State of Israel
Desalination Division

Sea Water Desalination in Israel: Planning, coping with difficulties, and economic aspects of long-term risks

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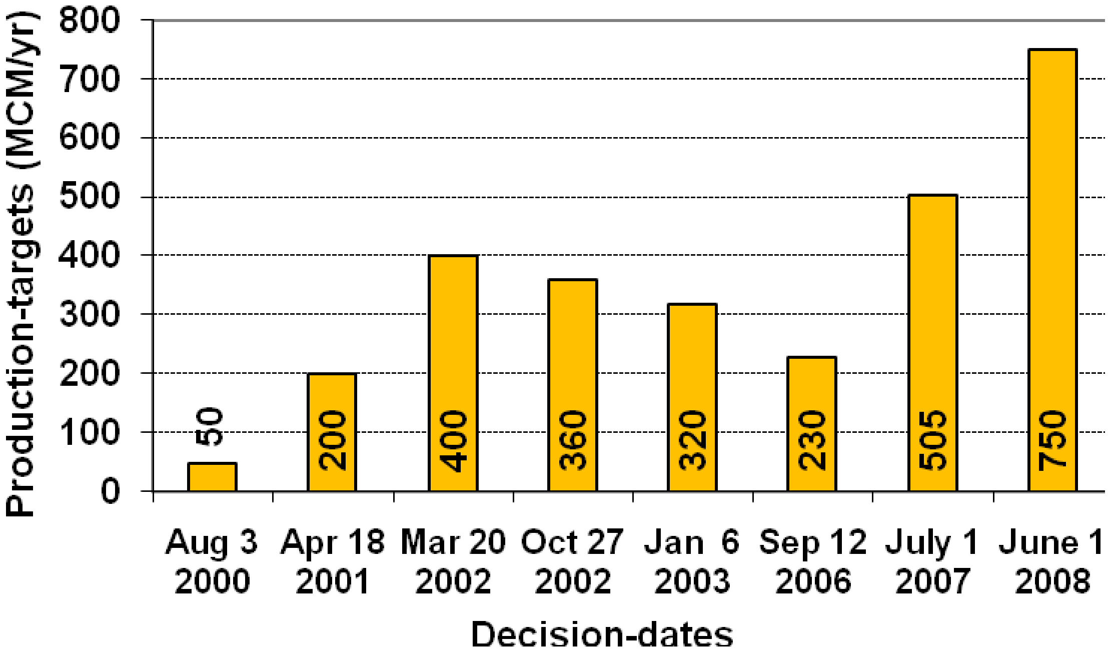
Past, Current and Future Sea Water Desalination

In 1999, the Israeli government initiated a long-term, large scale SWRO (Sea Water Reverse Osmosis) desalination program. The program is designed to provide for the growing demands on Israel's scarce water resources, and to mitigate the drought conditions that have characterized most years since the mid-1990's.

Since the initiation of the desalination program, there have been several changes in government decisions regarding the targeted annual quantity of desalinated water to be produced (Figure 1). These changes in target-production volumes were influenced by short-term changes in the history of inter-annual rainfall, and by changes in national consumption rates. The initial target capacity of 50 million cubic meters (MCM) per year was re-set in 2002, to 400 MCM/year. This target was reduced in 2003 to 230 MCM/year in response to an unprecedented large amount of rainfall in 2002. In July 2007, subsequent to several drought years, the targeted production-capacity was re-set to 505 MCM/year, to be reached by the year 2013. Additional drought conditions led to a further increase in target capacity in 2008, to 750 MCM/year to be reached by the year 2020. From the 750 MCM, 600 MCM will be provided as quickly as possible.

