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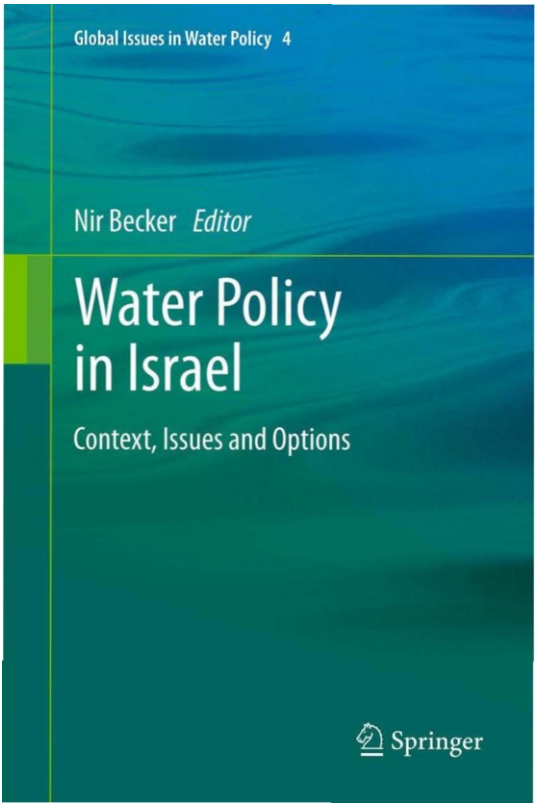

Chapter 5
Rehabilitating Israel's Streams and Rivers

David Katz and Alon Tal

5.1 Introduction

For the first several decades of Israel's existence, water left in streams was considered a waste of a precious resource. Streams themselves were seen as hazards to be managed, with little perceived value other than serving as convenient conduits for disposal of sewage and other unwanted effluents. As a result, the country's streams were largely denuded, polluted, and rerouted to reduce flood risks. Legal, institutional, and political frameworks that have emerged over the past 20 years promoting rehabilitation of the country's streams signal a shift in public perception and public policy. In addition, recent advances in desalination infrastructure adding substantial quantities of freshwater and improved sewage treatment standards further raise the prospects of a new deal for Israel's streams. After years of intensive development and chronic water scarcity, however, several challenges still stand in the way of stream rehabilitation. This chapter reviews the causes of degradation of Israel's streams, recent policy measures to promote their rehabilitation, and the primary obstacles still facing actual rehabilitation.

5.2 A Brief History of Degradation of Israel's Streams

Sixteen primary streams flow into the Mediterranean while another 15 reach the Jordan River or the Kinneret Lake (Israel Ministry of Environment 2012). Before the modern period, these local streams contained healthy aquatic ecosystems that

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were habitats for fish, turtles, and even crocodiles. They also provided innumerable "ecosystem services" including watering holes for terrestrial wildlife and grazing, power for mills, and a myriad cultural services for local communities.

Already prior to the founding of the State of Israel, these streams were being channelized to prevent flooding, and their waters diverted to supply water to nascent cities and a burgeoning agricultural sector. When Israel codified its Water Law in 1959, the law was considered progressive for its time, specifying that water was a public good and that the government had a responsibility to manage it for the public's benefit. However, it turned out to be detrimental to the ecological integrity of the country's streams. Section 6 of the law defined those activities for which water could be utilized. These were (1) household needs; (2) agriculture; (3) industry; (4) industry, commerce; and (5) public services. Legally at least, nature was not a legitimate user of water. This oversight reflected not so much a cavalier attitude toward Israel's streams as a reflection of values that prioritized economic development with little regard for ecological matters.

Israel adopted an aggressive national strategy of water infrastructure development. In the 1950s Israel was still an indigent country, with enormous economic stress associated with both maintaining a large military and absorbing a huge influx of refugees that doubled the nation's population in a decade. During the 1950s and 1960s, massive water projects such as the Yarkon-Negev pipeline and the National Water Carrier, symbols of great national pride, more than doubled the amount of available water across the country. The water went to stave off the thirst of a population undergoing geometric growth and to supply irrigation water for rapidly expanding agricultural activity.

