Limitations of navigation through Nubaria canal, Egypt

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ABSTRACT

Alexandria port is the main Egyptian port at the Mediterranean Sea. It is connected to the Nile River through Nubaria canal, which is a main irrigation canal. The canal was designed to irrigate eight hundred thousand acres of agricultural lands, along its course which extends 100 km. The canal has three barrages and four locks to control the flow and allow light navigation by some small barges. Recently, it was decided to improve the locks located on the canal. More than 40 million US$ was invested in these projects. This decision was taken to allow larger barges and increase the transported capacity through the canal. On the other hand, navigation through canals and restricted shallow waterways is affected by several parameters related to both the channel and the vessel. Navigation lane width as well as vessel speed and maneuverability are affected by both the channel and vessel dimensions. Moreover, vessel dimensions and speed will affect the canal stability. In Egypt, there are no guide rules for navigation through narrow and shallow canals such as Nubaria. This situation threatens the canal stability and safety of navigation through it. This paper discussed the characteristics of Nubaria canal and the guide rules for navigation in shallow restricted waterways. Dimensions limitation for barges navigating through Nubaria canal is presented. New safe operation rules for navigation in Nubaria canal are also presented. Moreover, the implication of navigation through locks on canal discharge is estimated.

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Introduction

River transport plays an important role in the development of countries which have navigable water ways. River transport has several advantages over other transportation methods. In Egypt, the Nile River is the main river transport route between different cities and locations along its course from Aswan, at Upper Egypt, to Cairo, at Lower Egypt. The harbors, which located at the Mediterranean Sea, are connected with Cairo and all Upper Egypt cities through the Nile River branches and some other canals. The river transport route between Cairo and Alexandria port, at the Mediterranean Sea, passes through Nubria and El-Beheeri Canals. Recently, the Egyptian government decided to improve the locks located at this waterway to increase transport capacity through the canal. The River Transport Authority (RTA) is investing more than 40 million US dollars for this purpose. However, the increase in barge dimensions or speed will affect the canal stability.

Fahmy [1], Shaheer et al. [2], and Elsersawy and Fahmy [3] investigated the suitable waterway dimensions in the main navigation channels in Egypt. They concluded that a channel...
width of about 42 m and a water depth of 2.3 m are needed to allow for two way traffic through Nubaria canal. Their calculations were based upon a design vessel of 100 m length, 7.5 m wide, and 1.6 m draught. However, some parts of Nubaria canal have smaller dimensions than their recommended dimensions. The required water depth is also not achieved in some parts of the canal along the year. Till now, there are no guide rules for navigation through Nubaria canal.

This paper discusses the limitations of increasing barge dimensions through Nubaria canal. A recommendation for the safe operation rules of navigation in Nubaria canal is also presented.

**Methodology**

**Nubaria canal characteristics**

Nubaria canal is a main irrigation canal at the north west of Egypt (Fig. 1). It was designed to irrigate eight hundred thousand acres of agricultural lands, along its course which extends 100 km. Several hydraulic structures control the flow and water levels through the canal [4]. The canal has an intake barrage and two intermediate barrages at kilometers 28 and 60. All barrages include navigation locks. Moreover, another fourth lock was constructed, at the end of the canal at kilometer 100, to allow navigation towards Alexandria port at the Mediterranean Sea through Mariout Lake.

**Canal section and water levels**

The canal bed width varies from 50 m at the canal intake to 32 m at the end part of the canal [4]. The 50 m bed width extends for 50 km of the canal length; meanwhile the 32 m bed width extends for 43 km (Table 1). The bed slope ranges from 3 to 6 cm/km except for very short distances where the bed is horizontal. The design maximum inflow passing through the canal intake is 11.90 million m$^3$/day (137.73 m$^3$/s) while the design minimum inflow is 7.95 million m$^3$/day (92.01 m$^3$/s). Table 2 shows the minimum water levels measured at different gauges along the canal (1997–2007) [5]. Fig. 2 shows the longitudinal canal profile, the design bed levels, and the minimum water levels along the canal.

