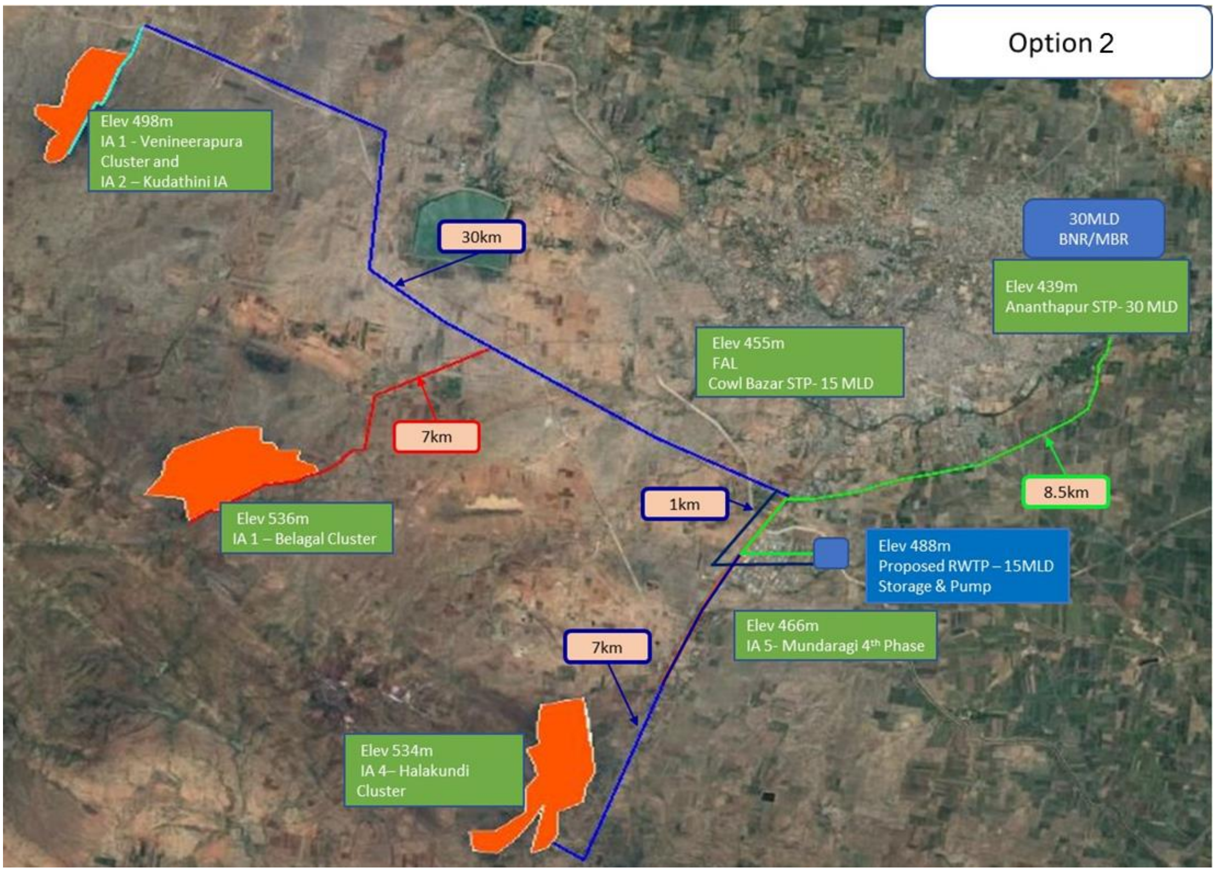


Figure 3-10: Aerial view of Option 2

3.3.3 Option 3: Construct new UWTP and RWTP at Ananthpur Road

Option 3 will have following features:

- Produces high quality treated effluent and meets CPCB standards,
- Lower capital cost as compared to Option 2,
- Uses multi-barrier treatment, and produces high quality product water
- Lower O&M cost as compared to Option 2, better suited scheme for recycled water production and distribution.

Treatment units in this option are as in Figure 3-11Figure 3-3.

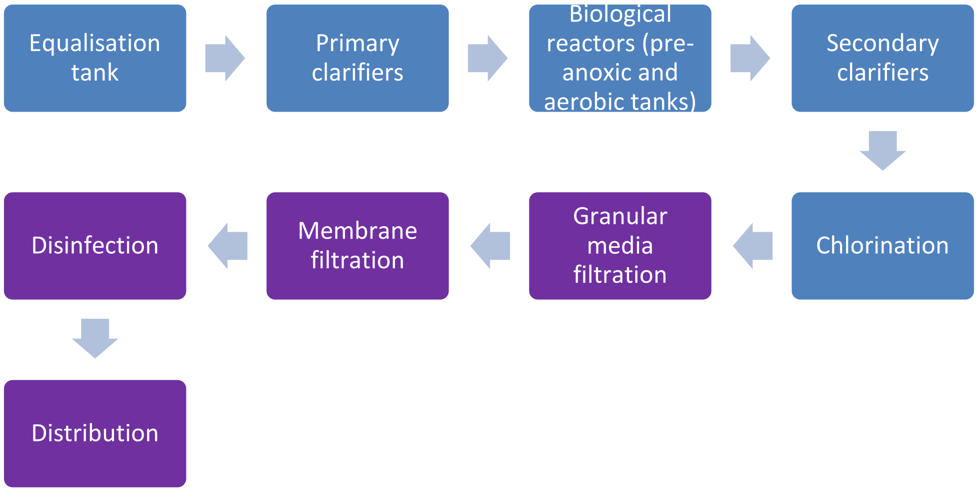


Figure 3-11: Treatment chain for Option 3

Option 3 recommends decommissioning the new construction of 30 MLD Ananthpur UWTP, and co-locate ARWTP at 30 MLD Ananthpur UWTP site.

The challenges and opportunities associated with Option 3 are shown in the table below.

Table 3-5: Challenges and opportunities associated with Option 3

Challenges	Opportunities
• Upfront higher capital cost investments, • O&M costs at two locations, • May require an external O&M contractor,	• Leveraging latest treatment technology, • Surpassing CPCB treated secondary effluent, • High quality recycled water production, • Higher industrial uptake leading to improved revenue generation through proper pricing.

The schematic and bird's eye view on terrain of Option 3 are presented in Figure 3-12 and Figure 3-13 respectively.

