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**BARBERTON WASTE WATER TREATMENT WORKS –
IAPS (INTEGRATED ALGAE PONDS SYSTEM)**

PRELIMINARY DESIGN REPORT

APRIL 2016

Our Reference: 1502121/ Reports

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WATER RESEARCH COMMISSION

EXECUTIVE SUMMARY

The proposed scope of work includes the development of an integrated algae ponds system (IAPS) at the Barberton WWTW with a capacity of 1000m^3/day. The IAPS will comprise of the following components:

- Construction of the inlet works (screen & degrit channels);
- Construction of an anaerobic digester;
- Construction of facultative pond;
- Construction of high rate algal ponds;
- Construction of algal settling pond;
- Construction of a clarifier
- Construction of a chlorination tank
- Construction of a sludge drying bed;
- Lining of all ponds; and
- Fencing of the site.

The Barberton WWTW - IAPS is funded by the Department of Science and Technology and the Water Research Commission, as an alternative for rural municipalities to treat domestic waste water effluent.

The above construction activities will require a formal environmental application in the form of a basic assessment EIA (Environmental Impact Assessment) to the Department of Environmental Affairs (DEA). The duration of this process will be 6 to 7 months.

The preliminary project cost has been revised and is estimated at ***R 10 878 829.85*** (excl. VAT).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

AIWPS - Integrated Wastewater Ponding System

ASP - Algal Settling Pond

BWWTW - Barberton Wastewater Treatment Works

DST- Department of Science and Technology

EBRU – Environmental Biotechnology Rhodes University

EDM - Ehlanzeni District Municipality

IAPS -Integrated Algal Pond System

ULM - Umjindi Local Municipality

WRC - Water Research Commission

WSA - Water Services Authority

WSP - Water Services Provider

1. INTRODUCTION

The Barberton Wastewater Treatment Works (BWWTW) is situated at coordinates 25°45'07.27"S and 31°01'57.57"E on the north western edge of the town of Barberton, in the Umjindi Local Municipality; in the province of Mpumalanga. The works is situated approximately 4.3 km from Barberton CBD. The works is operated by the Umjindi Local Municipality (ULM) on the basis of a management contract where the ULM acts as Water Services Provider (WSP) for the Ehlanzeni District Municipality (EDM) who is the Water Services Authority (WSA). Ownership of the works therefore currently vests with the EDM. The Demarcation Board has determined that the Mbombela and Umjindi LM's will be amalgamated after the recently held local government elections and a new municipality will be formed. It is anticipated that the new local municipality will be a WSA and will therefore assume executive authority for Water Services (Water and Sanitation).

Umjindi Local Municipality had expressed interest in the funding provided by the WRC (Water Research Commission) for the development of an IAPS (Integrated Algal Pond System). WRC had awarded funding for the establishment of an IAPS plant at the Barberton WWTW, located in the Umjindi Local Municipality. Based on the available funding provided by WRC, it was decided to construct 1Ml/d using IAPS at the Barberton WWTW.

"For many years sanitation problems in South Africa have been due to a lack of knowledge and correct implementation of environmental controls. The same problems come about again due to, not a lack of knowledge, but to diminishing resources, communities cannot cover the costs of adequate sanitation control, lack technical service staff and the political exploitation of the poor and the under privileged. In an attempt to rival technical – intensive operations such as activated sludge, EBRU together WRC (Water Research Commission) pioneered development of the IAPS (Integrated Algae Pond System)" – IAPS Technical Description A. Keith Cowan and Dave S. Render.

The goal of this project is to construct an independent and fully operational IAPS plant treating domestic effluent at a larger scale than previously conducted in South Africa.

2. PROJECT LOCATION

The study area is the town of Barberton. Its suburbs and dependent peri-urban areas.