Figure 1: Government Targets for Annual Desalination Production Capacity



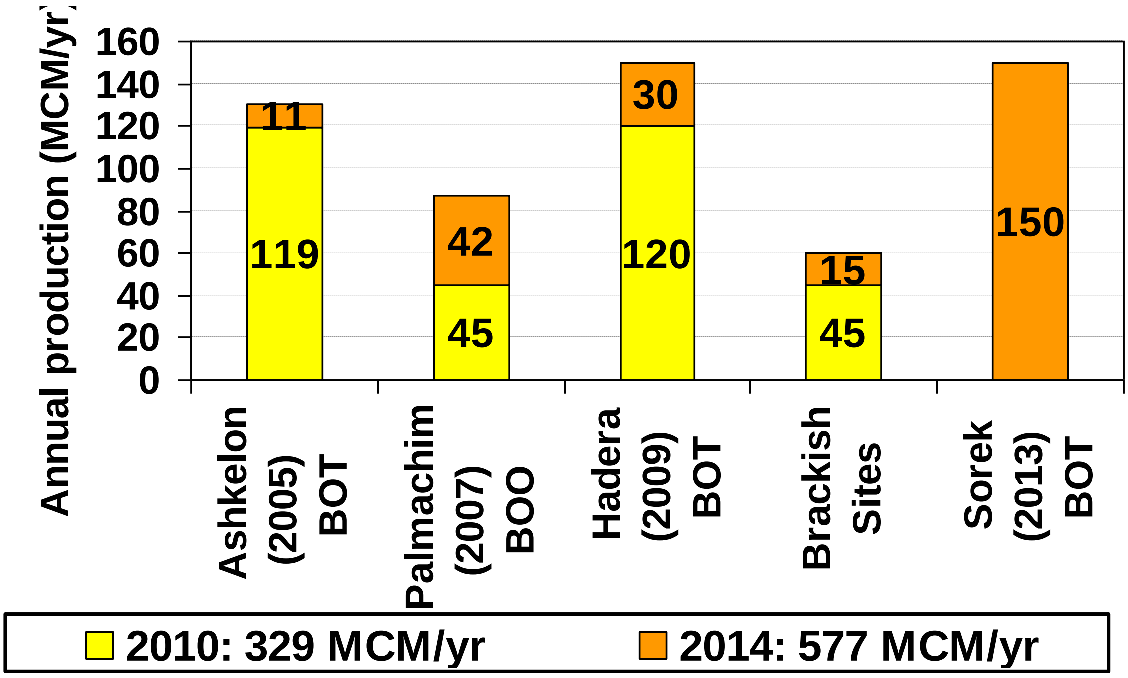
Construction of the first large-scale (116 MCM/year) desalination facility was initiated in 2002 by private companies that won the government's public tenders for construction, maintenance, and operation of the facility. Subsequent desalination facilities all follow the same fundamental procedures of public tendering and bids by the private sector for the construction and operation of each facility.

Israel’s long-term large-scale reverse-osmosis sea water desalination program began contributing potable water to the national water grid in 2005. Three large-scale seawater desalination facilities and some smaller brackish water desalination facilities currently (2010) provide 320 mcm of Israel’s potable water requirements (to all sectors). This volume is equivalent to approximately 42% of the current domestic water requirements. Desalinated production capacity is expected to increase to 577 MCM/year; and 750 MCM/year by the respective years 2014; and 2020 (Figure 2).