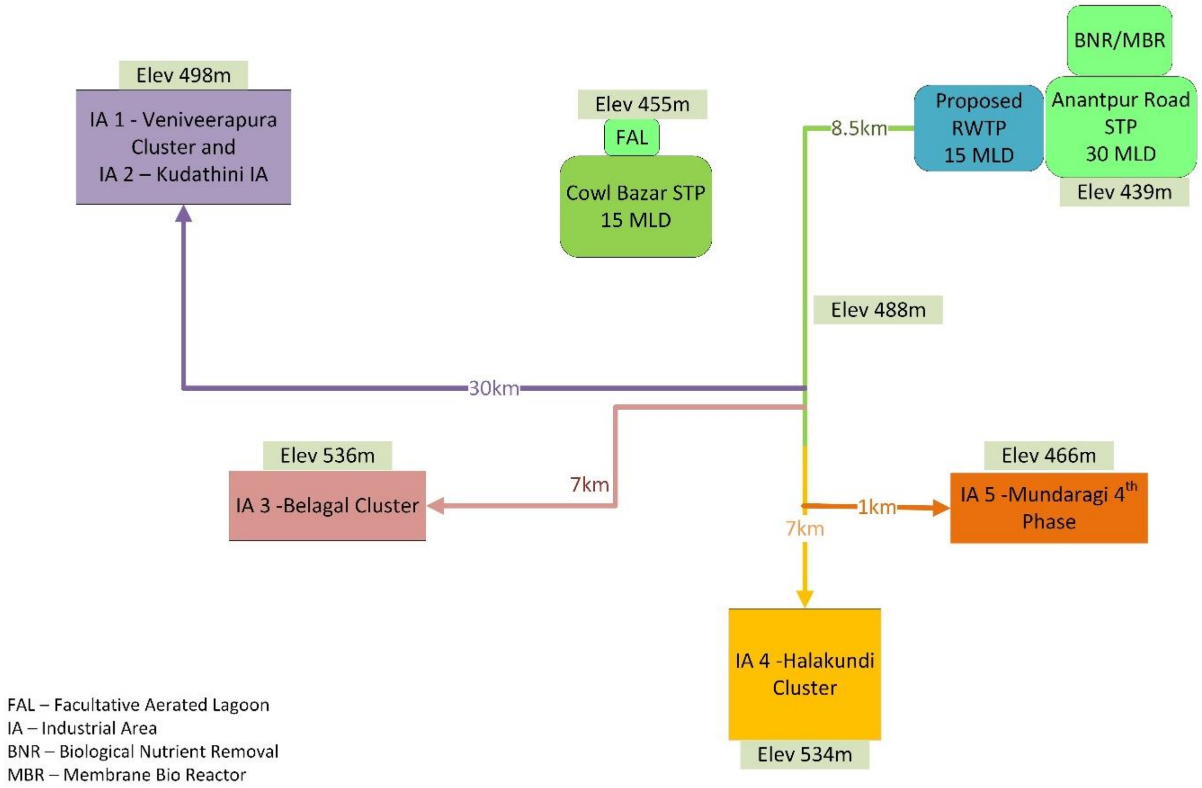


Figure 3-12: Schematic for Option 3

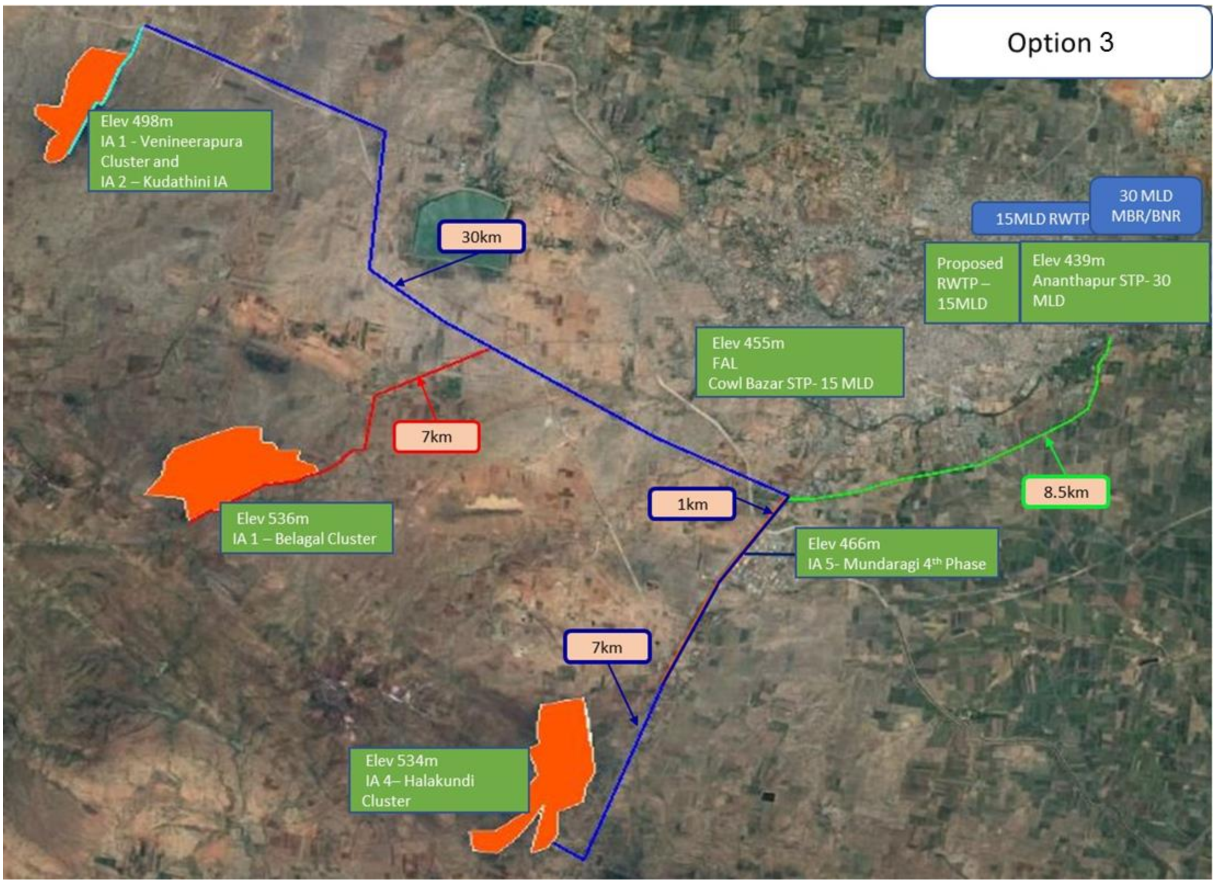


Figure 3-13: Aerial view of Option 3

3.4 Potential approach

To summarise, two potential approaches for this pilot reuse and recycle scheme have been developed and are explained as below.

1. **Approach 1**: In this approach, a stand-alone and a new RWTP will be constructed which will have secondary treated effluent from both existing UWTPs (30 MLD Ananthpur Road and 15 MLD Cowl Bazaar) as input, and treated tertiary effluent will be supplied/sold to the industries. In this approach there will be no storage of tertiary treated effluent.
2. **Approach 2**: In this approach, the existing 15 MLD capacity Cowl Bazaar UWTP will be decommissioned, and a new RWTP will be co-located at Ananthpur Road along with existing 30 MLD UWTP. The tertiary treated effluent from RWTP will be conveyed to a Recycled Water Storage and from this storage, recycled water will be supplied/sold to the industries.

Figure 3-14 depicts potential approaches of implementing recycle and reuse scheme.

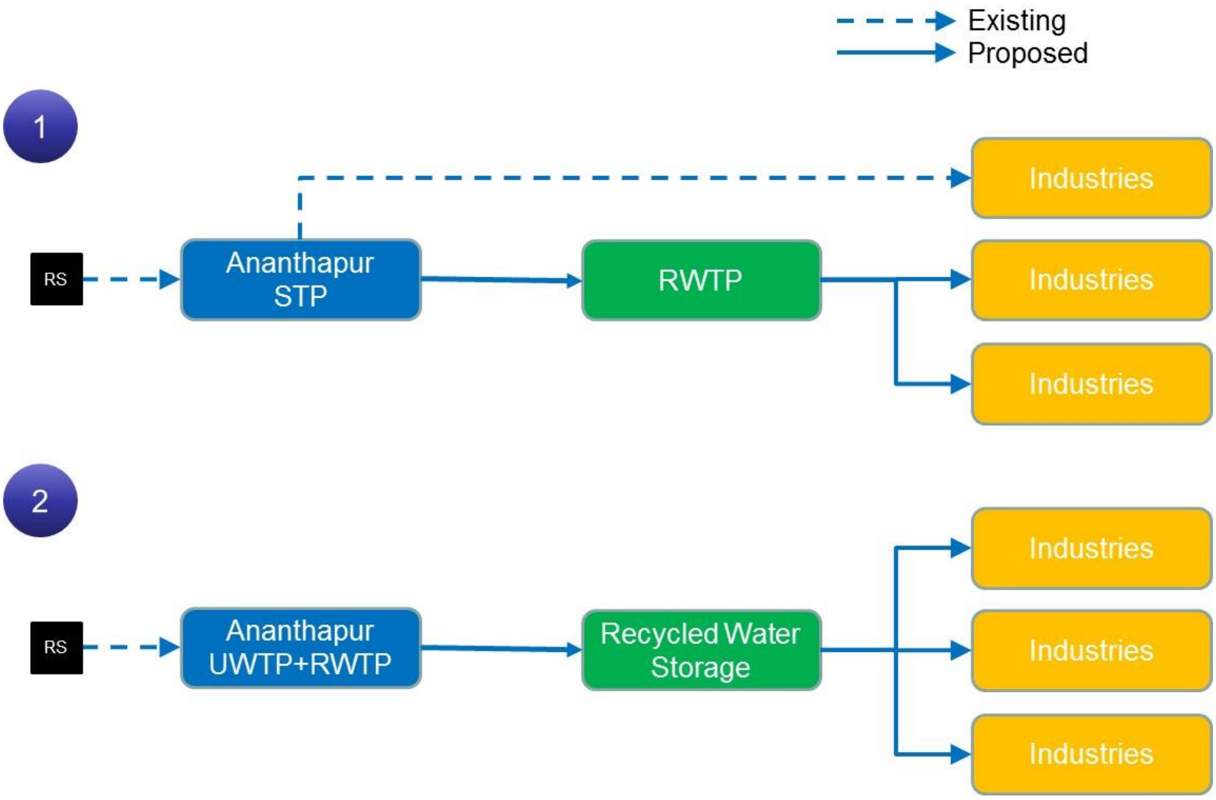


Figure 3-14: Potential approaches of implementing RWTP scheme

3.5 Way forward

- Selection of most preferred recycle and reuse scheme (out of options 1 and 2) and treatment technology will be based on Quadruple Bottom Line, which will depend on social, environmental, technical and financial criteria.