It can be shown from Table 2 and Figs. 1 and 2 that, the canal is divided into three reaches. The 1st reach extends from the intake barrage to Bostane Barrage (at km 28), where the minimum water depth ranged from 2.55 m to 3.70 m. The 2nd reach extends from Bostane Barrage to km 57.5, where the minimum water depth ranged from 2.60 m to 3.55 m. The 3rd reach extends from Janklees barrage (at km 61) to the end of the canal (at km 100), where the minimum water depth ranged from 1.85 m to 2.05 m.

Fig. 3 shows the variation of water levels at the 3rd reach during year 2010 [5]. It can be shown that the min. water level was 2.55 m, which corresponds to min. water depth of 1.9 m. However, the water depth ranged between 1.95 and 2.0 m, for more than 10 months of the year.

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**Table 1** Characteristics of Nubaria canal cross section [4].

| Location | From (km) | To (km) | Canal bed width (m) | Bed slope (cm/km) |
|----------|-----------|---------|---------------------|------------------|
| 0        | 3.18      | 50      | 6                   |
| 3.18     | 7.40      | 40      | 6                   |
| 7.40     | 10.00     | 55      | 5                   |
| 10.00    | 57.50     | 50      | 5                   |
| 57.50    | 62.00     | 32      | 0                   |
| 62.00    | 80.00     | 32      | 6                   |
| 80.00    | 82.50     | 32      | 0                   |
| 82.50    | 86.00     | 32      | 3                   |
| 86.00    | 95.70     | 32      | 4                   |
| 95.70    | 100.00    | 32      | 0                   |

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**Fig. 1** Nubaria canal location and course [4].
Canal critical bends

On the other hand, the canal has many bends along its course (Fig. 1). The characteristics of these bends affect the navigation along the canal. Some of these bends have no serious effect on navigation as their radii are larger than 1000 m. However, there are other bends with small radii and high deflection angles. The characteristics of these critical bends are described in Table 3.

Table 2 Measured min. water levels and corresponding min. water depths along Nubaria canal (1997–2007) [5].

| Year | Intake | Bostan barrage (km 28) | Janaklees barrage (km 61) | km 100 lock |
|------|--------|------------------------|---------------------------|-------------|
|      | D/S    | U/S                    | D/S                       | U/S         | D/S | U/S | D/S | U/S | D/S | U/S | D/S | U/S |
|      | Water level | Water depth | Water level | Water depth | Water level | Water depth | Water level | Water depth | Water level | Water depth |
| 1997 | 7.3    | 2.55                   | 6.4             | 3.15          | 6.37         | 3.12          | 4.62         | 2.37          | 4.3        | 2.05 |
| 1998 | 7.5    | 2.75                   | 6.9             | 3.65          | 6.8          | 3.55          | 4.5          | 2.25          | 4.0        | 1.75 |
| 1999 | 7.5    | 2.75                   | 6.95            | 3.7           | 6.4          | 3.15          | 4.4          | 2.15          | 4.1        | 1.85 |
| 2000 | 7.6    | 2.85                   | 6.13            | 2.88          | 6.1          | 2.85          | 4.35         | 2.1          | 4.28       | 2.03 |
| 2001 | 7.9    | 3.15                   | 6.9             | 3.65          | 6.8          | 3.55          | 4.2          | 1.95          | 4.13       | 1.88 |
| 2002 | 7.8    | 3.05                   | 6.4             | 3.15          | 6.2          | 2.95          | 4.3          | 2.05          | 4.2        | 1.95 |
| 2003 | 7.9    | 3.15                   | 6.75            | 3.5           | 6.4          | 3.15          | 4.3          | 2.05          | 4.2        | 1.95 |
| 2004 | 8.3    | 3.55                   | 6.8             | 3.55          | 6.77         | 3.52          | 4.3          | 2.05          | 4.2        | 1.95 |
| 2005 | 8.3    | 3.55                   | 6.68            | 3.43          | 6.65         | 3.4           | 4.32         | 2.07          | 4.22       | 1.97 |
| 2006 | 8.2    | 3.45                   | 6.48            | 3.23          | 6.4          | 3.15          | 4.15         | 1.9           | 4.05       | 1.8 |
| 2007 | 7.9    | 3.15                   | 6.4             | 3.15          | 6.37         | 3.12          | 4.4          | 2.15          | 4.15       | 1.9 |

