Technologies Applied in the Toshka Project of Egypt

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Background

The Toshka Project, located in Egypt (see Figure 1), involves excavating a canal to carry about 380 billion ft^3 of water every year from Lake Nasser to the Toshka Depression, southwest of Aswan. This will eventually create a new valley to the River Nile in the western desert of Egypt in addition to the currently existing prehistoric river course. Before discussing the Toshka Project, it is important to first identify the following (see Figure 2):

- Toshka Region
- Toshka City
- Toshka Depression (in Arabic: *Mon-kha-fadd Toshka*)
- Toshka Bay (*Khore Toshka*)
- Toshka Spillway (*Ma-feed Toshka*)
- Toshka Canal (*Sheikh Za-yed Canal*)

The *Toshka Region* is located southwest of Aswan, about 600 miles south of Cairo. *Toshka City* is a new metropolitan city that is planned to serve a future population of 5 million. *Toshka Depression* is a natural depression in that area with an average diameter of 14 miles and a storage capacity of 1,665 billion ft^3. *Toshka Bay* is a shoot off Lake Nasser towards Toshka. *Toshka Spillway* is a free spillway discharging the water of Lake Nasser when it exceeds its highest storage level of 620 ft. It is a 14-mile long, man-made canal connecting Toshka Bay with the Toshka Depression and works as a safety valve for Lake Nasser, upstream of the High Dam.

Toshka Canal is the heart and soul of the Toshka Project. It is a new canal conveying the excess water of Lake Nasser that is pumped into it through a giant pumping station that elevates the water about 175 ft. The water then flows through the canal to reclaim and irrigate 534,000 new acres in the western desert of Egypt (El-Hag-Gar, 2001). The Toshka Project is an integral part of a much larger, mega project, the Southern Valley Development Project (SVDP), that aims at doubling the amount of cultivated land in Upper Egypt through developing the Toshka, East El-O-Wee-Nat, and the New Valley Oases (Ministry of Water Resources and Irrigation, 2000).

The Southern Valley Development Project

The SVDP is *not* a mere irrigation or agricultural project. The SVDP is a multifaceted, multiphase, development project that mainly involves horizontal expansion and land reclamation projects in the southern part of the Nile Valley in Egypt. It is a national, integrated,

Figure 1. Egypt.

Figure 2. The Toshka Project (Younan, 2001).

massive development project, aiming mainly at creating a balanced, re-organized Egyptian map from the demographic, habitation, economic, and security points of view. Total investments for implementing this project by 2017 are estimated at some US$ 100 billion, of which 20% to 25% is pledged by the Egyptian government to construct the main canal and its four offshoots, the pumping station, major roads, and main electricity network. The remaining 75% to 80% is to be supplied by the private sector.

Agriculture in the SVDP is only a base for the integrated development planned. Industry, mining, alternative energy production—and possibly oil and gas production and storage—and tourism are other parts of the vision, with plans for desert safaris, car rallies, conferences, and medical tourism.

Objectives of the SVDP include:

1. Adding new areas of agricultural land lying in the Southern Valley region.
2. Establishing new agricultural and industrial communities based on the exploitation of the agricultural raw material available in the new land.
3. Attracting and retaining a workforce, thus gradually dealing with the problem of overpopulation in the old Nile Valley.
4. Constructing an efficient network of main and side roads in accordance with the development objectives and plans.
5. Promoting tourist activities in such regions rich in ancient monuments.

The Toshka Project Infrastructure

The Toshka Project infrastructure includes the main pumping station (*Mubarak pumping station*), the Toshka Canal, water production wells and artificial charging, and wind and sand storm breakers (Wahby, 2001).

Mubarak Pumping Station (MPS)

The Toshka Project begins with the main pumping station—also known as *Mubarak pumping station (MPS)*—located on the left bank (west) of Lake Nasser, and north of Toshka Bay. More specifically, the pumping station is located 5 miles north of Toshka Bay spillway canal, 28 miles south of intersection with the Abu-Simbel/Aswan main highway. From this intersection it is 133 miles to Aswan northward and 37 miles to Abu Simbel southward. When completed, it will deliver 12,000 ft^3/sec into the main feeding canal.

