

### 11.3 Annex 3: Calculations for Average Incremental Cost (AIC)

Determination of projected costs and tariffs require project definition and cost estimates. The following calculations are based on research findings in Mombasa.

#### *Project definition and cost estimate*

Recent engineering studies concluded that there was need to improve bulk water supply and to strengthen the distribution network in Mombasa and the coastal area. Among other outputs, the studies defined two main project components:

- Bulk water supply development for Mombasa and
- Improvements to water distribution network in Mombasa.

The total construction cost of the bulk supply component is estimated at US\$223 million. The operation and maintenance costs for this component is estimated at US\$1.82 million per year. It is assumed that these costs will remain constant for the life of the project since flow of water is by gravity.

The construction cost for the component to improve the distribution network is estimated at US\$62 million. Assuming commercial management, the optimal operation and maintenance costs for the distribution system is estimated at about Ksh27/= (US\$0.37) per m<sup>3</sup>.

The total capital costs to implement both the bulk supply component and improvements in distribution network is estimated at US\$285 million.

#### *Project Scenarios*

Two different scenarios for determination of the average incremental cost (AIC) for Mombasa are considered. The scenarios are based on implementing the two project components recommended by the recent engineering studies. It is assumed that NWCPD succeeds in obtaining low interest, long term investment capital to undertake bulk supply development, transmission and distribution works. The following assumptions have been made to facilitate determination of AIC costs:

- Capital costs are only incurred at the end of construction period, after which the project starts to produce benefits.
- The only benefits delivered by the project are in form of revenue from sale of water. In practice, infrastructure projects, and more so water projects, deliver social and economic benefits, most of which cannot be easily quantified.
- Annual operation and maintenance (O & M) costs are constant. In many infrastructure projects, O & M costs increase over time as the infrastructure gets old. O & M costs could also reduce over time if management efficiency increases in the operations and maintenance phase of a project.
- The life of the project is assumed to be only 25 years for purposes of calculating the AIC. It is known that such projects have a much longer life span. In particular, most gravity based water projects deliver benefits for longer periods, sometimes as long as fifty to a hundred years. The existing Mzima pipeline water project is over 45 years old and still producing the same quantity of water it was producing 45 years ago at minimal operation and maintenance cost.

- The quantity of water produced by the infrastructure and sold to customers is constant throughout the life of the project. In practice, some water projects operate at a low capacity on commissioning and achieve full production capacity a few years later as population and water demand increases. Since Mombasa is a capacity constrained city with suppressed demand, high willingness to pay but with problems of obtaining investment capital, it is assumed that the project now under consideration will be operated at full capacity soon after commissioning. Other projects will come on line after a few years to help meet the water demand of the growing population.

The total capital cost for both project components is US\$285 million. Provision for rehabilitation of the system is made at US\$10 million. It is assumed that this amount will be spent in the 10th year after commissioning. Both scenarios 1 and 2 assume that financing will be available to finance bulk supply and improvements to the distribution network. It is assumed that the full costs of improving the water supply system will be met from water sales from the entire region.

The following further assumptions are made:

- Financing is secured at 8% per annum with a grace period equal to the construction period, so that repayments commence after commissioning when water is sold to customers.
- Management of the distribution system will be on commercial basis.

The operation and maintenance cost for Sabaki (Baricho) water source has been estimated at US\$0.59 per m<sup>3</sup>. It is assumed that Marere and Tiwi maintain production at capacities of 12,000m<sup>3</sup>/day and 6,000m<sup>3</sup>/day respectively and that Baricho source maintains its present contribution of 72,000m<sup>3</sup>/day. The total amount of water distributed by the strengthened network is assumed to be 176,400m<sup>3</sup>

Scenario 1 assumes a high level of management efficiency estimated at 15% unaccounted for water (UFW) and 90% bill collection efficiency. For this scenario, the average incremental cost of water works out as US\$1.08 per m<sup>3</sup>. With the present exchange rate of KSh73/= to the US\$, the Average Incremental Cost is about KSh78.85/= per m<sup>3</sup>

Scenario 2 assumes a moderate level of management efficiency at 20% unaccounted for water (UFW) and 85% bill collection efficiency. For this scenario, the average incremental cost of water works out as US\$1.21 per m<sup>3</sup>. With the present exchange rate of KSh73/= to the US\$, the Average Incremental Cost is about KSh88.30/= per m<sup>3</sup>.