The exploitation of the nation's existing freshwater sources resulted in overpumping which, in turn, led to drastic declines in aquifer levels to the point that several of the springs supplying the nation's streams ceased to flow. Streamflow is considered by many aquatic ecologists to be a master variable (e.g., Poff et al. 1997), as it effects not only the size of available habitat but its temperature, its ability to process nutrients, stream geomorphology, and numerous other aspects of ecological functioning. A recent report stated that flow in a full two-thirds of all springs monitored were severely reduced and/or actively witnessing declines (Stutolsky and Perlmutter 2012). Several streams that had perennial flow became intermittent streams. Some that had been intermittent or ephemeral ceased to flow altogether. Streamflow in the lower portion of the Jordan River – Israel's only river – declined by over 95% relative to natural flows, with current streamflow consisting primarily of agricultural runoff and semi-treated sewage (SPNI 2008). Flow in the Yarkon stream, which runs through the heart of Tel Aviv, Israel's largest metropolitan area, is less than 2% of historic flows (ibid. 2008). Of all of Israel's streams, only the headwaters of the Jordan remained with significant shares of natural flow and functioning natural ecosystems.

Other surface water resources were also damaged irreparably. The Huleh wetlands and lake were home to an extraordinary collection of biodiversity that included the greatest concentration of aquatic plants in the entire Near East, 18 species of fish, and countless local and migratory bird species (Zigelman and Gershuni 1954).

In order to free up more arable agricultural lands, the marsh was completely drained and the ecosystem extirpated. This was the largest of the major "swamp draining" projects conducted by Zionist land agencies which together erased some 97% of Israel's natural wetlands (Glazman 2006).

In addition, to the decline in flows, Israel's streams became repositories for sewage, industrial wastes, heavy organic discharges from fish ponds, and even trash. While most municipal and industrial sewage now receives some treatment, the beds of these streams still house decades worth of residues containing heavy metals and organic chemical compounds. The streams have also suffered from a range of nonpoint pollution sources, including agricultural and urban runoff.

Not all of the pollution in Israel's stream originates in Israel. There are 15 streams that cross the Palestinian/Israeli border. Twelve of these are major streams that flow year-round in a westward direction toward the Mediterranean Sea, carrying sewage and other pollutants from the Palestinian Authority, or from lands that will probably be outside Israeli jurisdiction. Only 30% of the Palestinian population in the West Bank is connected to a sewage network, with the remainder relying on cesspools (PHG 2010). Similarly, there are three major streams with easterly flow that cross into the Palestinian Authority. At least part of each of these streams can be defined as highly polluted, posing a health hazard to users, endangering flora and fauna, and unfit for recreational or consumptive uses.

The toll of decades of intensive development of water resources, combined with lax pollution regulation, predictably took a large toll on the country's natural ecosystems. Environmental conditions in ephemeral or low-flowing streams tend to be particularly fragile. Ecosystems are naturally under stress due to the short rainy season and the high annual losses due to evapotranspiration during the dry summer months (Gasith and Hershkovitz 2010). Some ephemeral streams stopped receiving water altogether, while others with ecosystems developed around periodic dry periods, began receiving effluent discharges year-round. These shifts affected vegetation cover, bank and bed stability, and sediment transport and storage.

The aquatic ecosystems, already vulnerable due to the high variability of stream flow, were decimated. Natural vegetation and fauna were often replaced by invasive species better adapted to contaminate to the new environments. In some cases, opportunistic flora so thrived on organic loadings that natural flow became clogged and floods ensued due to impaired drainage during winter rains. Almost a quarter of endemic fish are endangered and five are already extinct (Goren 2002). Of the six indigenous amphibian species in Israel, none enjoy a stable population, and four are either endangered (two critically) (Gafny 2002).[1]

In sum, the systematic overexploitation of Israel's natural water sources, intense industrial and agricultural development, and copious quantities of inadequately treated sewage placed a severe burden on the nation's streams and the native wildlife that depended on them. For decades these impacts were either overlooked or deemed

[1] Nature lovers rejoiced in November 2011 when the painted frog, for 50 years thought to be extinct globally as a result of the Huleh drainage, miraculously reappeared (Rinat 2011). But their future is not clear, as the wetland habitat that supported the species has virtually disappeared.

the price the nation had to pay for progress. Beginning in the 1990s, however, a gradual shift toward recognition of the value of stream ecosystems and a desire to rehabilitate them began.

5.3 A Change in Perspective

A combination of increasingly pernicious environmental conditions in Israel's streams, a decline in the economic and political influence of the agricultural sector in Israel,[2] and an increasingly concerned environmental awareness among the public all converged to initiate a change in the government's approach to stream management. Initial changes beginning in the 1990s were both regulatory, establishing bodies to promote stream rehabilitation, and financial, including financing upgrade of sewage treatment infrastructure. The decade also witnessed the country's first large-scale ecological rehabilitation project, the reflooding of part of the Huleh wetlands, a project that proved both potential environment and economic value of ecological restoration.