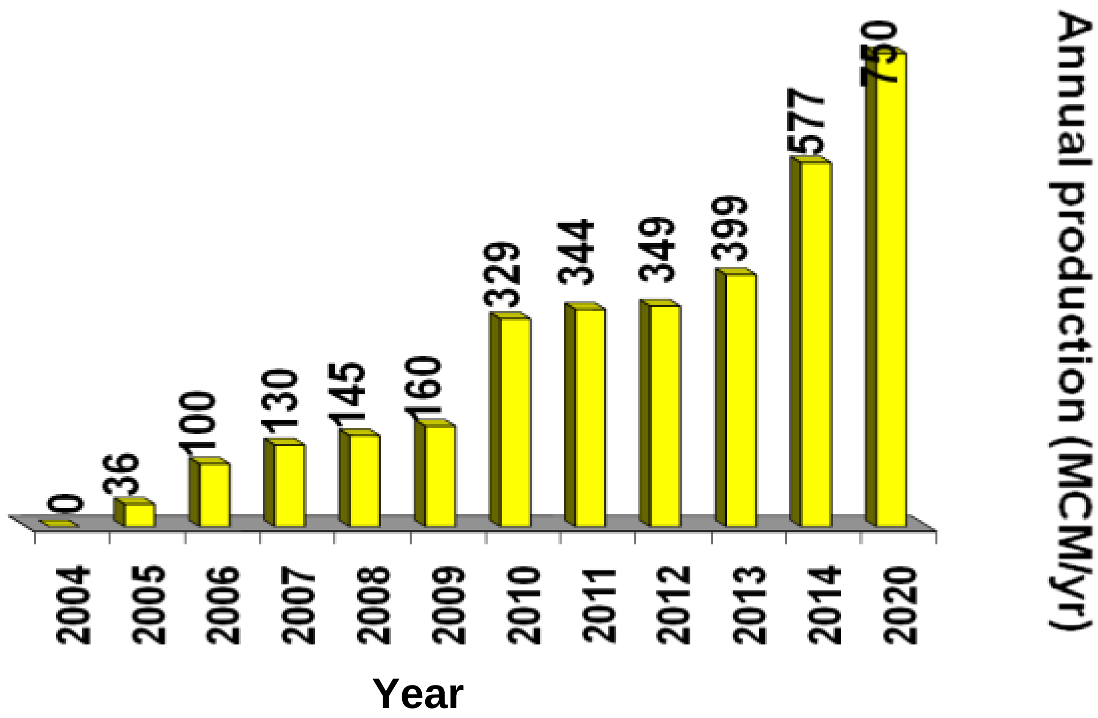
Israel’s desalination facilities are essential to sustainable potable water supplies in the State, since they supplement the severely limited natural resources to a level that meets existing national potable water demands. Desalinated supplies will allow Israel to close the gap between national water supply and demand by 2014, and to realize plans to maintain this sustainable consumption-state in the upcoming decades. According to targets outlined in the Water Authority’s Master Plan for Water Sector Development for the period from 2010 to 2050, by the years 2015, 2025, and 2050 respectively, the construction of additional desalination facilities are expected to increase desalinated supplies to approximately 22.5%, 28.5%, and 41% of all national potable water demands (62.5%, 70%, and 100% of the domestic water demands). Any supplementary desalinated water that becomes available during these years will be used to aid in replenishing Israel’s natural water systems.

The national planning program for desalination (TAMA) is in the process of expansion of the national seawater desalination sites. The current planning scheme (TAMA 34 / B / 2) has set aside sites for the production of 750 MCM/year of desalinated water. In addition, a new planning scheme has been initiated (TAMA 34 / B / 2 / 2), with the goal to increase total annual production of desalinated water to 1.75 billion cubic meters (BCM/year) by 2040. During the coming months, the national desalination and water conveyance system will be under review in order to finalize details of the planned desalination facilities and upgrades to the national pipe-conveyance grid. This series of projects is valued at over 10 billion shekels, to be used over the coming decade.

Figure 2: Sea Water Desalination a) in each desalination facility in 2010 and 2014, and b) nationally, from 2004-2020



a)