2.1 PHYSICAL AREA

The proposed Barberton WWTW IAPS is located adjacent the existing Barberton WWTW, an activated sludge plant, with anaerobic and aerobic reactors, clarification, disinfection, lagooning and screw press dewatering for sludge handling with a treatment capacity of 9.65 Mℓ/day (Green Drop System (GDS) Report, 2014). The existing Barberton WWTW treats collected effluent from the following areas:

- Barberton
- Bonanza Gold Mine
- Emjindini
- Glenthorpe
- Staatgrond
- Umjindi NU
- Verulum

Umjindi is situated in the south-eastern part of Mpumalanga on the escarpment. The Municipal Area forms part of the Ehlanzeni District Municipality. There are nine listed wards within the Umjindi Local Municipality. The treated final effluent from the Barberton WWTW is discharged into a tributary of Suidkaap River. The figure below shows the areas served by the Barberton WWTW.

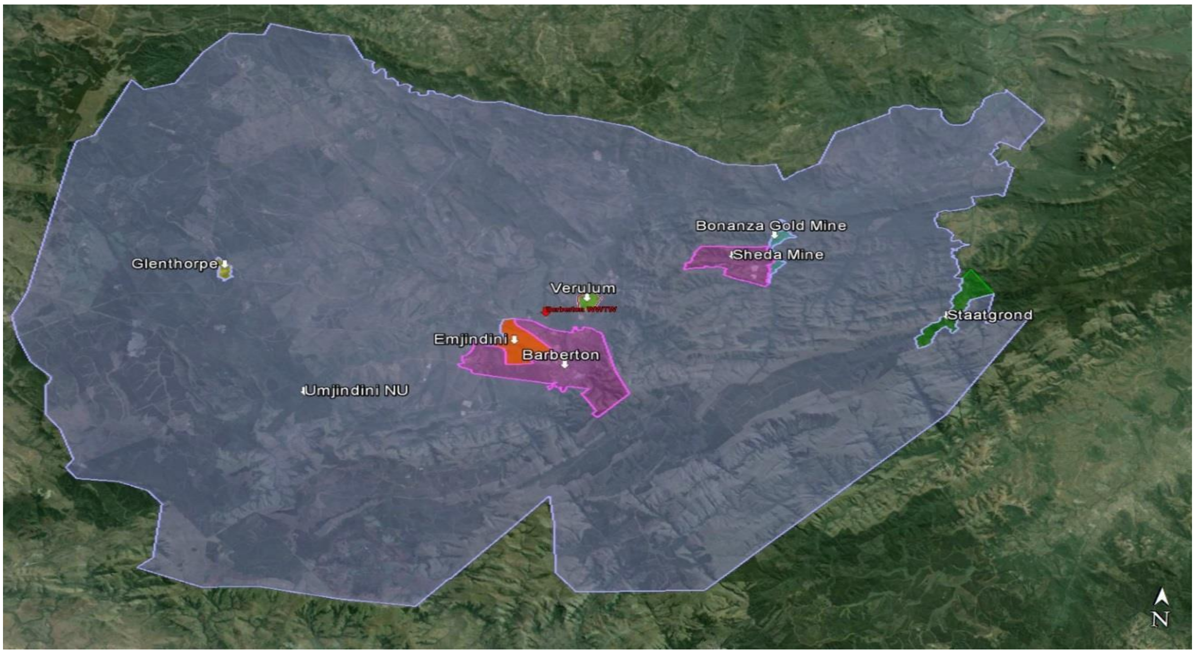

Figure 2-1: Barberton Layout within Umjindi LM

The proposed Barberton WWTW – IAPS will treat effluent diverted from the existing 400mm diameter outfall sewer located near the Barberton WWTW to the proposed IAPS site adjacent the existing works. The same effluent catchments served by the existing WWTW will be served by the Barberton WWTW – IAPS, although the treatment capacity will be significantly smaller.

2.2 WEATHER AND CLIMATE

Barberton is situated in the sub-tropical Lowveld area. The weather is temperate with a generally warm climate. The diurnal temperature variation is depicted in the graph below.

The weather and climatic information was sourced from www.worldweatheronline.com and covers a 15-year period.