The construction of the pumping station has been undertaken by the European Egyptian Japanese Consortium and led by London-based Skanska Cementation International. Engineering group ABB was awarded the contract to supply all the electrical equipment by Japanese Hitachi (part of the European Egyptian Japanese Consortium) in 1998. The contract included the high-capacity frequency converters for the pump motors (Water Technology, 2003).

The multistage MPS is one of the world's largest, designed to have a maximum static head of about 175 ft, which guarantees its operation when the water level in Lake Nasser reaches its lowest level of storage (445 ft; Abdel-Rahman, 2001). SonTek/YSI has provided the Toshka Project with four Argonaut-SLs to continuously record and display flow and level data for day-to-day operation of the canals. Data will also be logged and used as a historical record for a mathematical model that will give optimal set points for the canal water level (Sontek, 2002). Twenty-four pumps (12 each side), each with a discharge capacity of 600 ft^3/sec, are being housed inside the pumping station. The maximum energy necessary to operate MPS during maximum lifting is 375 M.W.

The station will be fed with 11 kV electrical power through a transmission line from a substation constructed close to the 11 kV switchgear building that is linked to the electric power double 220 kV line from Aswan High Dam with a length of 160 miles. The MPS is also an integral part of a concurrent project called the New Valley Development Project (NVDP), aimed at establishing an agro-industrial development in an adjacent area of about 988,000 acres.

Loughborough-based Morris Material Handling supplied five cranes having the combined qualities of size and flexibility required by the MPS project: three cranes with a capacity of 130t for lifting pumps and two smaller 30t gate cranes, each with a lift height of approximately 180 ft. One 130t goliath and the two 30t "odd-leg" goliaths were mounted on top of the completed pumping station. The 130t goliath lifts the pumps from the pump room to the loading bay, and the two 30t odd leg goliaths lift gates within the station. The two 130t overhead traveling pump room cranes started operation on site in mid-2001 with the other three cranes being installed on top of the pumping station at

the end of 2002. These 5-500 series cranes were chosen because of their versatility to meet varying customers' requirements. Built on-site, the cranes for this project were designed and manufactured in the UK, with Morris staff commissioning the machines on-site in Egypt (Water Technology, 2003).

Under a turnkey lump sum contract, with operation supervision during a guarantee period of 48 months, the MPS includes the design, construction, and maintenance of the following:

- An intake channel, 3 miles long, conveying water from Lake Nasser to the suction basin of the pumping station. Part of the channel (1 mile) is dry excavation (volume of excavation is 187 million ft^3), and the rest (2 miles) is wet excavation (volume of excavation is 196 million ft^3). The wet excavation is done using three gigantic dredgers (the world's largest at 200 ft arm length) for excavation under water.
- A reinforced concrete pumping station having length x width x height dimensions of 462 x 132 x 231 ft located as an island in the center of the suction basin. The lower 165 ft of its height will be permanently submerged underwater. Project designers for the concrete structure are Germany's Lahmeyer International and Cairo-based Hamza Associates.
- Twenty-four discharge concrete ducts having width x height dimensions of 9 x 8 ft, delivering the water from the pumps to the Toshka Canal via the discharge basin.
- Two annex buildings housing the 11 kV switchgear and the diesel generators.
- Three workshops: electrical workshop with laboratory, mechanical workshop, and automotive workshop.

Groundbreaking of the Toshka Project took place on January 1998, and excavation work at the MPS site started on June 1, 1998. The station was scheduled to be completed in 2002 at a cost of US$ 400 million. However, on January 12, 2003 during the celebrations of the 5th anniversary of the project's groundbreaking, only two pumps were put to work in a test operation with symbolic power enough to let water fill limited parts of the new Toshka Canal, only to a modest depth.