Detailed calculations for each of the two scenarios are presented below.

*Scenario 1: AIC calculation based on high level of management efficiency*

Scenario 1 assumes a high level of management efficiency.

Further assumptions are:

- Unaccounted for water (UFW) is 15% so that 85% of water produced is sold (billed for).
- Revenue (bill) collection efficiency of the water utility is 90% (with commercial management). This means that 90% of the water sold is actually paid for.

Total Capital Cost of the second Mzima pipeline, storage, & distribution  
US\$285,000,000

Annual O&M cost (Mzima bulk supply, 86400m<sup>3</sup>/day) US\$2,000,000/yr

Annual O&M cost (Baricho & Tiwi bulk sources, 78,000@US\$0.59)US\$16,797,000/yr

Annual O&M costs (distribution system with commercial management)US\$8,000,000yr

Total operation and maintenance costs US\$26,797,000/yr

Annual water produced 176,400m<sup>3</sup>/day 64,386,000m<sup>3</sup>/yr

Annual water sold (@15% UFW) 54,730,000m<sup>3</sup>/yr

Annual water sold and paid for (@90% bill collection efficiency) 49,260,000m<sup>3</sup>/yr

Discount Rate 8%

With these assumptions, the average incremental cost for the project is calculated as shown below.

# ANNEXES

**Table 11.1. Scenario 1: AIC calculation based on high level of management efficiency (15% UFW and 90% bill collection efficiency)<sup>1</sup>**

| Year | Capital Costs in '000 US\$ | Operation and Maintenance Costs in '000 US\$ | Total Costs in '000 US\$ | Discount Factor at 8% Discount Rate | Present Value of Total Costs in '000 US\$ | Water sold and paid for in '000m <sup>3</sup> /yr | Present Value of Water sold and paid for in '000m <sup>3</sup> /yr |
|------|----------------------------|--|--------------------------|-------------------------------------|---|---|--|
| 1    | 285,000                    | 16,797                                       | 301,797                  | 0.926                               | 279,464                                   | 25,000  | 23,150   |
| 2    |                            | 26,797                                       | 26,797                   | 0.857                               | 22,965                                    | 49,260  | 42,216   |
| 3    |                            | 26,797                                       | 26,797                   | 0.794                               | 21,277                                    | 49,260  | 39,112   |
| 4    |                            | 26,797                                       | 26,797                   | 0.735                               | 19,696                                    | 49,260  | 36,206   |
| 5    |                            | 26,797                                       | 26,797                   | 0.681                               | 18,249                                    | 49,260  | 33,546   |
| 6    |                            | 26,797                                       | 26,797                   | 0.630                               | 16,882                                    | 49,260  | 31,034   |
| 7    |                            | 26,797                                       | 26,797                   | 0.583                               | 15,623                                    | 49,260  | 28,719   |
| 8    |                            | 26,797                                       | 26,797                   | 0.540                               | 14,470                                    | 49,260  | 26,600   |
| 9    |                            | 26,797                                       | 26,797                   | 0.500                               | 13,399                                    | 49,260  | 24,630   |
| 10   | 10,000                     | 26,797                                       | 36,797                   | 0.463                               | 17,037                                    | 49,260  | 22,807   |
| 11   |                            | 26,797                                       | 26,797                   | 0.429                               | 11,496                                    | 49,260  | 21,133   |
| 12   |                            | 26,797                                       | 26,797                   | 0.397                               | 10,638                                    | 49,260  | 19,556   |
| 13   |                            | 26,797                                       | 26,797                   | 0.368                               | 9,861                                     | 49,260  | 18,128   |
| 14   |                            | 26,797                                       | 26,797                   | 0.340                               | 9,111                                     | 49,260  | 16,748   |
| 15   |                            | 26,797                                       | 26,797                   | 0.315                               | 8,441                                     | 49,260  | 15,517   |
| 16   |                            | 26,797                                       | 26,797                   | 0.292                               | 7,825                                     | 49,260  | 14,384   |
| 17   |                            | 26,797                                       | 26,797                   | 0.270                               | 7,235                                     | 49,260  | 13,300   |
| 18   |                            | 26,797                                       | 26,797                   | 0.250                               | 6,699                                     | 49,260  | 12,315   |
| 19   |                            | 26,797                                       | 26,797                   | 0.232                               | 6,217                                     | 49,260  | 11,428   |
| 20   |                            | 26,797                                       | 26,797                   | 0.215                               | 5,761                                     | 49,260  | 10,591   |
| 21   |                            | 26,797                                       | 26,797                   | 0.199                               | 5,333                                     | 49,260  | 9,803  |
| 22   |                            | 26,797                                       | 26,797                   | 0.184                               | 4,931                                     | 49,260  | 9,064  |
| 23   |                            | 26,797                                       | 26,797                   | 0.170                               | 4,556                                     | 49,260  | 8,374  |
| 24   |                            | 26,797                                       | 26,797                   | 0.158                               | 4,234                                     | 49,260  | 7,783  |
| 25   |                            | 26,797                                       | 26,797                   | 0.146                               | 3,912                                     | 49,260  | 7,192  |
|      |                            |  |                          | TOTAL PRESENT COSTS                 | 545,312                                   | TOTAL PRESENT VALUE OF WATER SOLD AND PAID FOR    | 503,336  |