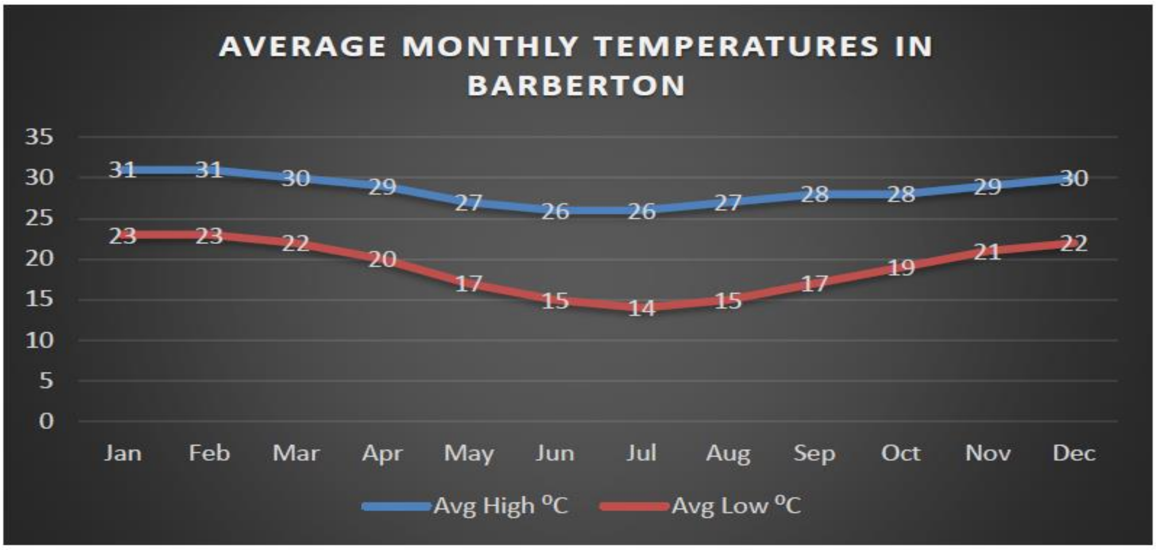

Figure 2-2: Barberton Temperature Profile

The temperature profile holds benefits for algal and other biological treatment processes as kinetics are speeded up relative to cold climes, leading to relatively smaller footprints and hence land requirements. Winter temperatures are on average above 10˚ C.

The area receives good rainfall. It is however susceptible to periodic drought. This can be ameliorated through the creation of adequate water storage. The implication of high rainfall is that storm water ingress can be above average and sludge drying through solar energy will have to be carefully considered, though still viable.

The rainfall pattern is depicted in the graph below.