The Toshka Canal

The Toshka Canal is the main canal of the project, having a length of 44 miles that branches into four subcanals, with a total length of 160 miles. The canal and its four subcanals are designed to carry a discharge of 900 million ft^3/day to reclaim and irrigate four areas: 118,600 acres, 118,600 acres, 198,000 acres, and 98,800 acres, respectively—totaling 534,000 acres, an area equivalent to the combined areas of three neighboring governorates: Aswan, Kena, and So-Haag (Ministry of Water Resources and Irrigation, 1999).

The maximum designed water depth in the canal is 20 ft and the bed width is 100 ft, with a longitudinal slope of 6.67 inches/mile. The side slopes of the canal are 2:1, making the width at its top 200 ft. While the evaporation from the canal is estimated to be 0.7%, its cross-section is being lined with dense concrete to prevent any water leakage. After excavation to the required section, an 8-inch thick layer of stabilized soil (a compacted sand/cement mixture) is placed. Before pouring the top 8 inches of padding concrete layer onto that sub-base, 0.04 inches thick polyethylene sheets are placed on top of the sub-base stabilized soil layer to completely cover and "seal" it. A total of over 200 million ft^2 of polyethylene sheets are expected to be used in that process (Ramsis, 2001).

Two huge aggregate excavating and processing systems have been constructed and are able to supply coarse and fine size aggregates for concrete mixing. With the addition of two other concrete batching plant systems, the concrete production rate could reach 86,000 ft^3 per hour, which can satisfy the capability of 20 million ft^3 per month concrete placing. Each batching plant has its own cooling system that guarantees a 45°F temperature for cooling concrete, even in extremely hot weather (Taha, 2001).

To date, 70 miles have been completely excavated, of which 25 miles have already been also padded. The strict commitment to the workplan helped in complying with the schedule set for concrete-padding works, even under extremely unfavorable weather conditions. The usual operating rates amount to more than 370 longitudinal feet per day. However, in some instances it exceeded 430 longitudinal feet per day. When finished, the Toshka Canal is

expected to have utilized over 40 million ft^3 of concrete. Quality assurance and quality control procedures guarantee that code requirements, technical specifications, proper work practices, and safety measures are rigorously followed in all engineering works.

Water Production Wells and Artificial Charging

Currently, water required for various applications is supplied through the available groundwater stored in the local aquifer. Along the main canal, five productive wells were constructed to irrigate about 740 acres. However, to fully utilize the available ground water, another 200 wells are being dug to serve an area of about 29,600 acres.

Meanwhile, the Egyptian Ground Water Research Institute (GWRI) carried out studies to use the excess in floodwater, discharged to the Toshka Depression since 1996-97, to charge the Nubian ground aquifer. Artificial charging is now being carried out with an expected initial cost of about US$ 3 million.

Wind and Sand Storm Breakers

Wind and sand storm breakers comprising two rows of kaya and ponsiana trees are being planted on each side of the main canal as well as its four branches to protect them from the wind and the sand storms that ravage this region throughout the year. Almost 65 miles of trees have been planted to date (Abol-Hag-Gag, 2001).

Data and Statistics

Total excavation work in the Toshka Project is estimated at 3,100 million ft^3—seven times that which was needed in the construction of Aswan High Dam (only 445 million ft^3). To date, about 2,700 million ft^3 of excavation work is complete. As for sand filling work, 290 million ft^3 out of 540 million ft^3 has been accomplished.

Basalt and gravel for concrete work are provided locally from the Toshka area, whereas sand is transported from the nearby Kom-Ombo (65 miles) and the cement from Ass-Yoot (220 miles). Patching plants are located at 3-mile intervals, and eight mixing units produce over 37,000 ft^3 per day. Special chemical additives are incorporated into the water used for mixing and curing concrete to keep its temperature at 45°F.

Currently, five companies are working on the site using seven padding machines to pad the sloping sides and the short horizontal parts at the berm and the bed levels (Kadry, 2001). The bottom segment of the canal padding is manually lined using mechanical concrete mixers, pumps, and vibrators for concrete placement.

To serve ongoing reclamation projects, the area is equipped with an electric power grid and an excellent network of roads. Over 90 miles of new passageways and asphalt roads, besides another 375 miles of rehabilitated roads, were completed, which form an efficient and vital communication and transportation network (Hass-ssan, 2001).