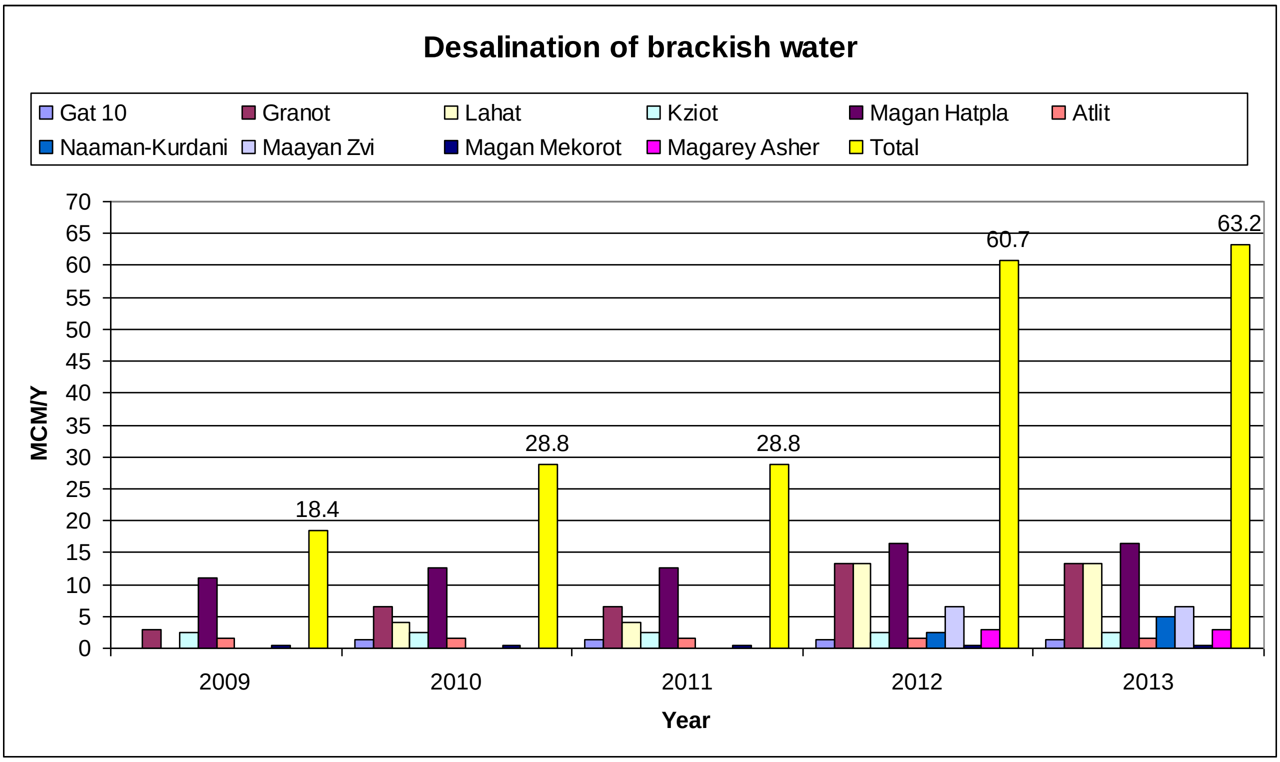


b)

Desalination of Brackish Water

In Israel several smaller desalination facilities desalinate brackish water from groundwater wells, rather than sea water (Figure 3). Such facilities exist in Eilat, the Arava, and the southern coastal plain of the Carmel. Total production of desalinated water from brackish sources is currently 30 MCM/year, and planned production is expected to reach 60 MCM/year, and 80-90 MCM/year by the years 2013 and 2020, respectively.

Figure 3: Brackish water Desalination program



Specifications of Existing and Planned Desalination Facilities

Ashkelon Desalination Plant

- At the time of construction, this plant was the biggest RO plant in the world.
- Among the most economical operating expenses for any desalination facility in the world.
- Constructed and in operation by VID Desalination Company Ltd group.
- Located south of the city of Ashkelon, in southern Israel.
- A BOT project (Build Operate & Transfer) for approximately 25 years.
- Construction initiated in 2003; water supply initiated on August 2005; fully operational in December 2005.
- Production capacity was 100 MCM/year.in 2005; 105 MCM/year in 2007; 111 MCM/year in 2008; 114 MCM/year in 2009; and approximately 120 MCM/year in 2010.
- In May 2010 the plant reached a total supply to date (across all operational years) of 500,000 MCM.