Evaluation of treatment technology will be based on influent water (raw sewage) quality, effluent requirement based on end uses, capital expenditure (CAPEX) and operation & maintenance (O&M) considerations.

4 Development of treatment scheme options and feasibility

This section describes and evaluates a shortlisted set of recycled water treatment plant options for the suitability of this project. Arriving at a treatment train for recycled water treatment is based on various parameters to meet the project specific objectives including economic, environmental and social criteria. Salt management is also a concern with large-scale advanced water recycling plants that use membranes such as RO.

4.1 Non-desalting treatment train options elected

Non-desalting options were systematically evaluated to achieve the project objectives and arrive at the most suitable process train.

Whilst there are many process options that could be considered, the selection of suitable options has been on the basis that the process and equipment used has been fully developed and has been proven operationally to be able to produce water of an acceptable standard. There are several processes and equipment which may prove suitable in the longer term but are not at this stage sufficiently developed to warrant serious consideration. From consideration of current processes and equipment available, the main process option emerges as the possible choice for the ARWTP. These are:

- Membrane Based Treatment Process (Microfiltration or Ultrafiltration)

Figure 4-1 provides a summary of the treatment option that have been considered in this study.

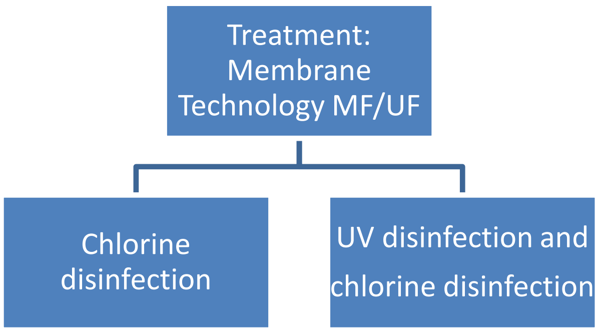


Figure 4-1: Process selected for Recycled Water Treatment Plant

Ultrafiltration low pressure membrane treatment process is considered in place of the conventional clarification and filtration. All other units are like conventional treatment except that membrane process has no chemical sludge generation for which no sludge handling option is considered.

Ultrafiltration membrane treatment is like filtration technology wherein suspended solids and other high molecular weight solutes are separated from water using means of a semipermeable membrane as a filter. This separation process is widely used in industries for purification of solutions. This technology can remove very fine particles and can be applied in cross-flow or dead-end mode.

Some of the key features of this treatment option are:

- State-of-the-art technology being used actively in Singapore, Australia and the United States,
- Reliable and proven technology in effective removal of microorganisms, pathogens and colloids

above the rated size,
- High technology (expensive solution),
- Automatic operation and maintenance.

The advantages and disadvantages of this are summarised in the Table 4-1.

Table 4-1: Advantages and disadvantages of this option

Advantages	Disadvantages
Fully automatic. Less human intervention	Unable to remove dissolved organics
Effective removal – microorganisms, pathogens and colloidal particles above rated size	High maintenance. Periodic removal of membranes [after every five (5) years]
No generation of chemical sludge – Sludge handling and disposal system is not needed	Membrane is susceptible to fouling. Solids recovery may drop due to fouling and of membrane
Compact technology. low area requirements	Energy consumption is high
	High capital cost
	Consistent feed quality to be maintained – Sensitive membrane

The two treatment options utilising non-desalting option and desalting option are shown in Figure 4-2 and Figure 4-3.

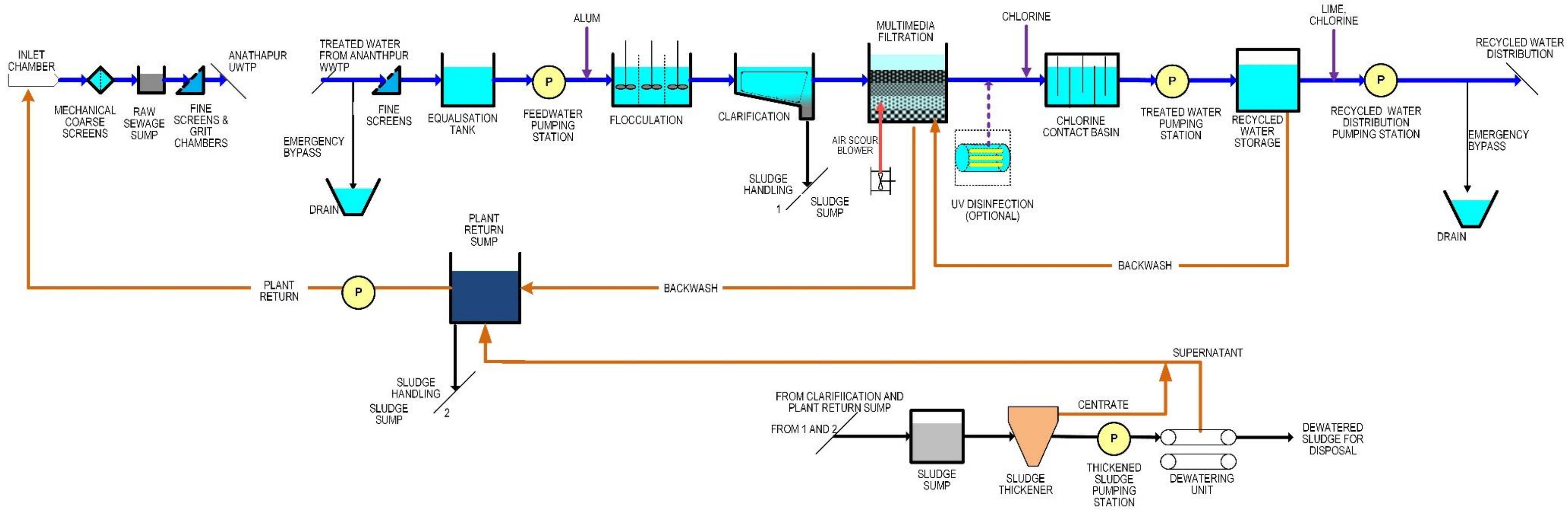


Figure 4-2: Process flow diagram for non-membrane treatment technology option, and using UV Disinfection (optional)

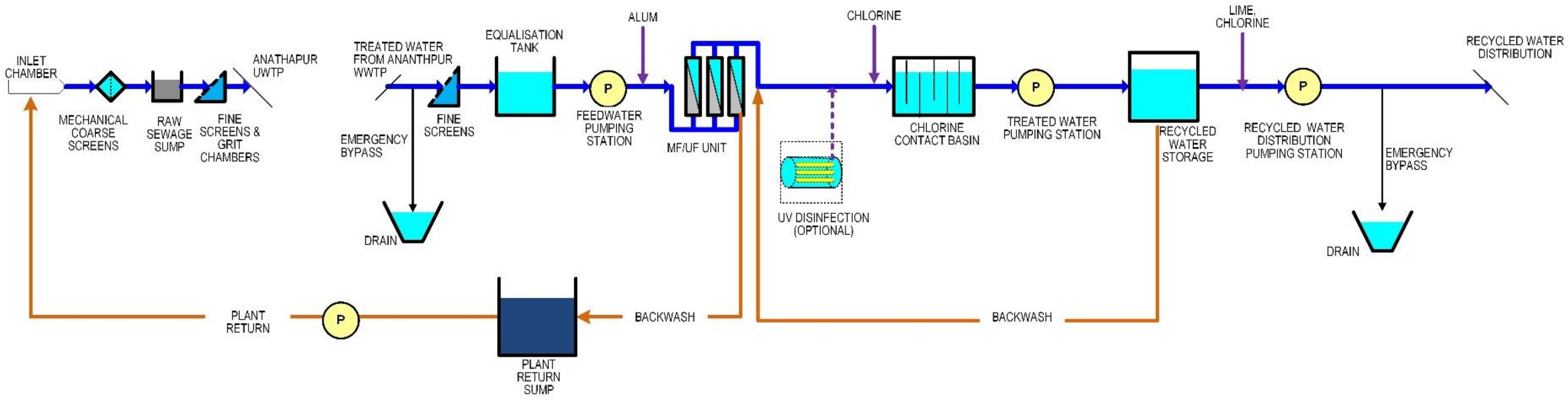


Figure 4-3: Process flow diagram for membrane treatment technology option, and using UV Disinfection (optional)

4.2 Ultraviolet (UV) disinfection system

Chlorine disinfection is the traditional disinfection process post any water treatment. However, it is also considered to use UV disinfection in addition to chlorine disinfection in this treatment. This addition of UV disinfection is strictly optional. This section provides the features of the UV disinfection system.