1. Average Incremental Cost = (Present Value of Total Costs)/(Present Value of water sold and paid for)  
= US\$545,312,000 / 503,336,000m<sup>3</sup> = US\$1.08per m<sup>3</sup>

In this scenario, the average incremental cost of water is US\$1.08 per m<sup>3</sup>. With the present exchange rate of KSh73/= to the US\$, the Average Incremental Cost is about Ksh78.85/ = per m<sup>3</sup>

In order to break even, the average tariff would be set at US\$1.08 per m<sup>3</sup>.

*Scenario 2: AIC calculation based on moderate level of management efficiency*

Scenario 2 is similar to scenario 1 above but at a lower level of management efficiency. In this scenario, the AIC is calculated assuming that UFW is 20% and bill collection efficiency is 85%.

|  |                              |
|--|------------------------------|
| Total Capital Cost of the second Mzima pipeline, storage, & distribution | US\$285,000,000              |
| Annual O&M cost (Mzima bulk supply, 86400m <sup>3</sup> /day)            | US\$2,000,000/yr             |
| Annual O&M cost (Baricho & Tiwi bulk sources, 78,000@US\$0.59)           | US\$16,797,000/yr            |
| Annual O&M costs (commercial management assumed)                         | US\$8,000,000/yr             |
| Total operation and maintenance costs                                    | US\$26,797,000/yr            |
| Annual water produced 176,400m <sup>3</sup> /day                         | 64,386,000m <sup>3</sup> /yr |
| Annual water sold (@ 20%UFW)   | 51,510,000m <sup>3</sup> /yr |
| Annual water sold and paid for (@ 85% bill collection efficiency)        | 43,800,000m <sup>3</sup> /yr |
| Discount Rate  | 8%                           |

With these assumptions, the average incremental cost for the project is calculated as shown below.

In this scenario, the average incremental cost of water is US\$1.21 per m<sup>3</sup>. With the present exchange rate of KSh73/= to the US\$, the Average Incremental Cost is about Ksh88.30/ = per m<sup>3</sup>

In order to break even, the average tariff would be set at US\$1.21 per m<sup>3</sup>.

The above calculations show that efficient management of a water utility has the potential to lower water tariffs.