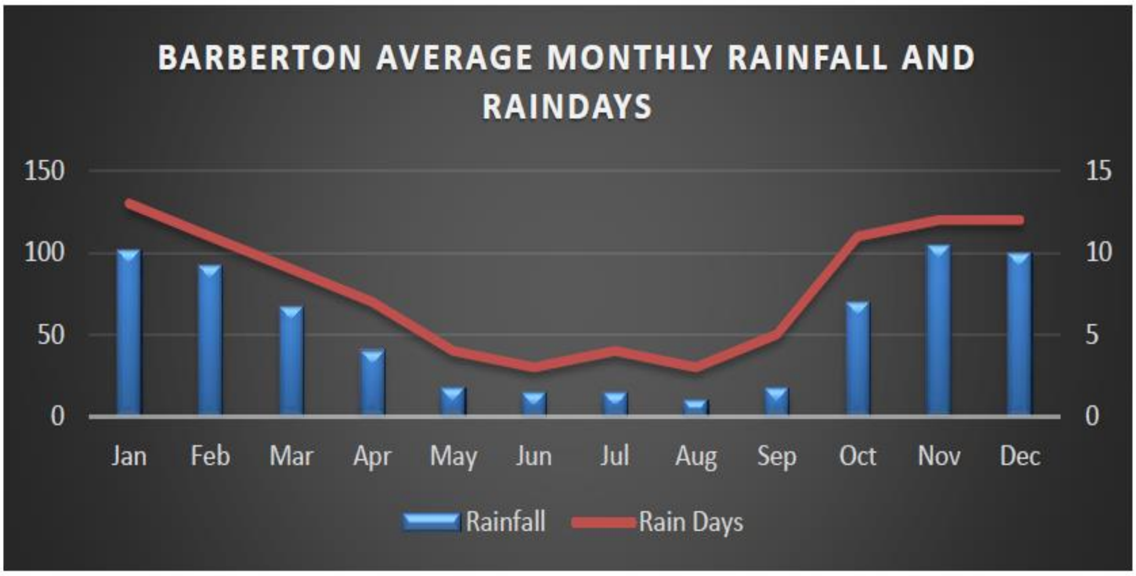

Figure 2-3: Barberton Average monthly rainfall and rain days

3. DESIGN PHILOSPOPHY

3.1 DESIGN PARAMETERS

The Barberton IAPS (Integrated Algae Pond System) plant is designed to a capacity if 1000m3/day. The capacity of the Barberton WWTW – IAPS will be able to treat effluent from approximately 1300 middle income households or 2000 low income households, based on the Guidelines for Human Settlement Development and Planning. The IAPS is sized and designed to treat domestic effluent of 100m3/d with a COD – 750mg/l. We have assumed at initial five day BOD loading of 375mg/l, for the sizing of the different ponds in the IAPS.

The various components of the IAPS are designed to treat the domestic effluent to the general standard prescribed by the Department of Water Affairs.

The Process Design Guide for Small Wastewater Works by DJ Nozaic and SD Freese, as well as the Waste Stabilisation Pond Design Manual by J. Ashworth and M. Skinner has been consulted for the sizing of the different ponds, which form part to the IAPS.

Wastewater limit values applicable to discharge of wastewater into a water resource:

Table 3-1: Revision of General Authorisation in terms of Section 39 of National Water Act, 1998 (Act 36 of 1998)

SUBSTANCE/ PARAMETER	GENERAL LIMIT	SPECIAL LIMIT
Faecal coliforms per 100 ml	1000	0
Chemical Oxygen Demand (mg/l)	75(i)	30(i)
pH	5,5 and 9,5	5,5 and 7,5
Ammonia (ionised or un-ionised) as Nitrogen (mg/l)	6	2
Nitrate as Nitrogen (mg/l)	15	1.5
Chlorine as free Chlorine (mg/l)	0.25	0
Suspended Solids (mg/l)	25	0
Electrical Conductivity (mS/m)	70 mS/m above intake to maximum 150 mS/m	50 mS/m above background receiving water, maximum 100 mS/m
Ortho-phosphate as phosphorus (mg/l)	10	1 (medium) to 2.5 (maximum)
Fluoride (mg/l)	1	1
Soap, oil or grease (mg/l)	2.5	0
Dissolved Arsenic (mg/l)	0.02	0.01
Dissolved Cadmium (mg/l)	0.005	0.001
Dissolved Chromium (VI) (mg/l)	0.05	0.02
Dissolved Copper (mg/l)	0.01	0.002
Dissolved Cyanide (mg/l)	0.02	0.01
Dissolved Iron (mg/l)	0.3	0.3
Dissolved Lead (mg/l)	0.01	0.006
Dissolved Manganese (mg/l)	0.1	0.1
Mercury and its compounds (mg/l)	0.005	0.001
Dissolved Selenium (mg/l)	0.02	0.02
Dissolved Zinc	0.1	0.04
Boron (mg/l)	1	0.5

4. PROPOSED SANITATION INFRASTRUCTURE

4.1 BACKGROUND

The funding allocated for the project by the Department of Science and Technology (DST) through the Water Research Commission (WRC) is for the construction of an IAPS (Integrated Algae Ponds System). This technology is based on Advanced Integrated Wastewater Ponding System (AIWPS) which has been used internationally in wastewater treatment processes for more than 30 years.

Extensive research by the Water Research Commission (WRC) and the Institute of Environmental Biotechnology at Rhodes University (EBRU), performed at an experimental plant in Grahamstown, has demonstrated that not only does this technology produce quality water as a final effluent but also hosts a range of other benefits. These benefits may include:

- Low cost biogas generated from anaerobic pond (future)
- High job creation potential
- Very low energy cost for operation
- Fertilizer generation potential from algae
- Final effluent may be safely used for food-gardening purposes
- Self-sustainable, if used as business to sell electricity or fertilizer

Although, it is possible to extract biogas generated from the anaerobic pond and generated fertilizer from algae production, the proposed facility will not have the necessary infrastructure to do so, due to constraints on the budget. The Umjindi LM can after the completion of the basic IAPS and with minor infrastructural additions be a position to extract biogas and generated fertilizer from algae.