Table 3 Characteristics of critical bends at Nubaria canal [4].

| Bend | Bend Location | Bend Radius | Bend Deflection Angle | Bed Width |
|------|---------------|-------------|-----------------------|-----------|
| 7.0  | 48            | 45          | 45                    | 45        |
| 7.5  | 40            | 45          | 45                    | 45        |
| 14.2 | 300           | 300         | 300                   | 300       |
| 28.0 | 350           | 45          | 45                    | 45        |
| 350  | 55            | 40          | 40                    | 40        |
| 40   | 35            | 40          | 40                    | 40        |
| 32   | 40            | 45          | 45                    | 45        |

Fig. 2 Nubaria canal longitudinal profile [4,5].

Fig. 3 Water level upstream km 100 lock (year 2010) [5].
Canal navigation condition

Different types of barges were using Nubaria canal for transporting goods from Alexandria harbor to Cairo and vice versa. These barges varied from self-propelled barges 7.5 m wide, 50 m long, and 1.6 m draft to a pusher and pushed dump barges 7.5 m wide, 100 m long and 1.6 m draft [2]. However, recently “RTA” allowed a company to use new self-propelled barges 12 m wide, 100 m length with a draft 1.8 m. The average monthly number of barges passing through Nubaria canal is about 200 units in both directions; which means that the daily traffic volume ranges from 3 to 4 barges in each direction. Accordingly, it can be concluded that the available water depth through the 3rd reach is too shallow most of the year. The canal width in the 3rd reach is less than three times the width of the new barges. On the other hand, there is no traffic management through the canal. There is no speed monitoring. There are no strict rules for navigation through the canal. There is no notice for mariners about water depth variations. This situation endangers the navigation safety and might end to damage the canal.

Navigation in canals and shallow waterways

Navigation through canals and restricted shallow waterways is affected by several parameters related to both the channel and the vessel. The parameters related to the target vessel are length (L), beam (B), maximum draft (d), speed (V), maneuverability, and traffic density. Meanwhile, the waterway characteristics that affect navigation are channel dimensions (width and depth), bottom material characteristics, current velocity, wind speed and direction [6–8].

Waterway width

Waterway width is to be designed to the target vessel; which is normally the largest vessel that the waterway is expected to accommodate safely and efficiently. The design width (Fig. 4) is considered the summation of width requirements for:

1. Ship maneuvering; (the maneuvering lane is the width required to allow for the oscillating track produced by the combination of sway and yaw of the vessel).
2. Counteracting crosswinds and cross current.
3. Counteracting bank suction.
4. Hydrodynamic interactions between meeting and passing vessels in two-way traffic.
5. Other allowance relating to navigation aids, cargo hazard, depth/draft ratio, and channel bed material.