# ANNEXES

**Table 11.2. Scenario 2: AIC calculation based on high level of management efficiency (15% UFW and 90% bill collection efficiency)<sup>1</sup>**

| Year | Capital Costs in '000 US\$ | Operation and Maintenance Costs in '000 US\$ | Total Costs in '000 US\$ | Discount Factor at 8% Discount Rate | Present Value of Total Costs in '000 US\$ | Water sold and paid for in '000m <sup>3</sup> /yr | Present Value of Water sold and paid for in '000m <sup>3</sup> /yr |
|------|----------------------------|--|--------------------------|-------------------------------------|---|---|--|
| 1    | 285,000                    | 16,797                                       | 301,797                  | 0.926                               | 279,464                                   | 24,000  | 22,224   |
| 2    |                            | 26,797                                       | 26,797                   | 0.857                               | 22,965                                    | 43,800  | 37,537   |
| 3    |                            | 26,797                                       | 26,797                   | 0.794                               | 21,277                                    | 43,800  | 34,777   |
| 4    |                            | 26,797                                       | 26,797                   | 0.735                               | 19,696                                    | 43,800  | 32,193   |
| 5    |                            | 26,797                                       | 26,797                   | 0.681                               | 18,249                                    | 43,800  | 29,828   |
| 6    |                            | 26,797                                       | 26,797                   | 0.630                               | 16,882                                    | 43,800  | 27,594   |
| 7    |                            | 26,797                                       | 26,797                   | 0.583                               | 15,623                                    | 43,800  | 25,535   |
| 8    |                            | 26,797                                       | 26,797                   | 0.540                               | 14,470                                    | 43,800  | 23,652   |
| 9    |                            | 26,797                                       | 26,797                   | 0.500                               | 13,399                                    | 43,800  | 21,900   |
| 10   | 10,000                     | 26,797                                       | 36,797                   | 0.463                               | 17,037                                    | 43,800  | 20,279   |
| 11   |                            | 26,797                                       | 26,797                   | 0.429                               | 11,496                                    | 43,800  | 18,790   |
| 12   |                            | 26,797                                       | 26,797                   | 0.397                               | 10,638                                    | 43,800  | 17,389   |
| 13   |                            | 26,797                                       | 26,797                   | 0.368                               | 9,861                                     | 43,800  | 16,118   |
| 14   |                            | 26,797                                       | 26,797                   | 0.340                               | 9,111                                     | 43,800  | 14,892   |
| 15   |                            | 26,797                                       | 26,797                   | 0.315                               | 8,441                                     | 43,800  | 13,797   |
| 16   |                            | 26,797                                       | 26,797                   | 0.292                               | 7,825                                     | 43,800  | 12,790   |
| 17   |                            | 26,797                                       | 26,797                   | 0.270                               | 7,235                                     | 43,800  | 11,826   |
| 18   |                            | 26,797                                       | 26,797                   | 0.250                               | 6,699                                     | 43,800  | 10,950   |
| 19   |                            | 26,797                                       | 26,797                   | 0.232                               | 6,217                                     | 43,800  | 10,162   |
| 20   |                            | 26,797                                       | 26,797                   | 0.215                               | 5,761                                     | 43,800  | 9,417  |
| 21   |                            | 26,797                                       | 26,797                   | 0.199                               | 5,333                                     | 43,800  | 8,716  |
| 22   |                            | 26,797                                       | 26,797                   | 0.184                               | 4,931                                     | 43,800  | 8,059  |
| 23   |                            | 26,797                                       | 26,797                   | 0.170                               | 4,556                                     | 43,800  | 7,446  |
| 24   |                            | 26,797                                       | 26,797                   | 0.158                               | 4,234                                     | 43,800  | 6,920  |
| 25   |                            | 26,797                                       | 26,797                   | 0.146                               | 3,912                                     | 43,800  | 6,395  |
|      |                            |  |                          | TOTAL PRESENT COSTS                 | 545,312                                   | TOTAL PRESENT VALUE OF WATER SOLD AND PAID FOR    | 449,186  |

1. Average Incremental Cost = (Present Value of Total Costs)/(Present Value of water sold and paid for)  
= US\$545,312,000/449,186,000m<sup>3</sup> = **US\$1.21 per m3**