Ultraviolet disinfection refers to a disinfection process using electromagnetic energy that it produces by a mercury arc lamp. The UV radiation disrupts the generic materials of the microbe resulting in stopping the reproduction of the pathogens.

UV light inactivates microbial pathogens by causing damage to microbial DNA and other protein-based structures within the organism (such as RNA, enzymes and cellular polymers).

The damage to the cell DNA often does not prevent the cell from undergoing metabolism and other cell functions, however; it is intended to prevent the cell from replicating, meaning that the pathogen can no longer infect a host.

The maximum absorbance of UV light by the proteins that make up DNA has been shown to occur at approximately 254 nm, hence the development of UV technologies that operate at this wavelength.

Low pressure, high output systems are available in both in-channel (open vessel) and in-pipe (closed vessel) systems. For the purposes of this design investigation, a medium-pressure in-pipe system is proposed. The selection of the UV system type and model can be considered during later design stages, if required.

Figure 4-4 elaborates on the strengths and weaknesses of UV disinfection system:

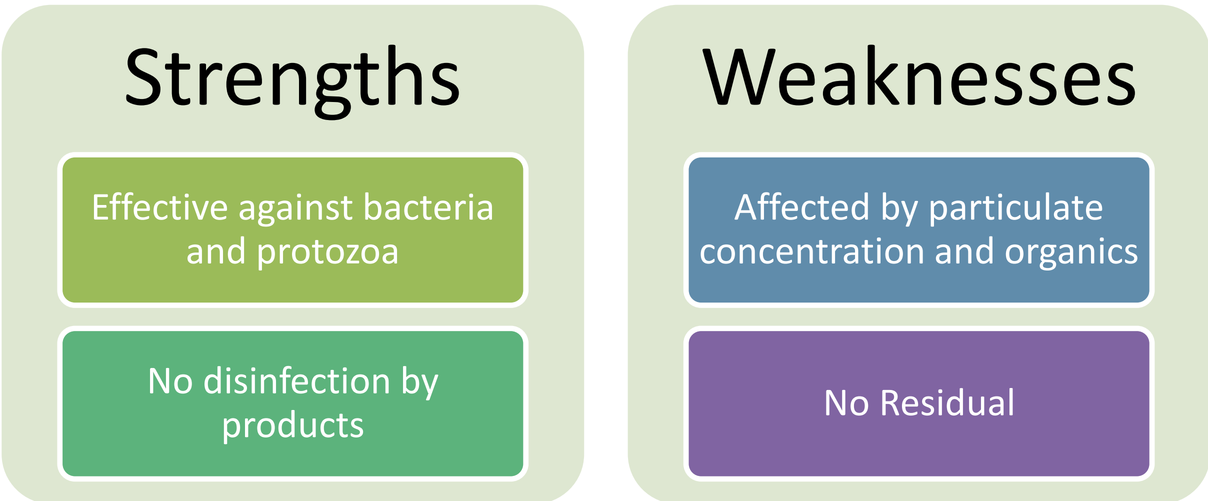


Figure 4-4: Strengths and weaknesses of a UV disinfection system

4.3 Preferred advanced recycled water treatment train option

It is understood that land availability is not an issue in Ballari UWTP as ample amount of land is available in the premises of existing 30 MLD UWTP on Ananthpur Road.

It is further evaluated that as the end use of the product water is strictly for non-drinking purposes, the water tariff needs to be in check. This implies that the CAPEX and OPEX of the treatment technology should be reasonable.

Factoring these criteria, the Membrane Treatment and Non-Membrane Treatment will be deliberated and selected in the Preliminary Design Stage.

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5 Product water integration

The pilot proposal submitted by Urban Development Department, GoK, clearly establishes the industrial demand and willingness of existing industries to consume tertiary treated used water. This willingness of industries to buy tertiary treated used water makes a strong case to implement this recycle and reuse scheme in Ballari City. These industries are located in different industrial areas around Ballari City, which are as below:

- Veniveerapura industrial cluster
- Kudathini industrial area
- Belagal industrial cluster
- Halakundi industrial cluster
- Mundaragi industrial 4th Phase

Further, potential industrial consumers would be:

- Two proposed large capacity steel plants with a combined potential demand of 15 MLD:
  - Arcellor Mittal and
  - Uttam Galva
- Industrial areas developed by Karnataka Industrial Area Development Board (KIADB) in the vicinity of Ballari City - Mundaragi (Phase I to IV), Sanklapura (Phase I, II) and Ananthpur Road IA, spread over 522 acres

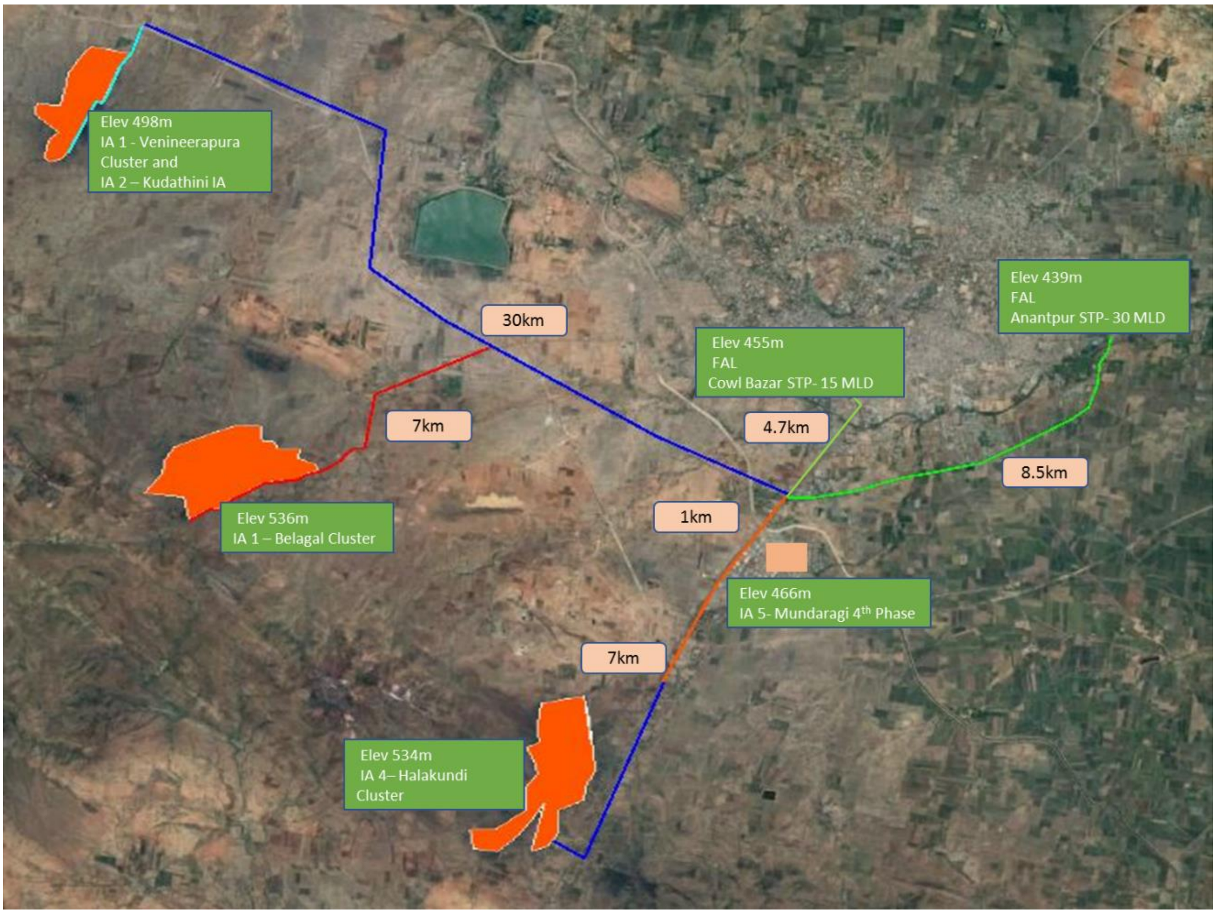


Figure 5-1: Potential product water users: Ballari ARWTP

5.1 Product water storage, conveyance and pumping options

Detailed reticulation system planning is not a part of the scope of this project. However, the Preliminary Design deliverable will provide details of most feasible storage, conveyance and pumping options.

It is assumed that the conveyance pumping options for end users will be further refined by KUWS & DB.

6 Financial assessment

This section outlines the basis of capital and operating costs for a 15 MLD (expandable to 25 MLD) Advanced Recycled Water Treatment Plant (ARWTP) to produce highly purified water suitable for non-drinking uses. This section details the preliminary cost estimates for both options of treatment (with and without UV disinfection option).

