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The Environmental Policy Center

Policy Document

The Dead Sea Basin

Assessment of Current Situation and Prospects for the Future

Under Continued Dead Sea Water-Level Decline

Jerusalem

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Preface

The continuing decline of the Dead Sea lake level is causing physical changes along its shores, which have an impact on daily life and on the development of the region. The magnitudes of the changes and their associated threats have fostered uncertainties that impede present activities and arrest previously planned development.

The decline in the water level and the associated physical changes are expected to persist and possibly even intensify in the future. Coping with these ongoing processes and future development require formulation of new strategies that take into consideration the impact of these changes.

A major cause of uncertainty is the seemingly haphazard proliferation of sinkholes, mostly in recently exposed areas along the shore. In response to this challenge, maps have been prepared of those areas where substrate failure is anticipated at various levels of certainty, beside areas of stable and safe substrate where development can proceed without restrictions. These maps, drawn upon in-depth studies, significantly reduce the level of uncertainty and allow the development of the region despite the above mentioned uncertainties. Yet new development concepts need to be accepted.

This document presents data on the present condition, and offers assessments and predictions concerning future conditions in the Dead Sea region. The document concerns with the **implications of the default option** i.e., the scenario that predicts **what is likely to occur in the Dead Sea and its surroundings if no steps are taken to arrest the decline in water level.**

The present document purports to assemble a reliable and comprehensive database of all the present phenomena and changes relating

to the Dead Sea and its shores, to analyze their significance, and to recommend a policy for the future of the region. The paper shows how to enable flourishing settlement in the vicinity of the Dead Sea shores, and how optimal and sustainable development may be assured.

Frame of work

Initiative for preparing the present document derives from the extensive changes that are currently taking place in the Dead Sea Basin, and the need to outline a national policy for its future. Analysis of the information obtained in the context of the present study shows unequivocally that the negative water balance of the Dead Sea will not improve in the foreseeable future. Water level will continue to drop at a rate of about one meter per year and possibly more. Therefore, a further 15-20 m decline in water level is expected before any remedial measures can take effect, even if immediate drastic action were decided upon, such as building a sea conduit (the "peace conduit") or the restoration of natural inflow. This reflects the time minimum required for studying the environmental consequences of any such project, the acquisition of complementary data, for planning and approval (especially for a multilateral project), for mobilizing resources, for initiating the operation of such a large-scope project, and for actual constructions.

It should be noted that even after implementation of a remedial program, raising of the lake level from 435-440 m below sea level (today's, year 2005 level is -418) to any target level will take many years from the inception of recharge. All the present problems, particularly substrate subsidence and land failure below the -400 m contour, will gradually dissipate only when the lake level again

approaches this level. In this respect it should also be noted that at a lake level above -402-400 the South Basin will be reflooded. It should however be recalled that much of the Southern Basin is currently occupied by the Dead Sea Works' and Arab Potash Co.'s evaporation ponds and therefore the rising water will be impeded by the dams surrounding these ponds, while possibly endangering them. Moreover, even if the target level will be set at today's -418 m level, turning the present trend of decline and refilling to this level will take at least another 30-40 years.

Therefore, the “default option” and its ensuing realities are valid and relevant to any foreseeable planning horizon (30-40 years, and possibly even more). At the same time, trend-turning steps should of course also be examined, in order to formulate a long term integrative and sustainable national policy.

The ongoing decline in the water level and the deterioration of infrastructure along the shores have generated a climate of uncertainty concerning the continuation of the current phenomena, future trends, the risks generated, and accompanying economic costs. The present document dispels much of this uncertainty and presents a multidisciplinary perspective and a well-grounded forecast of the future of the Sea and its shores. This forecast constitutes a basis for formulating a policy of management and development that meets the changing conditions, and can enable ongoing activity and development of the region's potential.

Structure of the Document

The document has three divisions:

- ❖ Policy directives for the future of the Dead Sea, including alternative land use planning adapted to changing regional conditions. This part summarizes the main findings of the study, their significance and recommendations.

- ❖ The main body of the document, which consists of a nine-chapter survey of the region's settlements, the physical substrate and water body, ecology and environment, land use, and an economic analysis.
- ❖ Appendices: data, and complementary analyses.