A schematic overview of the proposed process is given in Figure 5-1 below.

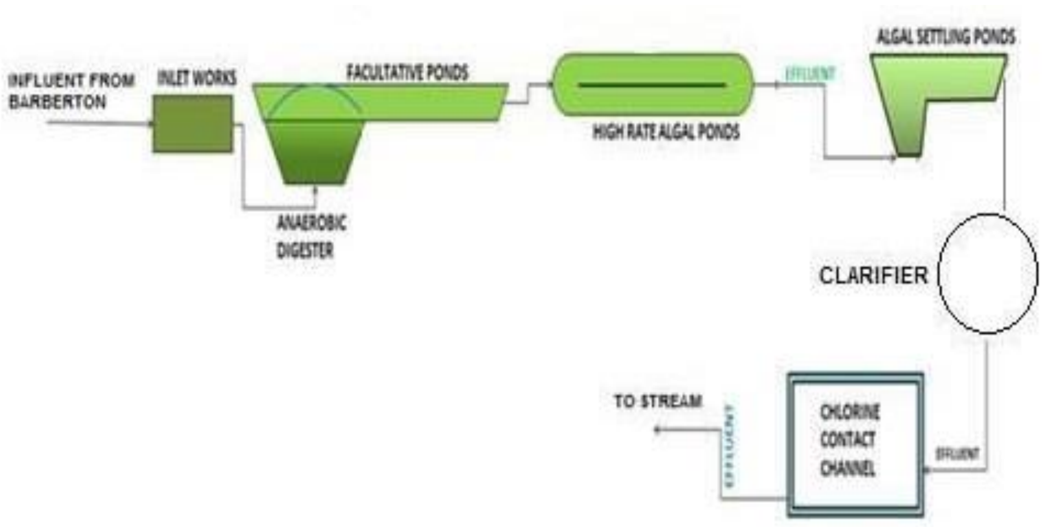

Figure 5-1: Proposed Barberton WWTW – IAPS Schematic

4.2 SCOPE OF WORK

The proposed IAPS at the Barberton WWTW, with 1000m^3/day effluent treatment capacity, will be contained on a 12 hectares of land. The indigenous vegetation on the land will be cleared prior to construction. The following components are proposed for the IAPS:

- Construction of the inlet works (screen & degrit channels);
- Construction of an anaerobic digester;
- Construction of facultative pond;
- Construction of high rate algal ponds;
- Construction of algal settling pond;
- Construction of a clarifier
- Construction of a chlorination tank
- Construction of a sludge drying bed;
- Lining of all ponds; and
- Fencing of the site.

The above construction activities will require a formal environmental application in the form of a basic EIA to the Department of Environmental Affairs (DEA). The duration of this process will be 6 to 7 months.

4.3 INLET WORKS

It is proposed that an inlet works equipped with two longitudinal grit removal channels to allow for one channel to be taken out of operation and cleaned via manual spading and/or flushing into a decantation chamber for dewatering. The inlet structure will be constructed with reinforced concrete.

Screening will be done manually with rakes and the collected screens (rag, non-bio-degradable solids etc) will be disposed of at a registered landfill site. The use of a stainless steel 316 manual screen configured as coarse screening at a bar spacing of 25mm is proposed.

Grit removal will be effected through an increase in the cross sectional flow area of flow that leads to a slowing down of the linear flow velocity to below 0.3 m/s, which will allow grit or detritus particles to drop out as the flow velocity cannot maintain effective suspension and carriage.

The channel length was calculated as 3m for a peak flow of 3750m^3/day. Hot dipped galvanized penstocks will be fitted in the channels to control flow conditions and to isolate the channels in the case of maintenance or cleaning.