The accuracy of the cost estimate is commensurate with the details provided to develop the design for this study. This is a preliminary estimate without detailed understanding of the water quality, geotechnical and other issues. The estimate would therefore be expected to have an accuracy of about ±30% and will change once more detailed information is available.

It is also to be noted that a more detailed costing will be provided in the next deliverable.

6.1 Basis of estimate

This section outlines the basis of the cost estimate and includes the methodology for developing the cost estimate including:

- The techniques used to obtain budget pricing for the capital cost estimates,
- The methodologies used in calculating the indirect cost estimates.

The comparative cost estimate was developed using JACOBS' Parametric Cost Estimating System (CPES). CPES was implemented to develop project specific capital and operating costs based on process design inputs and local adjustment factors.

To complement the cost estimating tool, several inputs were provided to refine the cost estimate for this project. These include:

- Cost estimates, technologies, labour rates and equipment rates used on local projects of similar nature,
- Confirmation of CPES cost estimates using local experience,
- Budget prices from suppliers for process equipment, piping, chemicals and other miscellaneous items.

Capital and operations and maintenance cost estimates were based on the conceptual design, preliminary drawings and equipment list.

Direct cost estimates for large equipment items such as the MF/UF membranes and UV were provided by suppliers and vendors. Estimates given by suppliers were then integrated into the CPES cost estimating tool.

Indirect costs such as approvals, engineering, commissioning and start-up have been estimated as a percentage of the total construction cost estimates.

6.2 Key estimating assumptions

The indirect, direct and operations and maintenance (O&M) costs were derived from underlying assumptions stated below:

- Being a concept design or planning level estimate, subjected to standards limits of accuracy, capital cost contingency allowance of 30% has been applied to all options and plant sizes,
- Overhead and profit costs were assumed at 15% of the total direct costs,

- Mobilisation, Bonds and Insurance costs were assumed at 1.5% of the total direct costs,
- A contingency cost of 30% of the total direct cost was assumed,
- Project Management costs were assumed at 3% of the total direct cost,
- Services During Construction (SDC), Commissioning and Start-up have been considered as a part of Project Management cost,
- Cost estimates for process equipment were a combination of supplier costs, CPES estimations for site work, concrete works, structural supports and buildings and the Schedule of Rates (SOR),
- Both capital and operating costs were based on the assumption that the plant will be programmed for construction commencement by middle - 2020,
- Labour requirements for operations management are assumed as an Administrative Assistant and Office Manager at 20 hours a week and Office Manager at 40 hours a week. Labour costs are assumed for two treatment plant operators working at 40 hrs a week with one operator in attendance 24 hours a day for seven (7) days a week,
- Spare parts are included in cost estimate for major process equipment,
- Electricity cost is assumed at INR 8/kWh,
- Land acquisition costs are not included in this estimate.

6.3 Project cost estimate

A summary of the Capital and Operational cost estimates is provided in this section.

Each costing estimate provides for the costing with and without an UV disinfection system.

It is further to be noted that 1 USD is considered as 70 INR for all costing purposes**.**

6.3.1 Capital cost estimate

This section provides a costing estimate for the capital and civil works for all options. The sizing provided in the previous section has been used for the costing estimate.

Table 6-1 provides a summary of the capital cost for all options of Ballari ARWTP.

Table 6-1: Summary of capital cost for Ballari ARWTP

Treatment Options	Total Treatment Cost (USD)	Total Treatment Cost (INR in Crores)	Cost per MLD (INR in Crores)
Using multimedia filtration without UV disinfection	$2, 509,450	17.5	1.2
Using multimedia filtration with UV disinfection	$3, 155, 500	22	1.5
Using MF/UF-Without UV Disinfection	$4, 628, 300	32	2.15
Using MF/UF-With UV Disinfection	$5, 274, 280	37	2.4

It should also be noted that this capital cost includes the indirect costs also.

6.3.2 Operation and Maintenance (O&M) Cost Estimate

The operating cost was based on the assumption that the plant will be programmed for construction commencement by mid-2020 and labour inputs as follows:

- One plant manager during the day (8 hours),
- One plant operator (24 hours, four people on 8-hour shifts),
- Technical support during the day.

A summary of the annual O&M cost estimates is provided in the following tables for the following treatment options.

- Treatment without UV Disinfection (Table 6-4),
- Treatment with UV Disinfection (**Error! Reference source not found.**).

Table 6-2: Annual O&M cost estimate (multimedia without UV disinfection)

Item	Cost (USD)	Cost (INR Crores)
Operation and Maintenance cost @2.1 Lac/MLD/Year	$45, 000	0.32
Power	$119, 500	0.83
Total Operational Cost	$164, 500	1.15

Table 6-3: Annual O&M cost estimate (multimedia with UV disinfection)

Item	Cost (USD)	Cost (INR Crores)
Operation and Maintenance cost @2.1 Lac/MLD/Year	$45, 000	0.32
Power	$193, 660	1.3
Replacement cost (@6% of Capital Cost of UV)	$35, 000	0.25
Total Operational Cost	$164, 500	1.9

Table 6-4: Annual O&M cost estimate for membrane based treatment (without UV Disinfection)

Item	Cost (USD)	Cost (INR Crores)
Operation and Maintenance cost @3.9 Lac/MLD/Year	$83, 570	0.6
Power	$297,530	2.1
Membrane Replacement (12% per year)	$307, 250	2.1
Total Operational Cost	$688, 350	4.8

Table 6-5: Annual O&M cost estimate for membrane based treatment (with UV Disinfection)

Item	Cost (USD)	Cost (INR Crores)
Operation and Maintenance cost @3.9 Lac/MLD/Year	$83, 570	0.6
Power	$297,530	2.1
Membrane Replacement (12% per year)	$307, 250	2.1
Replacement Cost of UV @6% of Capital Cost of UV	$35, 000	0.25
Total Operational Cost	$723, 350	5.1

It can be observed that O&M expenditure is very high as compared to treatment using multimedia filtration. This is because membrane technology requires more energy and also has a membrane replacement cost.

6.4 Assumptions and limitations

As there is no precedence of plants catering to water reuse applications on a large scale (specifically for a large-scale UF unit) in India, there were several constraints on obtaining costs from local suppliers. Hence, some of the key factors considered in costing were based on similar overseas plants and data available from vendors/equipment suppliers not locally present.

Other assumptions and limitations of the feasibility study that can have a bearing on the project cost are given as follows:

- Limited water quality data – The sewage characteristics are based on limited sampling regime, hence the plant design parameters may vary after extensive testing spread spanning across a year,
- Limited engineering design – The objective and scope of project appropriated only high level design during the study. No major project specific engineering problems and their mitigation have been considered during the study,
- Subsoil (geotechnical right of way, litigations, traffic issues, soil conditions etc.),
- Wastewater (used water) availability – It has been assumed that the sewage would be available in required quantity within the acceptable range as indicated elsewhere,
- Conditions – Good subsoil conditions warranting any special soil treatment or foundation design has been envisaged for this project,
- Power supply – It has been assumed that Ballari City Corporation/KUWS & DB would be able to obtain reliable power source and required amount of uninterrupted power for the project,
- Land costs – It is assumed that encumbrance free land at no cost would be available for this project.

7 Project delivery options

Infrastructure provisioning is complex and has many delivery options. Each delivery model ranging from the conventional to the more nuanced has its relative strength and disadvantages. For the purpose of this exercise few of the traditional and established models have been considered and compared in the context of a hybrid – public, private partnership (PPP) model.

Traditional models discussed as follows:

- Design Bid Build (DBB)
- Design Build (DB)
- Design Build Operate (DBO)
- Design Build Finance Operate & Transfer (DBFOT)

7.1 Design Bid Build

This model is ideally suited where there is sufficient time and desire to complete design documentation prior to tendering. This model also attracts a large pool of potential Tenderers giving rise to increased competition. Given the design certainty there is greater scope for competitive price. That said, there is little incentive or need for innovation from the contractor. Since the scope is generally well defined there is little likelihood of scope creep or wholesale change to requirements. The contract value is set before construction commences.

This model is ideally suited where there are high levels of certainty with regard to cost and quality and the project risks are well defined, clearly understood and easily allocated to the appropriate party. High level of KUWS & DB involvement and control will be required during the design phase and a clear-cut division is present between design and construction.

While freezing up design well in advance provides some level of cost certainty and control for KUWS & DB there are a number of issues that need managing:

- Separate design and construction mean no single point of responsibility for the project,
- Potential claims and delays due to design deficiencies and separation of design from construction,
- Minimal opportunity for innovation input from the contractor,
- Retains the risk of constructability of design, fitness for purpose and overall design,
- Potential lack of focus on life-cycle costs and considerations.