A. Findings, implications, and policy guidelines

1. A state of uncertainty disrupts the routine of life and limits long-term planning

- ❖ The present condition of the Dead Sea reflects the regional water shortage, and is a consequence of the policies of the Jordanian, Syrian, and Israeli governments in exploiting the water resources of the Basin for water supply, and the extraction of the sea's salt by industrial plants in Israel and Jordan. Over one billion cu./m of fresh water per year are prevented from flowing into the Dead Sea, as they did in the past. The mineral industries increase the water deficit by an additional 250 million cu./m per year in the evaporation pans located in the South Basin, which otherwise would have been dry. The ensuing situation causes damage and adversely affects everyday life in the region, while uncertainty about its future increases.
- ❖ The drop in the water level leads to continual changes in the location of the shoreline and in the prevailing physical conditions along the shores. These changes affect the stability of infrastructures, threaten and cause damage to buildings, roads, bridges, agricultural lands, and other infrastructures. They also prevent immediate accessibility to the shoreline and impair the touristic attractiveness of the region.
- ❖ The high level of uncertainty of existing trends and the degree of risk that they pose has brought existing development programs to a halt and prevents the promotion of programs which could realize the potential of this unique region

2) Dispelling uncertainty and providing a reliable forecast for the dynamic changes in the Dead Sea basin

- ❖ The Dead Sea's rate of decline in the near future will be about 1 m per year; hence, by the year 2025 lake level will have dropped to about 440 m below sea level, and by 2050 to about 465 m below sea level.
- ❖ **The Dead Sea is not expected to disappear** even if no measures are taken to change the negative water balance of today. Although water level will continue to decline in the coming years, it is likely to approach a stable situation in about 200 years, at a level about -550 m below mean sea level. At this stage the lake's maximal depth will be about 180-200 m and its surface area will have shrunk to 450 sq.km.

The reduction in the surface area and the increase of salinity of the remaining brine will reduce the volume of annual evaporation, and subsequently, when evaporation will equal inflows to the lake, lake level will stabilize.

Prior to this, lake level will continue to drop significantly while the lake's surface area will shrink at a slower rate than it has done hitherto. For comparison: lake level in 1950 stood at -395 m and surface area was about 1,000 sq.km; today, lake level is -418 m and surface area is about 650 sq.km. The reason is that after the total desiccation of the shallow South Basin, the remaining sea is located in the deep North Basin where further drop in sea level is reflected by a relatively smaller horizontal migration of the shoreline.

- ❖ This policy document presents and discusses maps of the future physical infrastructure, including:
 - ◆ The location of the likely future shorelines in space and in time.
 - ◆ Subsidence and regions prone to the emergence of sinkholes, categorized into active sinkhole sites, areas in which there is a potential for sinkholes, areas in which the possibility of sinkholes can not be ruled out, and areas in which sinkholes are not expected to develop.
 - ◆ Exposure of mud flats, steep slopes, and regions prone to landslides and mudslides.
 - ◆ Accelerated undercutting and deepening of the creeks, which threaten to damage roads, bridges and other infrastructures.
 - ◆ Undermining the stability of natural water pools such as Einot-Zukim, Kaneh, and Samar, and damage to these unique sites.
 - ◆ Loss of underground water storage capacity, which diminishes the onetime reserve of the aquifers that drain into the Dead Sea from all directions, as a result of the decline in the water level. This loss is expected to be relatively small, not exceeding few tens of millions of cubic meters per year, far less than claims made in the past, mainly by Jordanian experts, of a loss of hundreds of millions of cubic meters annually.

3) Irreversible damage to the shore habitat and to unique species

- ❖ The ecology of the lakeside oases is of both local and universal value. They serve as important rest stops along birds' migration routes, and as a source of water and food for the birds and larger mammals of the Judean Desert. Dropping lake levels cause

changes in the shore habitat, creating rapid-flow gullies which may breach pool embankments. Also, the local groundwater table may be lowered and salinities may rise. The overall effects may include a reduction in biodiversity, changes in migration patterns, and damage to unique local ecosystems.

4) Economic implications of the default option

- ❖ The financial value of the default option can be quantified by means of a "Restoration Costs", which is a balance between the cost of damages to agriculture and to the road networks against the benefits accruing to the Dead Sea Works by increase of the salt concentration in the North Basin.
- ❖ The Dead Sea mineral industries in Israel and in Jordan draw economic benefit from the past changes, and may anticipate further benefits in the coming decades. Increased water salinity increases the efficiency of salt extraction. After subtracting the production costs resulting from the decline in the water level, the profit gained from increased salinity amounts to an additional 100,000 tons of potash produced per year (this for the Israeli Dead Sea industries only). With raw potash selling at about 12 Euro per ton, this represents about 1.2 million Euro, or about 6.8 million Israeli Shekels (NIS) per year. The capitalized value of the annual income supplement is about 78 million NIS over 20 years and 107 million NIS over 50 years.
- ❖ The following table presents data on the Restoration Costs and the costs of direct damages that stem from changes in the water level:

Type of damage	Costs in NIS	
	Capitalized for 20 years	Capitalized for 50 years
Undercutting of roads, bridges, and drainage channels by creek entrenchment	31,000,000	38,000,000
Sinkholes in roads	12,00,000	15,000,000
Agriculture	12,000,000	12,000,000
Total cost of damages	55,000,000	65,000,000

- ❖ The sum of benefits to the Israeli, Syrian, and Jordanian economies from the use of fresh water subtracted from the water balance of the Dead Sea are not taken into account in this study. The subject will be examined in the future, along with the assessment of possible measures for changing the negative water balance of the Dead Sea.
- ❖ The Restoration Costs method examines the cost of rehabilitating the infrastructures affected by the decline in lake level, but does not consider the loss of unique natural values associated with the Dead Sea, and the Dead Sea's economic value as an environmental resource, although the present paper presents a preliminary attempt to quantify these values.

5) Operation of evaporation ponds in the South Basin affects the lakeside hotels

- ❖ Differences in the natural setting and the environmental conditions along the North and South basins of the Dead Sea generate a totally different situation. The South Basin

today consists almost entirely of extensive evaporation ponds. Whereas along the North Basin sinkholes formation is brisk, in the South Basin, along the western shore of the evaporation pond no. 5 and southward they are comparatively rare. Today the area is still being investigated, and not much is known neither about sinkhole formation within the evaporation ponds and the industrial terrain, nor about sinkhole-promoting subsurface conditions.

- ❖ The presence of the evaporation ponds provides an economic basis for the proliferation of thriving lakeside spa hotels. However, the ponds accumulate some 20 cm of salt per year on their bottom, and maintenance of a constant water depth in the ponds requires raising the brine level, thereby threatening the hotel foundations. Various alternatives are currently examined under the auspices of the Ministry of Tourism and in accordance with a special government decision, aiming at a solution for the hotels until 2030, when the Dead Sea Works' concession expires.
- ❖ At present there are no data or estimates concerning the life expectancy of the Dead Sea Works beyond their concession period. However, the continued existence of the evaporation ponds has major implications for the development of their terrain, and indeed of the whole South Basin, and for the continued existence of the hotel and spa business.

6) Land uses

- ❖ Land use along the shore belt, where most of the dynamic changes are taking place, is mostly allotted to tourism, and a small part to farming. Most of the built-up areas,

industrial plants and tourist centers are far from the shore, beyond the zone of latter-day shore retreat.

- ❖ Nevertheless, the decline of water level causes shorelines to retreat a considerable distance from the tourist facilities and from former beach access routes. Risk-free shoreline access is one of the issues that need imminent attention if safe beach recreation is to be maintained.

- ❖ Land use plans at all levels were prepared before the dynamic changes of the shore belt had been recognized and investigated. Consequently, some of the future development areas overlap areas of land failure and sinkhole risk.

- ❖ Potential areas of development which are free of the limitations stemming from the anticipated development of sinkholes have been identified between the regions prone to the emergence of sinkholes and the cliff Escarpment.

In conclusion: understanding the implications and consequences of the existing situation provides a basis for rethinking, and for outlining principles and directives regarding the future development of the shores of the Dead Sea. These will enable uninterrupted development and the realization of the region's potential.

B. A new approach to planning

Conventional shoreline planning strives to utilize the advantages offered by the water line, and focuses on the longitudinal dimension. Thus, previous plans for developing the Dead Sea shore recognized the value of shoreline proximity and emphasized a north-south, shore-parallel axis hugging the water line. Present-day conditions cast doubt on the feasibility of those plans. Local infrastructure collapse and land failure together with the rapid receding shorelines have rendered them questionable, if not obsolete.

The findings presented in this paper highlight the problems. These tend to accumulate in the wake of the retreating water line, by exposing a steadily widening belt of sinkhole formation from the approximate -400 m topographic contour downward (and eastward). These issues should prompt the need for a rethinking of the planning concept along the shoreline. Our present recommendation, which needs further consideration, is that the classic north-south, shore-parallel axis be replaced by an east-west, shore-perpendicular planning concept, from the Rift escarpment in the west to the waterline in the east - wherever it happens to migrate.

Such planning envisages the connection of areas atop or just below the escarpment to sites at its base, which may extend to the lake's shore. Along such an axis there would be opportunities for settlement and tourism, such as lodgings and recreation facilities, and transverse infrastructures that would provide safe and easy access from the very rim of the escarpment to the beaches far below.

This approach has significant advantages:

- ❖ It links the features and qualities of the Judean Desert to those of the Dead Sea, with its uniqueness of being the lowest place on the world's continents.
- ❖ The view from the rim offers better perspectives of the Dead Sea, including the creeks and canyons of Moab on the opposite shore, views that are not available to visitors on the shore below.
- ❖ Shoreline constructions would be restricted to appropriate localities, and controlled so as not to spread north and southward along the shores.
- ❖ The east-west planning option minimizes the use of subsidence and land failure — prone infrastructure. The shore will be accessed only through a structurally safe road system. There will be no need to build and maintain major infrastructures along these roads, where they cross into the sinkhole and subsidence prone areas.