A rectangular flow measuring flume (Parshall, Khafaghi or similar approved) with an electronic level sensor will be installed to measure the height of flow and then convert the flow height into a volumetric flow rate. The daily flow measurements will provide information for the effective control of the Barberton WWTW - IAPS. It is proposed that a data logger be installed for downloading of flows at fixed regular time intervals in order to determine peak flows and/or night flows.

4.4 ANAEROBIC DIGESTER

A single anaerobic digester with a capacity to treat 1 Ml/day is proposed. The ponds will be desludged to ensure adequate operation and sufficient capacity in the ponds. This pond will have depth of 5m to get anaerobic conditions in the pond. The pond has been designed with a freeboard allowance of at least 500mm.

Desludging of approximately 1500m^3 of total sludge volume may occur once in 5 to 10 years. This is dependent on the characteristics of the waste water, particularly the percentage of the suspended solids. During desludging, the inflow to the inlets works will be closed off. The entire plant will be shut down for a day at most, and the flow diverted to the existing WWTW.

Based on the average dry weather flow of 1,000m^3/day and an estimated BOD organic loading of 375mg/ℓ, the required volume of the anaerobic ponds was calculated as 3 000m^3 to achieve a hydraulic retention of 3 days. The 3 day hydraulic retention will ensure a BOD reduction of at least 40% in the primary treatment process as per the "*Process Design Guide for Small Wastewater Treatment Works, DJ Noziac, 2010*."

4.5 SLUDGE DRYING BED

For sludge management, sludge drying beds will be constructed on the site with an area of 450m^2. The estimate volume of sludge obtained during desludging is approximately 1500m^3. The dewatered sludge will eventually be disposed of at a registered landfill site.

4.6 FACULTATIVE POND

A facultative pond will be constructed to create combined pond volume of 17 000m^3. The ponds will create a hydraulic retention time of 17 days, which will induce an estimated BOD organic reduction of 50% in the secondary treatment process ("*Waste Stabilisation Pond Design Manual, J Ashworth, 2011*").

The pond bottom will be sloped 1.8 m to 2.5 deep to create an anaerobic layer near the bottom followed by an anoxic layer in the middle and an oxygen rich layer near the surface.

From the facultative ponds effluent will be conveyed to the High Rate Algal Ponds.

4.7 HIGH RATE ALGAL POND (HRAP)

Flow from the Facultative pond is subjected to photosynthetic oxidation in the HRAP.

Three shallow, paddle-driven raceways each with a hydraulic retention time of 1 day each are proposed. Interconnecting pipework will be configured such that the raceways may be operated either in series or parallel to allow for flexibility in the operation of the system as well to ensure that hydraulic retention times are adjustable according seasonal or site effluent specific requirements.

The algal raceways will allow for rapid algal growth, a high rate of photosynthesis and elevated levels of pH and dissolved oxygen.

With a combined hydraulic retention time of 3 days complete disinfection in the HRAP is believed to be a very real possibility.

A gentle paddle wheel designed to keep the linear velocity at approximately 0.15 – 0.3 m/s ensures maintained pond mixing. This velocity and mixing keeps the algal flocs in suspension near the surface and within the sunlight penetration depth.

Effluent from the HRAP is conveyed to the Algal Settling pond.

4.8 ALGAL SETTLING POND (ASP)

The algal biomass produced in the high rate algal pond is removed via separation in the Algal Settling Pond. The algal settling pond is rectangular in shape with one end significantly deeper than the other.

Effluent from the HRAP enters the Algal Settling Pond (ASP) near the base of the deeper end of the ASP end exists via an overflow weir at the opposite (shallow) end of the ASP. Approximate 250mm away from the overflow weir at the outlet end of the pond will be a scum board which will extend a minimum of 500mm below the top water level.

From the ASP effluent will be conveyed to a chlorine contact channel.

4.9 CLARIFIER

The treatment capacity of the proposed clarifier will have to be confirmed during the detailed design stage. At this stage it is assumed that the clarifier will be capable of treating approximately 7450m^3/d.

From the clarifier, the effluent will be conveyed to the chlorine contact channels.