7.2 Design Build

This delivery model is ideally suited where KUWS & DB's requirements are tightly specified before tender and do not change after that. The decision to award a Design Build contract generally stems from the desire to reduce the overall project cost by giving the contractor the opportunity to contribute construction experience into the design resulting in innovation and efficiencies. Furthermore, through a single point of accountability, the contractor is better placed to manage design risks and will be in a position to take on fixed price contract. While the Contractors normally warrant the design including "fitness for purpose", generally the following issues need to be managed:

- Longer tender periods are needed to allow Tenderers to assess design risk,
- KUWS & DB may pay a premium to transfer design risks and also retains whole-of-life asset risk,
- Will likely lose focus on life-cycle costs considerations and,

- May be liable for time and cost overruns through claims from the contractors.

7.3 Design Build Operate

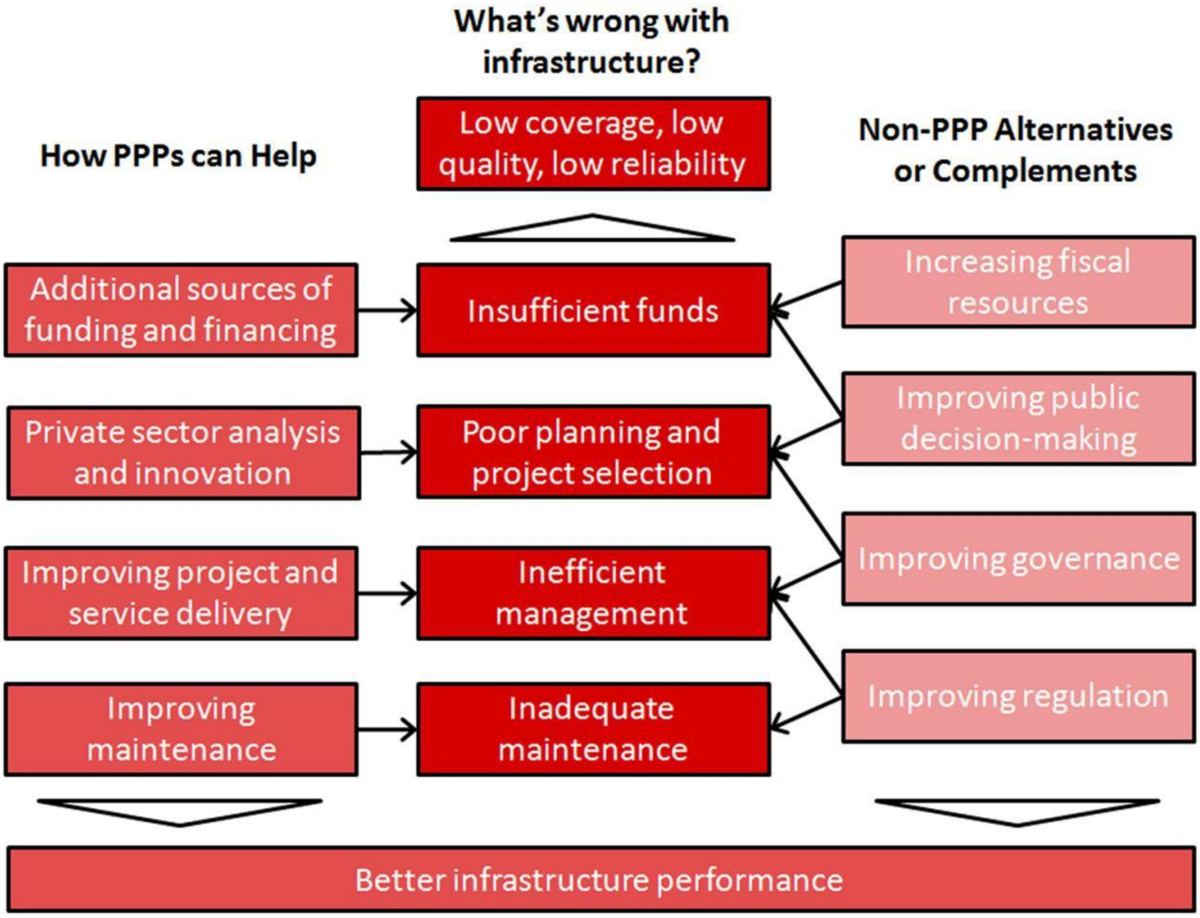
In this delivery model, the contractor also has ongoing maintenance obligations in addition to design and construction. While the features of Design Build delivery model are retained, through "operate", there is an added transfer of life-cycle risk to the contractor, which encourages design efficiency and quality construction and finishes to reduce long-term costs. As discussed above, this model is ideal where there is an opportunity to bundle services/maintenances and thereby create whole-of-life efficiencies.

DBO delivery option is suitable where there is a need to outsource asset management activities and KUWS & DB wishes to encourage and/or reward the contractor to incorporate reliability and maintainability into the design. That said, there are still a number of issues that need to be managed during the delivery phase. Some of them are:

- Longer tender period needed for Tenderers to assess design and maintenance risks,
- KUWS & DB may pay a premium to transfer design and maintenance risks,
- Success relies on well-defined functional and service specifications,
- A large number of stakeholder resources may be required if multiple concept designs are being developed,
- Changes to design may require contract negotiations,
- Ability to make variations needs to be addressed in the contract,
- Higher agency tendering costs and resourcing costs that need to be offset against potential cost savings and efficiencies.

7.4 Design Build Finance Operate and Transfer

Design Build Finance Operate and Transfer (DBFOT), or PPP refers to long-term partnering relationships between the public and private sector to deliver services. It is an approach that Government has adopted to increase private sector involvement in the delivery of public services. A well-structured and implemented PPP can improve value for money in infrastructure provision. It provides a framework to appropriately allocate risk, harvest benefits from whole of life costing, creates opportunities for innovation by specifying outputs in a contract rather than prescribing inputs and enhance asset utilisation as private parties are motivated to use a single facility to support multiple revenue streams thus reducing the cost of any particular service from the facility. Overall it should allow KUWS & DB to acquire services at the most cost-effective basis, rather than directly owning and operating assets.



Source: World Bank

Figure 7-1: PPP delivery models provide better infrastructure performance

That said, to be successful, the project must be built upon a diagnostic that provides a realistic assessment of the current constraints. Project appraisal typically involves assessing the project against the following four criteria:

- Feasibility and economic viability,
- Commercial viability,
- Value for money,
- Fiscal responsibility.

All of the above require careful consideration of the technical issues, legal, regulatory and policy frameworks, institutional and capacity status surrounding the project.

7.4.1 Feasibility and economic viability

The intent here is to determine whether the underlying project makes sense, irrespective of implementation as a PPP or through traditional public sector procurement. This requires confirming that Ballari ARWTP is central to policy priorities and overall infrastructure plans. It then involves carrying out feasibility studies to ensure the project is possible and economic appraisal to check the cost- benefit is justified.

7.4.2 Commercial viability

This determines whether the project is likely to be able to attract good-quality sponsors and lenders by providing robust and reasonable financial returns. Normally preliminary market sounding sessions are carried out to prepare potential bidders ahead of the procurement. This will also help KUWS & DB to assess the likely reaction of the market to the proposed PPP procurement and KUWS & DB's preliminary thinking on the salient aspects of the PPP contract. This will help KUWS & DB to gauge the potential level of bidding interest and also the valid concerns, which the industry may have on the draft PPP structure.

7.4.3 Value for money

The purpose of this criterion is to assess whether developing the project as the proposed PPP can be expected to best achieve value for money, compared to other traditional options after considering that the risks have been allocated optimally.

7.4.4 Fiscal responsibility

Last but not least is the fiscal responsibility assessment which determines whether the project's overall revenue requirements are within the capacity of users, KUWS & DB or both, to pay for the infrastructure service. This involves checking the fiscal cost of the project – both in terms of regular payments, and fiscal risk and establishing whether this can be accommodated within prudent budget and other fiscal constraints.

7.4.5 Delivery option recommendation

Based on the above comparison and assessment, the Design Build Finance Operate and Transfer (DBFOT) or PPP, is the recommended for KUWS & DB's Ballari ARWTP.

According to The National Water Policy 2002, private sector participation should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible. The National Water policy states that the service provider role of the state has to be gradually shifted to that of a regulator and water-related services should be transferred to community and/or private sector with appropriate PPP models.

Government of India's draft National PPP Policy sets several objectives for PPPs:

- Harnessing private sector efficiencies in asset creation, maintenance and service delivery,
- Providing focus on life cycle approach for development of a project, involving asset creation and maintenance over its life cycle,
- Creating opportunities to bring in innovation and technological improvements,
- Enabling affordable and improved services to the users in a responsible and sustainable manner.