Figure 4: Ashkelon desalination plant.

Palmachim Desalination Plant

- Located north of Kibbutz Palmachim, in the central part of Israel.
- A BOO project (Build, Owned & Operate) for 25 years.
- The owner is Via Maris Desalination Ltd.
- Construction started in May 2005. Water supply started in May 2007.
- Production capacity was initially 30 MCM/year
- Subsequent to an expansion in April 2010 production capacity of the plant is currently approximately 45 MCM/year.

Figure 5: Palmachim desalination plant

Hadera Desalination Plant

- Located west of the city of Hadera, north of the Hadera stream, in north-central Israel.
- A BOT project (Build, Operate & Transfer) for 25 years.
- Construction began in June 2007.Water supply began in December 2009.
- Production capacity was initially 100 MCM/year.
- Subsequent to the expansion of the facility by the end of this year (2010) (Figure 6), the plant will provide approximately 127 MCM/year.
  To date, the Hadera Plant is the largest SWRO in the world in operation.

Figure 6: Hadera desalination plant

Ashdod Desalination Plant (yet to be finalized)

- The plant will be located in the industrial zone of Ashdod, in south-central Israel.
- The project will be executed by Mekorot Initiating and Development Ltd., which received a concession for construction and operation of the facility from the Israeli government.
- Construction is forecast to be initiated in the end of 2010.
- The production capacity will be 100 MCM/year.
- Water production at full capacity is forecast for the end of 2013.

Soreq Desalination Plant

- The plant will be located south-west of the city of Rishon Letzion, north of the Soreq stream, in north-central Israel.
- A BOT project (Build, Operate & Transfer) for 25 years.
- The agreement with SDL group for the BOT project was signed in mid-January 2010.
- The production capacity will be 150 MCM/year.
- Water production at full capacity is forecasted to the end of 2013.

The Enlargement of Existing Desalination Plants

A tender process was initiated in early 2009 to expand existing desalination facilities (Ashkelon, Palmahim, Hadera) by an additional 60 MCM/year per facility. These expansions have either been completed, or are scheduled for completion by the end of 2010.

Energy and Cost-Efficiency of Sea Water Desalination

Numerous policy-based, technological, mechanical, architectural, and managerial factors contribute to making Israel's large-scale desalination facilities among the most energy-efficient and cost-efficient in the world (Figure 7). Currently, the national average energetic and financial cost of production per cubic meter of desalinating water in Israel is respectively, 3.5 kilowatt hours and US 65¢. The most recent tender was priced at US 52¢ for the Sorek facility (150 MCM/year).

The Israeli government tailors its tenders and the associated bidding system in a way that maximizes energy and cost efficiency in the construction and operation of these large-scale desalination plants. Energy-conservation is promoted in the following ways:

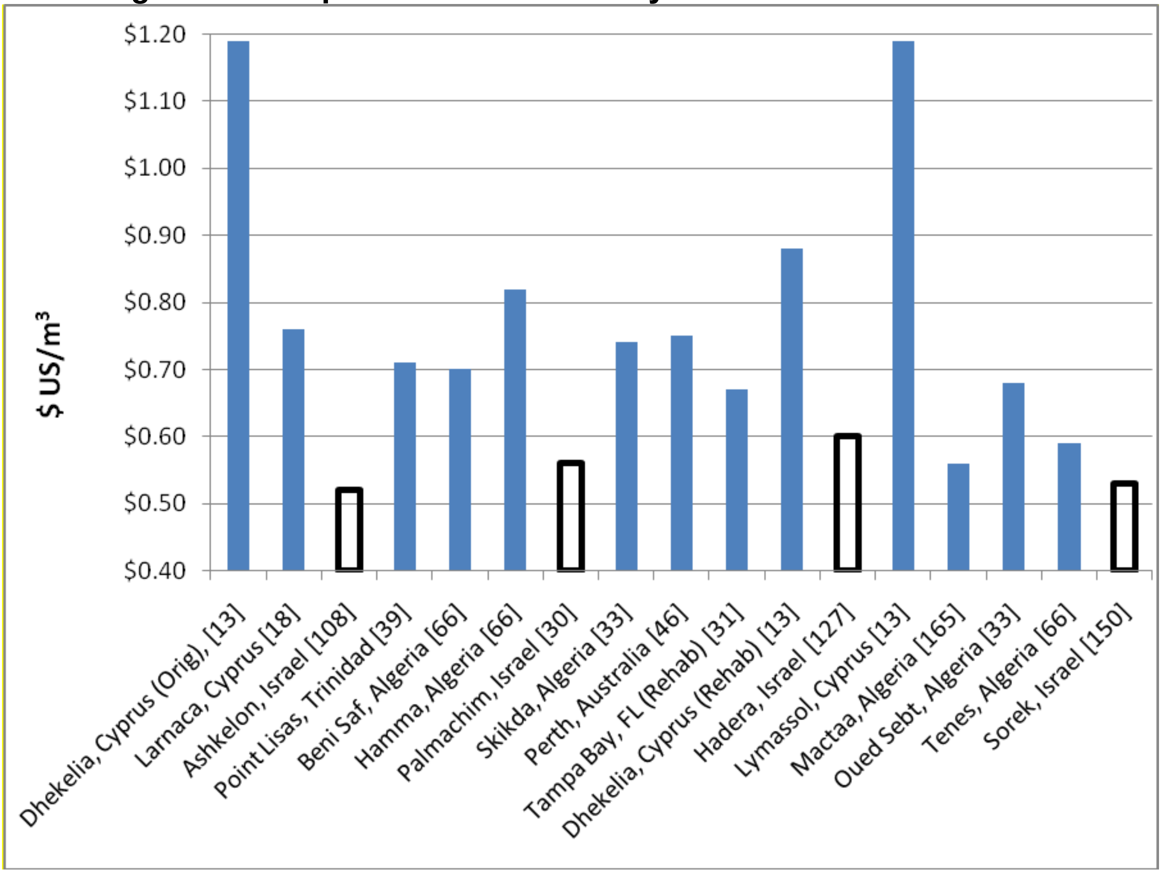
- The cost of production per cubic meter is of key importance in winning a tender bid. Thus, the reverse osmosis method of desalination wins tender bids, rather than alternative technologies, since this reduces production-costs. The reverse osmosis method of desalination involves separation of the salt molecules from the water by use of special-purpose membranes. These membranes were developed in Israel in the 1960's by Professor Sidney Loub. Reverse osmosis is now a well-known technology for desalination, with a notable advantage of low operating expenses relative to the alternative thermal desalination systems. Relatively low energy-requirements in reverse osmosis systems are responsible for low operating expenses.
- Scores on the bidding system favor natural gas power generation rather than coal generators. Natural gas power generation produces only 20% of the CO2 emissions generated by coal power-plants. Natural gas power generation is also approximately 7 to 8% cheaper than the energy provided by the national (coal-driven) power system. This savings reduces the cost of producing the desalinated water, thereby raising the bid-score further (since cheaper water scores higher).
- Builders of the desalination facility are permitted to build a power plant that not only provides power to the desalination facility, but also provides additional energy that can be sold to the national power grid, at a profit to the builders. This allows further reductions in the costs of the desalinated water-product (thereby increasing the bid-score further).

Two examples of the many other important factors responsible for the energy and cost-efficiency of Israel's large-scale desalination facilities are:

- ➢ Efficient technological energy-recovery systems that re-use energy in the midst of the desalination process.
- ➢ A government policy for dividing all risks between the private companies that receive the tender, and the government. For example, the take-or-pay policy ensures that the

government will pay for the agreed-upon volume of water that is supplied by the desalination facility each year, even if less than that volume is actually required or used.