5.3.1 Statutory Amendments: Necessary but Not Sufficient

Israel had long had in place statutory authority that ostensibly could be used for purposes of protection and rehabilitation of streams. Israel's Water Law of 1959 obligated the government to protect the quality of the nation's water sources. However, as mentioned, it does not explicitly mandate protection of the aquatic ecosystems dependent on these water sources. As early as 1965 Israel passed the Streams and Springs Authorities Law that empowered the Minister of Interior (now Environment) to create an independent authority to coordinate the oversight of activities to protect a stream or river. Such authorities are empowered to undertake steps to protect and conserve the stream and its banks as well as abate nuisances and prevent pollution. However, it took 23 years for the first authority to be declared in the Yarkon Stream in 1988, with the Kishon Authority, the only other stream authority, following suit only in 1994.

In 1993, the government founded a national Stream Restoration Administration,[3] with representatives from several governmental agencies as well as

[2] According to Israel's Central Bureau of Statistics, as of 2011, agriculture accounted for only 1% of the national gross domestic product and less than 2% of employment (Central Bureau of Statistics 2012). This is down from nearly 25% of employment in the 1950s and early 1960s.

[3] In Hebrew, the word "shikum" can be interpreted as restoration or rehabilitation. Ecologists tend to reserve the term "restoration" for instances in which normal or historical ecological functioning has been restored to an ecosystem without the need for outside help. In the case of Israel, plans are generally for "rehabilitation" which represents only partial restoring of ecological functioning.

nongovernmental organizations. The new administration, however, served mostly has an ad hoc advisory body and did not create a clear national strategy or establish a clear division of responsibilities. The vacuum at the national level was filled by several initiatives by regional agencies. Numerous stream and drainage basin authorities began to coordinate rehabilitation work as well. The first was the Yarkon Stream Authority with a 50-million-dollar effort over the years, which was followed in the Kishon and others. A critical first step in rehabilitation efforts involves creating a master plan that can serve as a blueprint for the myriad activities which need to be part of a restoration program. By 2012, rehabilitation master plans had been developed for 27 different streams or stream segments, and work was under way to prepare one for the lower Jordan River as well. Ultimately, however, statutes and master plans cannot create the funds and political will that is necessary to ensure water supplies, upgrade sewage treatment, enforce discharge standards, or provide the resources to bring the public to the streams.

5.3.2 Financing Wastewater Treatment

Perhaps the most significant improvement to the quality of streams in Israel in the 1990s came as a result of upgrading of sewage treatment. Between 1990 and 2010, Israel invested nearly $2 billion in wastewater treatment facilities (Israel Ministry of Environment 2010). In 1995 there were 15 advanced wastewater treatment facilities in Israel. By 2005 32 plants were fully operational, treating 80% of the nation's total wastewater at at least a secondary level (Inbar 2006). Much of the wastewater was delivered to farms as recycled effluent, and the wastewater that was released in the streams contained significantly lower organic loadings and pathogens than previously. The investments produced substantial dividends in terms of environmental quality as measured by several water quality parameters in the country's major streams. Between 1994 and 2000, levels of organic carbon, total nitrogen, and total phosphorus inputs into major streams all declined by more than 40% (Shapira and Mazor 2001).

5.3.3 Reflooding the Huleh: Israel's First Major Ecological Rehabilitation Project

Reducing pollution loads is a critical step in rehabilitating streams, but merely reducing the level of damage in highly impaired ecosystems is not sufficient to restore ecological functioning. In fact, little progress was made in actually rehabilitating stream ecosystems in the decade following the establishment of the Stream Restoration Authority. Israel's first progress toward actual restoration of aquatic habitat came about not as a result of the authority's work, but rather, at

the site of the first and largest land reclamation (i.e., wetland drainage) project, in the Huleh Valley. The Huleh wetlands, located at the northern-eastern tip of Israel, covered 60 km^2 including a 14-km^2 lake. Early state leaders viewed the wetlands as a source of malaria and an impediment to agricultural production. By 1958, the Huleh Valley was entirely drained, with only a small 310-ha area reflooded and kept as a reserve and reminder of the original landscape. Agriculture in the valley was dramatically expanded.