PPP allows the public sector to get better value for money in the delivery of public services. Moreover, by switching its role from a provider to a buyer of services, the Government can focus on its core responsibilities of policy-making and regulation. Through close partnership with the private sector, efficiency gains and other benefits can be reaped.

With significant growth projections in municipal and industrial water demand in the last decade (from 2006 to 2016) and anticipated growth in the coming years, the need for increased investment infrastructure will only be on the rise. PPPs can help increase the funding available for infrastructure, that is, bring in more revenue to pay for infrastructure services over time. Further accessing finance through a PPP can help KUWS & DB with additional source of funding because the capital cost of the project is spread over its lifetime through availability payments rather than incurred upfront.

In order for the projects to be commercially viable contractual arrangement needs to be balanced, clear and respected by both parties. In addition, the legal and regulatory framework needs to be empowered for allocating appropriate risks to the parties. The project should be both economically viable for the public sector and financially viable for the private sector. This means that KUWS & DB, which is in charge of setting the water tariffs, needs to set realistic performance indicators, pragmatic time frames and balanced water tariff to ensure affordable service for all and adequate revenues to cover project costs. Further details of this delivery option will be developed in a separate report.

7.5 Public acceptance

The following key recommendations are made for the adoption and implementation by KUWS & DB:

- **Strategic plan for water reuse:** It is recommended that KUWS & DB accepts and adopts the proposal to develop and implement large-scale water recycling as a means to help meet water demand for Ballari City.
- **Non-**drinking water reuse project: At this stage, it appears that establishing advanced recycled water treatment plant (ARWTP) in the premises of the existing Ananthpur Road UWTP will be advantageous from O&M perspective. This ARWTP will initially be designed and constructed to deliver up to 15 MLD of recycled water for non-drinking water purposes and can be upgraded to 25 MLD at a later stage.

7.6 Potential risks and risk register

A project risk register needs to be prepared for the project covering various types of project risks such as technical, regulatory, stakeholder and strategic. Besides indicating the risk likelihood and risk impact, it also proposes mitigation measures.

This project risk register should be regularly reviewed and updated during the implementation of this project. The next design phase for this project should consider the project risks identified during this feasibility study.

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8 Conclusion and recommendations

It is possible to achieve various objectives set forth for this study including augmenting the water resources for Ballari City with a systematic approach balancing the technical, economic and social aspects.

8.1 Process options

Whilst there are a large number of process options that can be considered suitable for the project, process options that are technically and operationally proven were considered.

Treatment process option that was shortlisted for analysis were:

- Non membrane based treatment and
- Membrane treatment: Microfiltration/Ultrafiltration Unit

Although the feasibility study identifies membrane and non-membrane based option, the detailed deliberation on adopted treatment scheme will be presented in Preliminary Design Report.

8.2 Project delivery options

After analysing various PPP delivery models. use of a DBFOT framework for the project delivery of a large scale non-drinking water reuse project at existing Ballari ARWTP seems to be an suitable option.

8.3 Cost estimates

A preliminary cost estimate for the following treatment technologies was made:

- Membrane treatment with UV disinfection
- Membrane treatment without UV disinfection

It was observed that the costing for conventional treatment was significantly lower than that of a membrane treatment in terms of capital costs, operating costs as well as cost estimate for power.

8.4 Report recommendations

The following actions resulting from this Feasibility Study are recommended:

- It is recommended that the proposed treatment schemes will be detailed further upon receiving of water quality information for Ananthpur UWTP. However, at this stage, membrane technology treatment process seems as the preferred option for the production of advanced treated recycled water without the generation of a salt or brine stream.
- It is recommended the product water be used for industrial purposes.
- It is recommended that further discussions take place within Karnataka State Government Officials to encourage and promote the use of recycled water.
- Whilst a high level risk assessment has been carried out for the project, it is recommended that a detailed risk assessment for the total scheme be carried out for the preferred process option once it is adopted.
- Conduct detailed wastewater sampling and analysis on the existing Ananthpur Road 30 MLD and Cowl Bazaar 15 MLD UWTP to improve characterisation of the influent for the proposed Advanced Recycled Water Treatment Plant.
- It is recommended that pilot testing be carried out for the selected process option to confirm the design criteria for the preferred filtration treatment process.

- It is recommended that a public education outreach engagement and consultation programme be undertaken prior to tendering of this project.
- It is recommended the PPP project delivery model be adopted for the implementation of this project.

Appendix A – Urban Waste Water Reuse Policy of Government of Karnataka

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Urban Waste Water Reuse Policy of Government of Karnataka (GoK)

The Government of Karnataka (GoK) approved the Urban Waste Water Reuse Policy in the year 2017 with an overall goal to establish an enabling environment for the reuse of municipal wastewater to maximise efficient resource use, protect the environment, address water scarcity, and enhance economic output. This policy focuses on the reuse of treated wastewater and the associated implications on sustainable sanitation and water resources availability, and considers integrated approach to urban water management emphasising on circular water economy. Some of the drivers for this policy are as below:

- Government of Karnataka seeks to position the state as a national leader in the sphere of integrated urban water resources management, and circular economy with respect to water and wastewater. Urban wastewater treatment and reuse is a critical aspect in the urban water cycle and will be guided by this policy.
- It is projected that by 2030, urban population will grow to more than 36 million. Currently, more than half of this urban population lives in Class I and Class II cities generating significant volume of wastewater. The capacity of current wastewater treatment infrastructure in the state is not sufficient to manage the total volume of wastewater being generated in these Class I and Class II urban centres. As per CPCB, existing wastewater treatment plants in the country are utilised at full capacity, and, on average, operate at 72% utilisation. Subsequently, it is estimated that more than 75% of the wastewater generated in Class I and Class II cities nation-wide is discharged on land or in natural water bodies without any treatment[6], causing environmental pollution and posing serious public health hazard. The GoK aims to increase the overall wastewater treatment capacity in the state and reduce the environmental pollution of surface water bodies through this policy.
- It is estimated that the urban water demand-supply gap in the state to increase from 24% in 2011 to 58% in 2030[7] because of rising urban population coupled with climate change factors. Further, it is estimated that the annual industrial water demand to increase more than three times, from 26 TMC in 2011 to 85 TMC by 2030, resulting in a demand-supply gap of 69% by 2030. Secondary treated wastewater (STW) offers a cost-effective and feasible solution for augmenting water supply for non-potable purposes to reduce this demand-supply gap.
- Other benefits of reusing Secondary Treated Wastewater (STW).
    - Reducing the discharge of untreated wastewater into surface water bodies and thus reducing environmental pollution and risk to human health.
    - Increasing the reliability of supply for industrial usage which leads to improved employment opportunities and economy.
    - Reduced energy consumption associated with production, treatment and distribution of freshwater.
    - Improved financial sustainability of Urban Local Bodies (ULBs) by monetising treated wastewater.

[6] International Water Management Institute (IWMI) and Water and Sanitation Program (WSP) (2016), Recycle and Reuse of Treated Wastewater in Urban India: A Proposed Advisory and Guidance and Document
[7] 2030 WRG (2014), Creating a Sustainable Water Future for Karnataka – Urban and Industrial Sectors

Vision of this policy

This policy envisages to achieve the vision of accelerated adoption of circular economy across major towns and cities of Karnataka with respect to wastewater treatment and reuse through the targets listed below:

- By 2020, 10 major cities[8] have adopted wastewater reuse principles and developed firm plans, to be increased to [100% of all major cities/towns by 2030].
- By 2020, 20% of all secondary treated wastewater (STW) is targeted for reuse across the state, in accordance with regulatory standards; to be increased to 50% by 2030, subject to responsible ecological return flow provisions approved under Integrated Urban Water Management Plans[9]

Key policy issues

This policy has deliberated upon key constraints that must be addressed in order to achieve the policy vision and they are as below:

- Lack of an integrated approach to urban water resources management
- Poor awareness with respect to safe capture, treatment and disposal of wastewater, health implications of using untreated wastewater.
- Viability of urban wastewater treatment facilities in terms of financials and meeting the regulatory standards
- Lack of clear guidelines and framework for implementation of projects in a manner that aligns stakeholder interests and priorities, and are operationally sustainable
- Institutional coordination among sectoral departments (industrial, urban, utilities, power, agriculture) and stakeholders for better facilitation.

National/International Policies and Frameworks

The concept of wastewater reuse and its need is well recognised in most policy and guidance documents in India, and this specific policy aligns with several others national and international policies/framework to be more relevant.