The above approach may invigorate shoreline plans, but these should nevertheless be based in every case on reliable data concerning the physical infrastructure, in both local and regional context. It should also be borne in mind that, apart from problems arising from the decline in lake level, the entire Dead Sea region is an area of high seismic risk, prone to ground movement, sliding and subsidence. This condition, not connected to the changing water level, must inevitably be taken into account in any planning and building operation.

C. Recommendations

- 1) The present document is intended for use by the Statutory Planning Authorities, the Regional Councils and the Government Departments responsible for infrastructures. The maps included in the report identify areas prone to the occurrence of sinkholes and subsidence. The Engineering Team of the Interministerial Committee on sinkholes evaluated existing and future planning and building in the region. A summary of the team's intermediate report as written is attached as an appendix to this document.
- 2) Each body that is responsible for any aspect of engineering infrastructures and facilities (the regional councils, PWD, the Electric Corporation, etc.) should carefully study the areas demarcated as prone to substrate failure. Since map resolution is not sufficient for detailed site planning, the following measures should be undertaken:
 - ❖ Systematic identification of buildings, stretches of road, agricultural uses, and other infrastructures that the maps show to be in land failure – prone areas, together with an assessment of the urgency of the risk.
 - ❖ Assessment of whether damage could be prevented and preparations to reinforce or replace the infrastructures that are at immediate risk.
 - ❖ Examination of alternatives, and ways for vacating those sites where damage cannot be prevented or where prevention is technically or financially unfeasible.
 - ❖ Determination of the means, technical and/or financial, by which either the prevention or its alternatives can be put into practice.
- 3) The Geological Survey of Israel will monitor changes in the physical infrastructure, and will routinely update the maps of sinkhole risk and associated subsidence. The Geological Survey and an engineering expert will also be consulted for the detailed planning, in order to define the risk as accurately as possible on a local scale.
- 4) A new regional master plan will be prepared for the western shores of the Dead Sea, revising previous plans. A new planning approach will be adopted, taking into account the dynamic changes in the substrate expected over the next 20 years, extending to 40 years from now.

Formulating the planning concept requires examining alternatives, which include directing future development to risk-free regions (the "white regions") as shown on the physical infrastructure maps. Planning should also include recommendations for developing infrastructures that will enable public access to the Sea at safe locations.
- 5) Following the updated regional master plan, the Ministry of Tourism and the regional councils will reexamine and update the existing master plan for lakeside tourism.
- 6) The Government will draft a conceptual plan that envisages the continued activity of the Dead Sea's mineral industries after the year of 2030 (when the Dead Sea Works' concession expires).
- 7) The professional and statutory bodies that deal with the regional water resources (the

Water Commission authority, drainage authorities, regional councils, and the Geological Survey) will keep the shoreline springs, the ground water and the surface creeks under surveillance, and will design a system of surface drainage adapted to the rapid changes caused by the declining water level. Attention should be paid to the overall factors that affect Dead Sea hydrology, such as the intensive exploitation of groundwater in the catchments area, and the discharge of effluents, treated and untreated, into its drainage basin.

- 8) The Nature and Parks Authority will keep a surveillance of changes in the biota of lakeside springs and oases, as related to the declining water level. The Authority should prepare measures for conserving these habitats, especially the ponds that may be breached as a consequence of declining lake level which would damage the special and rare natural habitat dependent on them.

- 9) The Government will devise the institutional administrative framework to ensure coordination and budgeting of all the required measures among the departments concerned, according to their respective responsibilities.

All who took part in preparing the current policy paper on the future of the Dead Sea call on the government to implement the above recommendations immediately, since, as noted, the present processes and the entailed risks will continue to exist for at least 20-30 years. This notwithstanding, a long-term assessment is needed for times beyond 30 years, of possible measures to change the trend of decline in the water level under different alternatives. Hence, the government should encourage completion of the policy paper by an assessment of the possible

measures for changing the negative water balance of the Dead Sea and for restraining the emerging trends as described in this study. Included in the to-be-completed policy paper, and in line with previous government decisions, are the studies of the implications of a sea-conduit (conveying water from the Red Sea or the Mediterranean) and of restoring most of the natural flow (particularly of the Jordan and the Yarmuk) to the Dead Sea. This should be done parallel to the feasibility study of the Red Sea — Dead Sea conduit (the “peace conduit”), due to be undertaken by international consultants under the auspices of the World Bank.