Figure 7: Exceptional Cost Efficiency of Israel's Desalination Facilities



The above figure illustrates a cost-comparison among international large-scale seawater reverse osmosis (SWRO) desalination plants that have been built between 1997 and 2010 (ordered from left to right by price-quote date). Israeli desalination facilities are shown in open bars, and facilities from other countries are shown by closed bars. Annual production volumes are indicated within square-brackets on the x-axis, in millions of cubic meters.

Coping with Difficulties and Economic Aspects of Long-Term Risks

Numerous challenges are associated with the construction and operation of desalination facilities, and the nature of these challenges have changed over time. Initially, budgetary constraints and opposition from the agricultural lobby were the biggest challenges. Current challenges are as follows:

Necessity and Pricing of Desalination -The challenge of convincing consumers that:

- Investing in sustainable water consumption is necessary
- Desalination is an appropriate and efficient tool for achieving sustainable water consumption
- The costs of desalination are necessary

These themes are very significant for future development of the water sector. They ultimately provide a budgetary source for short and long-term (several decades) planning and implementation of the future water sector.

Land-Use for Desalination - There is a belief among some "Green" organizations and NGO's of all kinds that the national water shortage is temporary and that in the future, Israel will receive all of the required water quantities without the need for water desalination. These organizations therefore argue that protection of nature and the coastal land is a higher priority than providing desalinated water.

The need for desalinated water provisions is certainly a necessity currently, and in the future. Nevertheless, the protection of nature is also a very important consideration. Achieving a balance between the nation’s water requirements and the desire to protect open coastal spaces is a very difficult challenge. It significantly delays the time required to secure statutory permits for the future construction of desalination facilities.

Meeting Requirements of the Ministry of Environmental Protection- Communications cover several issues such as:

- Determining the location for outflows of effluent (high-salinity water) to the sea
- Setting parameters for effluent water quality
- Setting quality parameters for outflows from brackish-water desalination facilities
- Setting quality parameters for desalination systems that are used for well-water purification from the aquifers (this includes nitrate elimination).
- Setting the research requirements for each of the desalination facilities

The time required to address all of these issues is lengthy, and leads to delays in obtaining statutory permissions for the construction of each facility.

Shortages of Coastal Properties - A shortage of coastal properties exists, due to coastal real estate development plans, and to land-occupation by the Ministry of Defense.. Formulation of agreements with the Ministry of Defense for the construction of desalination facilities are feasible, but add long delays in obtaining statutory permits.

Meeting Requirements of the Ministry of Health- The requirements of the Ministry of Health are extensive and time intensive, and include updates to drinking water quality regulations. These updates require concomitant adjustments to the desalinated water supplies.

The Ministry of Health also requires "protection radiuses" around desalination facilities, which can be impediments, particularly to the development of inland brackish water desalination facilities.

Obtaining Agreements for Pipe-Transport – Pipelines are required, to connect the desalination facilities to the national pipe-conveyance grid. These connecting pipelines typically pass over privately owned land. Agreements to allow the pipe system to cross private land must be made with each of the respective land-owners. This is the most difficult and time-consuming procedure involved in the construction of the connecting pipeline.

Lengthy Construction Time – Planning and construction of the desalination facility itself is an enormous, time-consuming endeavor. The key elements from start to finish are: completion of the tender process, obtaining all of the statutory permits, and construction of the desalination facility and the water transport infrastructure. Approximately five to seven years are required to complete this entire process, from the time that a governmental decision is made to construct a new desalination facility, to initiating supply of desalinated water to the national grid.

Concluding Statements

The planning, construction, and long-term operation of desalination facilities involve daily challenges, decision-making processes, and creative innovations that maximize the efficiency of each new (and always unique) facility. Israel’s continuing success in overcoming each new challenge is the key to achieving sustainable national water use with independent national water resources. This has been the goal of the water sector since the founding of the State of Israel. Success in implementing Israel’s long-term desalination construction plan is important for enhancing the growth and prosperity of the State of Israel.