| Vessel maneuverability | Good | Moderate | Bad |
|------------------------|------|----------|-----|
| Basic maneuvering lane width | 1.3B | 1.5B | 1.8B |
| Additional width is required to cover | | | |
| Cross wind | | | |
| – <15 knots | 0.0B | 0.0B | 0.0B |
| – 15–33 knots | 0.3B | 0.4B | 0.5B |
| – >33 knots | 0.6B | 0.8B | 1.0B |
| Bank suction (clearance) | 0.5B | 0.75B | 1.0B |
| Longitudinal current | | | |
| – <1.5 knots | 0.0B |
| – 1.5–3.0 knots | 0.2B |
| – >3.0 knots | 0.4B |
| Vessel clearance (for two way traffic) | 1.0B |
| Traffic density | | | |
| – <1 vessel/h | 0.0B |
| – 1–3 vessel/h | 0.2B |
| – >3 vessel/h | 0.4B |
| Cargo hazards | | | |
| – Low | 0.0B |
| – Medium | 0.5B |
| – High | 1.0B |
| Water way depth | | | |
| – D/d > 1.5 | 0.0B |
| – 1.5 > D/d > 1.15 | 0.2B |
| – D/d < 1.15 | 0.4B |
| Channel bottom surface (for D/d < 1.5 only) | | | |
| – Smooth and soft | 0.1B |
| – Smooth and hard | 0.1B |
| – Rough and hard | 0.2B |
| Aids to navigation | | | |
| – Excellent | 0.0B |
| – Good | 0.1B |
| – Moderate (infrequent poor visibility) | 0.2B |
| – Moderate (frequent poor visibility) | 0.5B |

Fig. 4  Waterway width [6–8].
Several researchers and navigation agencies introduced guide lines for the estimation of the water way width, in straight reaches, taking into consideration all the above factors [1–3,6–9]. Therefore, the recommended water way width can be estimated as a function of the design vessel beam \((B)\) according to Table 4.

It should be noted that there are other width widening standards related to cross currents; however it does not exist in Nubaria canal.

**Water way depth**

On the other hand, the waterway design depth is considered the summation of depths required for:

1. Static vessel draft.
2. Trim and squat allowance.
3. Bottom material allowance.

Meanwhile, the actual waterway depth includes the design depth in addition to over depth allowance for silting processes and sounding/dredging tolerance (Fig. 5).

**Ship squat**

The amount of ship squat depends on several factors, including ship speed, depth of the channel, and geometric characteristics of the ship. The maximum vertical ship motion below the vessel’s static position (ship squat) may be found from the following equation [6,10]

\[
Z \left( \frac{d}{D} \right) = 0.298 \left( \frac{V}{\sqrt{gd}} \right)^{2.289} \left( \frac{D}{d} \right)^{-2.972} F_w
\]

where \(Z\) is the ship squat (sinkage and trim); \(d\) the vessel draught; \(D\) the channel depth; \(V\) the vessel speed; \(g\) the gravity acceleration; \(W\) the channel width; \(B\) the vessel beam; and \(F_w\) is the channel width factor.

\[
F_w = \frac{3.1}{\sqrt{W/B}}
\]

where \(W < 9.61B\)

**Bottom material allowance**

The bottom material allowance, also known as the Net Underkeel Clearance, is by definition the minimum safety margin between the keel of the vessel and the project waterway depth. It is recommended to be taken as follows [6]:

- 0.25 m for soft bottom;
- 0.60 m for medium bottom material (sandy soil);
- 0.90 m for hard bottom (rock).

On the other hand, a simple general guideline for minimum depth clearance requirements in channels are given by PIANC [9] as

\[
\frac{\text{Water depth}}{\text{Ship draft}} \geq 1.3 \quad \text{for wave height} \leq 1.0 \text{ m}
\]

**Ship speed limit**

The speed at which the design ship will be operated in the proposed channel should be selected carefully. Operational considerations limit ship speeds because of the need to reduce ship squat and vessel wave effects on the waterway. The important parameter that governs ship waves in shallow water is the depth Froude number [8,11]:

\[
F_h = \frac{V}{\sqrt{gh}}
\]

where \(F_h\) is the depth Froude number; \(V\) the ship speed in meters/s (feet/s); \(h\) the water depth in meters (feet); and \(g\) is the acceleration as a result of gravity in meters (feet) per \(s^2\).