1. United Nations Sustainable Development Goals (SDG): Specifically, SDG 3: Good health and well-being; SDG 6: Clean Water and Sanitation; SDG 8: Decent Work and Economic Growth; SDG 11: Sustainable Cities and Communities.
2. National Water Policy 2012
3. National Service Level Benchmarks
4. Power Tariff Policy (revised, 2016)
5. AMRUT
6. Karnataka State Water Resources Policy
7. Government Order for Promoting Wastewater Reuse in Bangalore
8. KSPCB Order for Promoting Wastewater Reuse in Urban Local Bodies

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[8] Class I and II cities, corresponding presently to 67 cities and town in Karnataka

[9] This provision accounts for the hydrological principle of return flows, whereby users of treated wastewaters are themselves new generators of wastewater; and whereby net withdrawal of the urban hydrological cycle is limited to evapotranspiration, embedded water in products, and/or lost return flows.

Coverage

This policy applies to all Class I and Class II urban centres in Karnataka and focuses largely on recycling after wastewater conveyance through sewer networks and treatment at sewage treatment plants. Separate guidance may be developed for smaller cities and towns that may have alternative wastewater conveyance and treatment systems in place (ex: faecal sludge management systems).

Policy Goals

The overall goal of this policy is to establish an enabling environment for the reuse of municipal wastewater to maximise efficient resource use, protect the environment, address water scarcity, and enhance economic output.
The specific performance benchmarks proposed to achieve the goals of this policy are as below:

a) Integrated Urban Water Resources Management

This would include strengthening state, city and local institutions to take up the approach in planning, implementation and O&M including through partnerships with private sector and community. It is proposed that at least 10 major cities/towns have adopted integrated water resources management plans, developed as multi-sectoral initiatives and incorporating wastewater reuse principles and implementation plans therein, by 2020; and that the initiative be augmented to include all major cities/towns by 2030.

b) Overall Urban Wastewater Generated

Reuse of not less than 20% of STW is targeted, as a combined average across sectors, of total urban wastewater identified urban centres of the state by 2020, in alignment with National Service Level Benchmarks (SLB) and with AMRUT program. Agricultural, industrial and urban non-potable uses will be considered to contribute to reuse the target. However, discharge of treated wastewater into water bodies will not be part of the target.

c) Water Consumption by Industry

This policy proposes that industrial estates/parks/zones/layouts within 30 km of a sewage treatment plant (STP) mandatorily examine, as a first option, available STW from the STP, provided that STW of the required quality is made reliably available at a cost to consumer that is comparable to the applicable tariff for provision of fresh water for industrial use in the region. The Department of Commerce and Industries mat set a voluntary target for use of STW to comprise (indicatively) 20% of the total state-wide industrial water use, including energy sector, by 2020. This goal shall be aligned with the volume of STW available for industry as per the integrated urban water management plans of the first AMRUT cities targeted under this policy by 2020.

d) Treatment of Urban Wastewater

The ULBs will aim for greater capture and treatment of wastewater generated through both centralised and decentralised options, with treatment systems progressively linked to reuse. This policy specifically seeks to acknowledge and encourage the practice of localised treatment of wastewater through constructed wetlands for the purposes of rejuvenation of urban and peri-urban water bodies.

e) Allocation of Secondary Treated Wastewater

Allocation of STW among different user sectors will be based on the principles as below.

i. Equity and Fairness
ii. Sustainability: to minimise subsidies required for O&M of the networks and wastewater treatment plant to meet regulatory standards

f) Pricing of STW and Operational Cost Recovery of Wastewater Treatment Plants

The following points are to be duly considered for tariff purposes:

- Tariff proposed (in Rs/KL) is applicable at the plant gate, or at in-city locations enroute of the sewerage network. The off-taker is responsible for meeting additional cost of conveyance to a specified location.
- Tariff proposed for any user category is comparable to the applicable tariff for provision of freshwater (municipal, industrial or other water supply; excluding agriculture) to the same category
- The principle of cross-subsidy is applied, as required

Tertiary treatment plants are to be established by urban centres only after establishing conditions for reliable demand/off-take for the entire volume of water so treated to pre-agreed quality standards. Reuse of treated wastewater is envisioned for the following broad sectors with quality standards as mentioned in Table 2-2, Table 7, and Table 8.

i. Agriculture

Table 22: Suggested minimum water quality criteria for agriculture reuse

Parameter	Unit	Value
Intestinal nematodes	No./liter	<1
Faecal coliforms	MPN/100 ml	Nil (for crop eaten raw) & <230/100 ml (for crops eaten cooked or non-edible crops
pH		6 - 9

Source: Chapter 7, Part A of CPHEEO 2013 Manual on Sewerage and Sewage Treatment

ii. Industry

Table 7: Typical water quality requirements for industrial reuse

Constituent (mg/L)	Industrial Application				
	Boiler Feed	Pulp and Paper	Textiles	Petroleum and Coal	Cooling Water*
Calcium	0.01 – 0.4	20	-	75	100
Iron	0.05 – 1.0	0.3 – 1.0	0.3 – 1.0	1	-
Manganese	0.01 – 0.3	0.05 – 0.5	0.01 – 0.05	-	-
Alkalinity as $CaCO_3$	40 – 350	100	-	125	-
Chloride	-	200 – 1000	-	300	100
TDS	200 – 700	-	100	1000	-
Hardness as $CaCO_3$	0.07 – 350	100	25	350	-
Ammonium - N	0.1	-	-	-	1 – 3
Phosphate – P	-	-	-	-	0.6
Silica	0.7 – 30	50	-	-	20
Colour (Hazen)	-	10 - 30	5	-	-

Source: Guidance Note for Municipal Wastewater Reuse and Reclamation in India, JICA
2013 CPHEOO Manual (Part A Chapter 7) discusses cooling tower water and boiler water in some details

iii. Urban non-potable including residential, commercial and institutional
  - Karnataka State Pollution Control Board (KSPCB) standards, depending on type of reuse

iv. Environment
  - KSPCB standards for discharge into rivers and water bodies; or as specified in CPHEEO 2013

Table 8: Suggested minimum water quality for environmental/recreational reuse

Parameter	Unit	Value
BOD5		≤ 10
TSS	mg/L	<5
Faecal coliforms	MPN/100 ml	Nil
pH		6.5 – 8.3
Total Kjeldahl Nitrogen (as N)		<5 for impoundments, <10 for horticulture/golf course
Dissolved Phosphorous (as P)		1
Colour (Hazen)		Non-detect

Source: Chapter 7, Part A of the CPHEEO 2013 Manual on Sewerage and Sewage Treatment

v. Energy and nutrient recovery
  - According to global benchmarks of potential energy and nutrient recovery

Support from GoK

The Government of Karnataka will be support in the following activities/initiatives:

i. Development of Integrated Urban Water Resources Management Plans
ii. Establishment of a Wastewater Reuse Resource Center
  a. Awareness and capacity building
  b. Project assistance
iii. Performance monitoring
iv. Financing of wastewater reuse projects

Roles and Responsibilities

A: Primary Departments		
	Department Name	**Role and Responsibility**
1	Urban Development Department, through DMA; KUWS & DB; KUIDFC; and BWSSB	• Implementation support; Establishment of overall enabling environment – supportive policies, capacity building, financing, IEC and awareness, etc.; • Establishment of performance monitoring body including PPP projects; dispute resolution mechanism. • Budget and resource allocation; operationalise Wastewater Reuse Resource Center • Active participation with relevant departments
2	Department of Industries and Commerce, through KIADB	• Establish voluntary target for treated wastewater to comprise 20% of the total state-wide industrial use by 2020 • Coordination and outreach to industries

3	Department of Energy	• Comply with GoI's revised Power Tariff Policy (2016) • Coordinate with thermal power plants with urban centres within 50 km radius for off-take of all STW available • Facilitate operational sustainability of WWTP
4	Department of Forest, Ecology and Environment, through KSPCB	• Establishment of and monitoring of compliance to standards and regulations on wastewater quality norms for various reuse categories
B. Secondary Departments		
1	Water Resources Department	• Overall water resources allocation and prioritisation • Align and being consistent with irrigation policies and practices for reuse of wastewater by agriculture
2	Department of Agriculture	• Monitor irrigation practices and use untreated wastewater for food production • Sensitise farmers on adverse health impacts on using untreated wastewater
	C: Urban Local Bodies	• Preparation of Integrated Urban Water Resource Management Plans, including demand assessment and stakeholder consultations • Ensure sufficient volume of STW for off-take through expanding sewerage network, IEC programs to promote connections • Outreach to Wastewater Reuse Resource Center for support in project identification, structuring and prefeasibility assessments • Funding for prefeasibility assessments

End of the report.