4.10 CHLORINE CONTACT CHANNEL

A chlorine contact channel, the final treatment stage, will be constructed to disinfect the treated wastewater. After the dosage stage, it is accepted that the effluent has met the general standard for waste water discharge set by the Department of Water and Sanitation.

4.11 MONITORING BOREHOLES

The exiting groundwater monitoring boreholes will be adopted for groundwater monitoring. These monitoring points are allocated upstream and downstream of the existing works and used to monitor the effect of the works on the quality of groundwater and to determine the water table level of the site will be located. It is a required from DEDEA and DWS that possible contamination of the groundwater be monitored.

4.12 ACCESS ROAD

The access road to the proposed IAPS is an existing unnamed gravel access road of the R38 - Dirkbas Avenue. However, it is foreseen that this will be compromised during construction. The access road will be repaired after the construction process has been completed.

5. LABOUR INTENSIVE CONSTRUCTION METHODS

The economy of the community can be boosted by the employment of labour form within the community, as well as the engagement of local suppliers or entrepreneurs. The design of the works will investigate the maximisation of labour absorption into the construction of the planned additions to the works, in line with Labour Intensive Construction (LIC) guidelines and the Expended Public Works Programme (EPWP).

It is envisaged that conventional tenders will be called for using labour-intensive construction methods where possible. The Contractor's method of construction will be predetermined in that he/she will be required to make use of local labour where available and feasible to execute the work defined as 'labour-intensive'. The basis of community construction will generally be carried out by means of task work forming the focus point of time and cost control. The compilation of the tender documents and schedule of quantities will be clearly indicated so that the contractor can price them accordingly.

Consideration will be given to include the following labour intensive construction methods in the tender to create maximum employment opportunities:

- Clearing and grubbing;
- Building work, foundation excavations and backfilling, trenching for building services;
- Mixing, transportation, placing and finishing of suitable concrete applications;
- Fencing (excavations, concrete work and erection of fence);
- Transportation and levelling of excess materials within specified distances;
- Shaping of all ponds before installation of liner and lining of the ponds;
- Cleaning and tidying up of the site;
- Excavation for side drains for the roads

The aforementioned information shall form part of the contract documentation and shall be monitored for the duration of the construction period.

6. INSTITUTIONAL AGREEMENT

This refers mainly to the inter-relationships amongst the parties involved including funders, implementing agents and consultants. The project is funded by the Water Research Commission through the Department of Science and Technology

Umjindi Local Municipality, through a proposal to the Department of Science and Technology and Water Research Commission secured funding for the initiation of the project.

Memoranda of agreements exist between the relevant parties, these outline in detail the terms of reference, conditions and objectives to which the project is to be executed.

7. GEOTECHNICAL INVESTIGATION

A geotechnical investigation will be required at the proposed Barberton WWTW- IAPS site. The findings of which will inform the detailed design of the proposed Barberton WWTW-IAPS. This investigation will be used to determine the characteristics of the *in situ* material in terms of the ability to excavate on site, whether there is geotextile liners required for ponds, check for the presence of groundwater on site etc.

8. SURVEY

As part of the permitting process for the design of the proposed Barberton WWTW, a survey of the envisaged site will be required.

9. ENVIRONMENTAL REGULATIONS

It is foreseen that some of the activities relating to the proposed Barberton WWTW – IAPS are listed items according to the NEMA Regulations 2014 and specific Government Notice Regulations 983, 984 and 985, and NEM:Waste Regulation 921 of 2013, as amended (Table 9-1).

Table 9-1: Listed activities for the proposed Barberton WWTW – IAPS

Listing notice	Activity number	Activity description	
GNR 983 of 2014	27	The clearance of an area of 1 hectares or more but less than 20 hectares of indigenous vegetation.	The proposed site exceeds 12 hectares but less than 20 hectares
GNR 921 of 2013	A (7)	The treatment of hazardous waste (sewage sludge) using any form of treatment at a facility that has the capacity to process in excess of 500kg but less than 1 ton per day excluding the treatment of effluent, wastewater or sewage	Desludging of approximately 1500m^3 of total sludge volume may occur once in 5 to 10 years.
	A (12)	The construction of a facility for a waste management activity listed in Category A of this Schedule (not in isolation to associated waste management activity)	The entire IAPS, including the sludge drying beds, will be constructed

A formal environmental application in the form of an Integrated EA and Waste Management Licence (Basic Assessment) Application will be submitted to the Department of Environmental Affairs (DEA). The duration of the process will be approximately 6-7 months.