As the ship speed increases, the shallow-water effects will increase up to the value of depth Froude number equal to unity, where critical open channel flow would occur. In practice, wave effects, squat and running trim, and ship resistance become very high at \(F_h\) values well below \(F_h = 1.0\), so that normally a self-propelled merchant ship would not exceed \(F_h\) of about 0.6. A further increase of wave effects, squat, and ship resistance occurs when ships sail in restricted navigation channels. The ratio of mid-ship cross-sectional area (normally, \(A_s\), is ship beam times draft or \(B T\)) and the channel cross

![Fig. 5 Waterway depth [6–8].](image-url)
section \((A_c)\) is used to characterize the relative channel restriction. The inverse of the above value of ship area \((A_s)\) to channel area \((A_c)\) is often described as the channel blockage ratio \((BR)\). The critical depth Froude number will change according to the channel blockage ratio \((BR)\) (Fig. 6).

**Navigation through bends**

Navigation through water way bends encounter maneuvering difficulties for the vessels. Vessel turning radius and the swept width depends upon vessel dimensions, water depth ratio \((h/T)\), and vessel maneuverability. The channel bend must be designed for the poorest turning vessel that is likely to use the channel. A minimum bend radius is required for vessels to proceed at a speed of 10 knots and to avoid widening approach to bend (Table 5) [6,7]. In case this minimum radius of curvature is not met, a supplementary width has to be added to the ship lane width of the straight channel to account for maneuvering difficulties.

**Results**

The dimensions and alignment of Nubaria canal will have an impact on the navigation through the canal due to its limitations in depth and width. According to the above design rules the navigation channel width can be estimated as a multiplier of the design vessel width. The design characteristics for navigation in Nubaria canal may be considered as follows [1–5]:

- Moderate vessel maneuverability.
- Cross wind speed < \(15\) knots.
- Longitudinal current < \(1.5\) knots.
- No cross currents.
- Medium traffic density (1–3 vessel/h).
- Low cargo hazards.
- Water way depth \(1.5 \geq D/d > 1.15\).
- Channel bottom surface is smooth and soft.
- Moderate aids to navigation with infrequent poor visibility.
- Slow vessel speed < \(10\) knots.

Therefore, the navigation channel width in straight reaches should be:

- \(3.7B\) for one way traffic.
- \(6.9B\) for two way traffic.

On the other hand the navigation channel width in case of excellent vessel maneuverability will be equal to “\(3.0B\)” for one way traffic and “\(6.0B\)” for two way traffic. Accordingly, the
maximum width for navigation vessels passing through Nubaria canal can be estimated, according to the actual canal cross sections (Table 1), as indicated in Table 6, for the case of moderate vessel maneuverability.

Moreover, Nubaria canal has some critical bends where the deflection angle varies from 40° to 52°, the radius of curvature ranges from 350 to 450 m (Table 3); and the canal width is not widened in the bends. Meanwhile, as the length of vessels navigating through Nubaria canal should follow the guide lines illustrated in Table 5. Therefore, it is recommended that the vessel length to be within 45–50 m, unless it is provided with special navigation systems to improve the vessel maneuverability. However, it should not exceed 100 m according to Shaher recommendations [2].

On the other hand, the limiting depth Froude number \( F_h \) for Nubaria canal, in the reach from km 57.5 to km 100, is about 0.5 considering the blockage ratio \( (A_s/A_d) \) within 5.5 (Fig. 6). Therefore, the limiting vessel speed shall be about 8 km/h (Eq. (2)). Accordingly, the squat at limiting speed will be 0.15 m (Eq. (1)). Furthermore, the limiting depth Froude number \( F_h \) for the reach from km 10 to km 57.5, is about 0.65 considering the blockage ratio \( (A_s/A_d) \) within 12.5 (Fig. 6). Therefore, the limiting vessel speed shall be 12 km/h (Eq. (2)).

As the total channel depth is the sum of the vessel draft and the vessel squat and the bottom material allowance. While, the bottom material of Nubaria canal may be considered soft to medium and the water depth of this reach of the canal varies between 1.95 m and 2.0 m. Then, the maximum draft for vessels navigating through Nubaria canal should not exceed 1.40 m, in minimum water level condition, and not to exceed 1.45 m in the rest of the year.