The Toshka Project Controversy

The Toshka Project has attracted the attention of many individuals and groups in Egypt as well as worldwide and created much controversy on whether it is a mirage or marvel (El-Khodari, 2000). Some are very enthusiastic and optimistic about it, to the extent of calling it "The New Delta Project" or "The Inverted Pyramid Project." On the other hand, the Toshka Project also has fierce critics, ranging from environmentalists worried about its demands on Nile water to economists who question its profitability.

Advantages of the Toshka Project include:

1. Dealing with the complex problems arising from skyrocketing population growth in Egypt that include jobs, food, housing, health, education, and transportation.
2. Doubling the amount of cultivated land in Upper Egypt.
3. Utilizing the massive amounts of water stored in Lake Nasser.
4. Facilitating power generation projects.
5. Offering venues for navigation and waterway transportation.
6. Promoting and developing fishery, tourism, and recreational activities.
7. Reaching new areas with fresh water and creating favorable conditions for the south-to-northwest water transfer.
8. May yield new archeological discoveries.
9. Relieving Lake Nasser from silt accumulating on its bed since the building of Aswan High Dam in the 1960s and

alleviating its negative effects on the lake's capacity as well as the High Dam's stability.
10. Construction of the new Toshka City that would serve a population of 5 million to relieve the overcrowded old valley.
11. Yielding botanical and animal resources that can be utilized in several pharmaceutical and fish-processing industries.
12. Developing an environment in the area of the new project to attract wild birds and animals.
13. Including solar and wind energy development used in generating clean electrical power to meet expected demand.

Disadvantages of the Toshka Project include:

1. Egypt is pouring money into desert reclamation—wasted finances that could have been used more productively in other urgent needs such as health care, housing, and education.
2. This project, in addition to other concurrent mega-projects in Egypt, is causing liquidity and cash flow crises by sucking the lifeblood out of the economy.
3. Poor cost-benefit analysis of the project.
4. Historically, Egyptians resist moving from their homes to new settlements in the desert, and the Toshka Project is no exception.
5. Unrealistic water resources management by diverting water badly needed in the traditionally most fertile land of the Nile Valley.
6. Egypt could even run short of water if other Nile basin countries to the south should build dams and divert some of the flow.
7. The negative effects this project may have on the River Nile ecology, particularly on wildlife, groundwater table level, irrigation, urbanization, and pollution.

The Future

A minimum of 720 billion ft^3/year of otherwise wasted water at Aswan can be saved by implementing water conservation projects in the upper Nile sub-basin, through the cooperation of Egypt and the Nile basin countries. This excess amount of saved water would be used to fill the Toshka Depression completely—through the Toshka Canal and the Toshka Spillway—turning it into a permanent storage reservoir that could be used as a stable water supply for irrigation.

A new canal would then be constructed to convey water from the depression northward towards the Cut-taara Depression through the western desert of Egypt, forming a new green valley parallel to the existing valley (Younan, 2001). This would create new communities aiming at expanding the Egyptian habitation land from the current 5% to about 25% of Egypt's area. Water would eventually be directed northward, as a second branch of the Nile and parallel to it, towards the Mediterranean Sea.

Started in 1998, the construction of the Toshka Project was hoped to be completed by 2004 with an estimated cost over US$ 2.5 billion. The Egyptian government wants to reclaim and cultivate some 534,000 acres (890 sq miles) around Toshka to deal with Egypt's population explosion, crowded cities, and falling per-capita farm output.

The construction of the Toshka Project in Egypt presents a challenge to engineering technology because work is sometimes done under extremely unfavorable weather conditions. Production rates never before attained are becoming the norm in order to keep the sizable project on schedule.

The first fruits of the promising success of the Toshka Project can be witnessed in many locations such as that around Productive Well No. 21, at the 45 mile landmark, where the volume and density of the green color of vegetables, fruits, and flowers extend for almost 60 acres—wholly cultivated in an area previously thought of only as barren, uncultivable desert.

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