A project specific Environmental Management Plan (EMP) will form part of the tender documents, while an Environmental Control Officer will ensure that the EMP is enforced and executed during the construction stage.

10. COST ESTIMATE

10.1 PROJECT COSTS

We have endeavoured to do a preliminary cost estimate. This means that the existing DST/WRC grant may not be adequate to add the spare capacity required without counter-funding from the Umjindi LM.

Description	Total
Inlet works	R 307 500.00
Anaerobic digester	R 827 400.00
Facultative Pond	R 4 183 000.00
Algal components	R 1 510 160.00
Fencing	R 233 450.00
Sub-Total (1): Construction Cost Ex. P&G and Contingencies	**R 7 061 510.00**
Preliminary and General @ 15%	R 1 059 226.50
Contingencies @ 10%	R 812 073.65
Sub-Total (2): Construction Estimate	**R 8 932 810.15**
PROFESSIONAL & OTHER FEES	
Professional Engineering Fees	R 1 143 399.70
Part time Site Monitoring - 6 months	R 144 000.00
Environmental Impact Assessment (Basic), with specialist studies	R 181 520.00
ECO (6 months)	R 60 000.00
Geotechnical Investigation	R 47 500.00
Survey	R 19 600.00
System Commissioning - EBRU	R 350 000.00
Sub-Total (2): Professional Fees and others	**R 1 946 019.70**
TOTAL (Ex VAT)	**R 10 878 829.85**

11. PROJECT PROGRAMME

We propose the following programme as indicative for the roll-out of the project, based on a 1 Ml/d upgrade IAPS.

Activity/Deliverable	Due Date
Inception Report	14 March 2016
Preliminary Design	29 April 2016
Detailed Design Report	30 June 2016
Tender Document	31 August 2016
EIA – Basic Assessment (RoD issued)	14 January 2017
Tender process	30 October 2017
Contractor appointment	05 January 2017
Construction completion	31 July 2017
Commissioning, optimization & exit	15 December 2017
Final Report	20 July 2017

12. CONCLUSION

Umjindi Local Municipality had expressed interest in the funding provided by the WRC (Water Research Commission) for the development of an IAPS (Integrated Algal Pond System). WRC had awarded funding for the establishment of an IAPS plant at the Barberton WWTW, located in the Umjindi Local Municipality. Based on the available funding provided by WRC, it was decided to construct 1Ml/d using IAPS at the Barberton WWTW.

The one disadvantage of pond systems is that they require substantially more land, than the conventional activated sludge plants.

The DST has recognised the IAPS process as a South African developed technology variant that has a role to play in driving costs of service provision down and improving levels of servicing. The DST and the WRC are willing to invest time, effort and funding to scale this technology and allow it to benefit the local government sector.

Umjindi LM has taken up this opportunity to become a pilot site and trailblazer in the development of IAPS in South Africa.

13. REFERENCES

Draft Umjindi Local Municipality Spatial Development Framework – 2008 Guidelines for Human Settlement: Planning and Design

Guidelines for Human Settlement: Planning and Design

Integrated Algal Ponding Systems and the Treatment of Domestic and Industrial Wastewaters Part 1 – The AIWPS Model - WRC

The Process Design Guide for Small Wastewater Works by DJ Nozaic and SD Freese

Waste Stabilisation Pond Design Manual by J. Ashworth and M. Skinner

ANNEXURE A

Preliminary Design Drawings

No.	List of Drawings	Revision
1.	1502121-W-100-Layout Plan IAPS	A
2.	1502121-W-101- Inlet works detail	A
3.	1502121-W-102- Anaerobic Digester detail	A
4.	1502121-W-103- HRAP Stage 1 detail	A
5.	1502121-W-104- HRAP Stage 2 detail	A
6.	1502121-W-105-Algae Settling pond detail	A