Discussion

Navigation traffic management in Nubaria canal

The above results indicated that, the reaches from km 57.5 to km 100 and from km 3.18 to km 7.40 should be operated as one way traffic; taking into consideration that the width of vessels navigating through Nubaria canal not to exceed 7.25 m. However, the vessel width is accepted to increase up to 8.5 m in case the navigation traffic is operated as one way traffic for the entire canal length.

Vessel parking facilities should be provided at lock locations. Moreover, vessel traffic monitoring system should be applied to Nubaria canal to control navigation traffic speed through it.

It should be noted that, exceeding the above vessel dimensions, draft, or maximum speed threatens canal bed and bank stability as well as endanger the safety of navigation through it.

Effect of navigation on Nubaria canal discharge

The navigation of vessels through the locks allows some of the water discharge to flow from the upstream side to the downstream side due to the filling and emptying process. The flow loss represents the volume of water drained to reduce the water level inside the lock chamber at each passage. This phenomenon does not have significant effect in case of rivers with large discharge. However, for small canals like Nubaria, this phenomenon might have significant effect on the losses in canal discharge. As described above, Nubaria has four locks along its course. The lock chambers are 16.0 m in width and 110 m in length. The head difference at km 100 lock is 5.0 m in average; whereas the head difference at the intermediate barrages is less than 1.0 m. Therefore, the loss in discharge in each navigation passage through km 100 lock is 8800 m³ approximately. The daily loss of discharge depends upon the navigation traffic scenarios through the 3rd reach of the canal. The 1st scenario may consider navigation traffic for 12 h in one direction and 12 h in the other direction. This means that six vessels will navigate through the 3rd reach in each direction; considering the navigation traffic density is 1 vessel/h. Therefore, the vessels are expected to navigate through the lock 6 times each day.

As a result, the expected loss of discharge will be 52,800 m³/day. This flow loss represents 1.0% of the maximum discharge passing through Janaklees barrage; while it represents 1.5% of the minimum discharge passing through this last reach of the canal. Moreover, the total annual water loss due to navigation is expected to reach 13.2 million m³/year (considering 250 working day/year).

On the other hand, a 2nd scenario for navigation traffic in one direction for 1 day and navigate in the other direction through another day. In this case, the lock will be used 24 times per day, considering the navigation traffic density is 1 vessel/h. Therefore, the expected loss of discharge will be 211,200 m³/day.

This flow loss represents 3.8% of the maximum discharge passing through Janaklees barrage; while it represents 5.9% of the minimum discharge passing through this last reach of the canal. Moreover, the total annual water loss due to navigation is expected to reach 52.8 million m³/year (considering 250 working day/year). It should be noted that this scenario increase the daily transport capacity by the double compared with the 1st scenario. However, it increases the water loss four times more than the 1st one.

It should be noted that, changing locks construction to be divided into two rooms exchanging the water between them will reduce the water loses to minimum.

Scour due to vessel propellers

Scour induced by propeller wash has become one of the most important issues for maintenance and design of navigation channels and harbor structures. The propeller jet produces a thrust in water, accelerating it and discharging it when a propeller is rotating. This jet velocity and associated shear stresses
depend upon the operating characteristics of the propeller and the speed of advance of the ship [12]. The jet velocity entrains the surrounding water and decays with distance from the propeller jet. Thus, the jet expands and the kinetic energy dissipates as diffusion.