However, soon after the draining, it became clear that the benefits of the project were much less than predicted, and the costs much higher. In the southern and central parts of the valley, the agricultural dividend that the project was supposed to create never materialized. As the groundwater table dropped, the peat soil began to degrade. Subsurface oxidation became a problem. The peat became black dust which was basically infertile. The dry summer months produced dust storms, while during the winter, fields were often flooded and unworkable, as the soil surface dropped by as much as three meters in some areas. The farmers in the area stopped cultivating the soils and sought alternative livelihoods (Hambright and Zohary 1998). In addition, the combination of soil degradation, agricultural activities in the northern part of the valley, and channelized flow led to increasing erosion and nutrient loading into the Kinneret Lake, Israel's primary source of surface water.

In order to improve water quality downstream and make use of the degraded land, authorities decided to reflood a portion of the valley. The project was completed in 1994 by the Jewish National Fund – the same organization that had led the drainage project 40 years earlier. The "Agmon" or mini-lake is only one square kilometer and, at an average of half a meter deep, far shallower than the original lake. Yet the new ecosystem quickly became a major tourist venue with an astonishing array wildlife, including tens of thousands of migrating cranes that winter on the site. In terms of broader policy significance, the project offered a "proof of concept" for advocates of stream rehabilitation who could now demonstrate that their efforts had both clear environmental and economic value.

5.4 The Potential for Genuine Progress

Recent years have seen several developments which bode well for the long-term prospects of improved surface water quality and stream rehabilitation. These include amendment of the Water Law to include environmental goals among the list of legitimate uses of water, a policy of large-scale desalination that should offset at least some of the pressures on natural water supplies, and significantly improved sewage treatment standards requiring tertiary treatment levels for nearly all municipal wastewater facilities. These policy changes have been accompanied by several initial projects designed to restore or rehabilitate streams and wetlands, including multimillion dollar efforts dredging and removing contaminants from the Kishon River.

5.4.1 Legal Recognition of Nature as a Legitimate Water Consumer

As mentioned, when passed, Israel's Water Law did not recognize nature as a legally legitimate recipient of water. This essentially meant that streams and wetlands were essentially left with whatever water, if any, remained after other legally recognized beneficial uses received their shares. In 2003, the Water Law was amended, adding environmental objectives as a legitimate objective for water allocations and stipulating that the Water Commission (now the Water Authority) submit a report about allocations to nature each year to the Knesset (Knesset 2004). The authority has since committed to finding water for stream restoration, called for proposals for determining water needs for environmental purposes, and included stream restoration in its long-term master plan for national water management (Israel Water Authority 2011).

5.4.2 Desalination

Israel's current commitment to desalination on a massive scale, as documented elsewhere in this volume, may reduce pressure on natural water resources, allowing water tables to rise and springs to flow again. As of 2011, nearly 300 million cubic meters (mcm) of water were desalinated annually, accounting for over half of all water supplied for domestic uses and nearly a third of all freshwater consumption for all uses. This amount is expected to increase to over 550 mcm by 2015 and to 750–1,000 mcm by 2020 according to various plans laid out by the Water Authority. Moreover, because currently over 70% of wastewater is treated and reused, each cubic meter desalinated actually adds 1.7 m^3 of water to the overall water supply. And given plans to increase the share of wastewater reused, these quantities can be expected to increase even further.

As a result, Israel's dependence on natural (rainfed) sources of water should significantly decline in the future. Current policy is to recharge aquifer levels in order to build a strategic reserve for future needs. While this will not raise water tables high enough for most springs to flow naturally again, it may help in isolated cases and should at least stunt the current trend of declining flows from springs (Stutolsky and Perlmutter 2012).

5.4.3 Effluent Standards

As Israel's sewage treatment improved, it became clear that meeting the existing standards would not be sufficient to bring its degraded streams back to life. The Ministry of Environment spearheaded an initiative to upgrade the existing

standards for biological oxygen demand (BOD) and total suspended solids (TSS). New standards for wastewater reuse were adopted in 2005 which establish a two-tiered criterion for sewage treatment: one for effluents discharged into streams and another for treated effluent delivered to agriculture. Though formally approved, a long phase-in period was allowed to allow for the necessary investment in upgrading sewage treatment infrastructure (Lawhon and Schwartz 2006). The standard replaces the 20/30 BOD/TSS standard with a uniform 10/10 BOD/TSS requirement. But many standards for other water quality parameters are bifurcated. Fecal coliform requirements are more stringent for irrigation (10 per 100 ml) than for streams (200 per100 ml) which presumably can benefit from dilution dynamics. At the same time, the standard for total nitrogen and phosphorus is tougher in effluent bound for streams (10 and 1 mg/l) than it is for irrigation (25 and 10 mg/l) in order to reduce the risk of eutrophication. No sewage treatment plant specifically designs its facilities for irrigation or stream release, but the very fact that special standards were designed to improve instream ecological integrity sent an important policy message about the seriousness with which Israel intends to pursue stream restoration.