The propeller jet may be divided into zone of flow establishment and zone with established flow (Fig. 7). The zone of flow establishment consists of a symmetry plane along the central flow axis. This symmetry forms two similar profiles with peaked ridges at the central. Later the velocities of these two peaked ridges will decay with distance of the propeller faces along the central axis. The diffusion of the jet is inclined at an angle of 13–15°. The zone of flow establishment extends from the efflux plane up to 3.25Dp [13]. The exit plane of a propeller flow is called the efflux velocity. This initial plane in front of the propeller is where the velocities within the jet are at a maximum. The efflux velocity of a propeller wash can be estimated using the equations [14,15]

\[ V_o = \zeta n D_p \sqrt{C_t} \]  

(3) And

\[ \zeta = \left( \frac{D_p}{D_h} \right)^{0.403} \left( \frac{C_t}{C_f} \right)^{-1.79} \bar{B} \bar{A} \bar{R}^{0.7} \]  

(4)

Meanwhile, the maximum velocity at the zone of flow establishment can be predicted using the equation [14]

\[ \frac{V_{max}}{V_o} = 0.87 \left( \frac{x}{D_p} \right)^{0.43} \]  

(5)

Moreover, the maximum velocity of the established flow zone can be predicted using the Hashmi’s equation [15].

\[ \frac{V_{max}}{V_o} = 0.638 [EX^{0.097}] \]  

(6)

where \( B \bar{A} \bar{R} \) is the blade area ratio; \( C_t \) the thrust coefficient; \( D_p \) the propeller diameter; \( D_h \) the hub diameter; \( n \) the number of revolutions per second of the propeller; \( P \) the pitch area ratio; \( V_o \) the efflux velocity; \( V_{max} \) the maximum velocity; \( x \) is the axial distance from propeller face.

If the propeller jet is restricted in a confined area such as a waterway or shallow water (in cases of minimum keel clearance), the remaining kinetic energy within the propeller jet will cause damage to the bed or banks. The bed scour will take place when the resulting shear stress acting on the channel bed exceeds the critical shear stress of the bed material. Therefore, the probability of bed scour occurrence should be checked according to the navigating vessels/barge propeller characteristics and the minimum keel clearance.

**Summary and conclusions**

This paper discussed the limitations of increasing navigation transport capacity through Nubaria canal. The dimensions and alignment characteristics of the canal were presented. The restrictions of navigation in shallow restricted water ways were discussed. The limitations for barge dimensions, draft, navigation speed, and traffic characteristics through Nubaria canal were estimated and discussed. Moreover, the effect of navigation traffic volume on water discharge losses through the third reach of Nubaria canal was also presented. The conclusions can be summarized as follows:

1. The reach from Janklees barrage at km 57.5 to km 100 lock as well as the reach from km 3.18 to km 7.40 should be operated as one way navigation traffic.
2. The width of vessels navigating through Nubaria canal should not exceed 8.5 m for one way traffic along all parts of the canal. However for two way traffic in some parts from km 10.0 to km 57.5, the vessel width should not exceed 7.25 m.
3. Vessel draft should not exceed 1.45 m.
4. Vessel speed should not exceed 8.0 km/h through the third reach of the canal from Janklees barrage at km 57.5 to km 100 lock. Meanwhile, vessel speed should not exceed 12.0 km/h through other parts of the canal.
5. The bends of Nubaria canal allow vessels with length up to 50 m to navigate without difficulty. Longer vessels should be provided with special navigation systems to improve the vessel maneuverability; however it should not exceed 100 m length.
6. The daily loss of canal discharge, due to navigation through locks, depends upon navigation traffic density and management. The estimated daily water loss, due to navigation through km 100 lock, varies from 52,800 m³/day to 211,200 m³/day based upon navigation traffic management. This water loss will reach 1.5–5.9% of the daily water discharge through the third reach of the canal.
7. The annual water loss at km 100 lock is expected to range from 13.2 million m³/year to 52.8 million m³/year, according to navigation traffic management.
8. Modifying locks construction by dividing it into two rooms exchanging the water between them will reduce the water losses to minimum.
9. Vessel parking facilities should be provided in both upstream and downstream sides of the locks.
10. Vessel traffic monitor system should be used to control and manage navigation through Nubaria canal.
11. A further study is needed to check the effect of barge propellers to induce bed scour.

**Conflict of interest**

The author has declared no conflict of interest.
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