5.4.4 Initiating Stream Protection and Rehabilitation Projects

In addition to the above-mentioned policy changes, Israel has also embarked on several projects of various scales designed specifically to rehabilitate springs and streams. Small projects include securing agreements to supply modest amounts of water to individual springs in the Galilee and an agreement that resolved a high publicized controversy over water from the Ein Gedi springs – a small but ecologically and historically significant desert oasis. In the case of the latter, the bulk of the waters were being captured directly from the springs for use by a bottled water company and for agricultural and domestic purposes in a nearby settlement. Today most of the waters are now captured downstream after flowing through a protected nature reserve.

A project to rehabilitate the Kishon stream, which flows through Israel's most industrialized area, represents Israel's first large-scale stream rehabilitation project. The stream has served for decades as the drainage canal for industrial effluents from large chemical industries, oil refineries, and other heavy industry in the Haifa region. Its waters have long been toxic and rancid. Beginning in the mid-1990s, tighter regulations on effluent discharges and upgrading of the local sewage treatment plant, as well as concerted action by the Kishon Stream Authority, resulted in significant reductions in inflows of major pollutants, including organic loads, ammonia, oils, and suspended solids (Nissim and Gutman 2011).

Reduction in pollution inputs, however, has not been sufficient to compensate for decades of accumulated stocks of pollution in the streambed sediments. A master plan for the rehabilitation of the Kishon was developed which has as its centerpiece a plan to dredge and treat the contaminated soil along the streambed. In order to

accomplish this, the course of the stream will be altered, adding a large meander downstream. Once in place, the contaminated land will be treated biologically and the soil used to create an urban park along the stream's new banks. This project is expected to be completed by 2015. Other elements of the master plan include acquiring additional water allocations for the stream as well as reintroduction of native flora and fauna. The master plan's price tag of nearly $60 million makes it the most expensive effort to date at stream rehabilitation in Israel. Roughly 60% of the funding for the rehabilitation project is to be paid by the oil refinery and chemical companies that are responsible for much of the historic pollution, with the national government footing the bill for another 30% and local authorities the remainder (Darel 2011b).

In sum, streams in Israel are no longer solely viewed as open sewage canals. There is growing recognition of the importance of streams from both an environmental and economic development perspective. The removal of certain statutory obstacles to stream rehabilitation and dedication of significant funding for desalination and wastewater treatment bodes well for the future of the ecological integrity of the streams in Israel, and some progress is being made in implementing aspects of many of the 27 master plans prepared for stream rehabilitation in Israel. The way forward, however, is not without substantial challenges.

5.5 Challenges and the Road Ahead

5.5.1 Administrative Obstacles

In a 2011 report on the state of stream rehabilitation policy in Israel, the nation's State Comptroller office noted that nearly 20 years after the establishment of the national Stream Restoration Administration, not one stream had actually been restored (State Comptroller 2011). The report cited numerous policy obstacles that remain to effective implementation of rehabilitation policy, among these overlapping policy mandates across government agencies, conflicts of interests within government agencies responsible for rehabilitation, and insufficient funding.

Over a dozen government agencies are responsible for some aspect of stream rehabilitation, including national ministries, local authorities, and specific agencies tied to the streams, such as drainage basins or stream authorities. The Stream Rehabilitation Authority – an interagency body – acts in an advisory capacity only and has no statutory authority. Among those with genuine operational powers, it is often unclear who is responsible for coordinating policy and what the hierarchy of decision-making is when agencies do not see eye to eye, as is often the case.

The Comptroller's report also criticized government policy for not taking a watershed basin approach to stream rehabilitation, even though it is widely recognized that such an approach is necessary for effective implementation. While the Ministry of Environment is authorized under the Streams and Springs Authority

Law to establish stream basin authorities, it has been reluctant to do so, in most cases conferring the responsibility for developing and implementing rehabilitation plans to the local drainage authorities. Its rationale for doing so has been not to create redundant bureaucracies. Yet it raises clear conflicts of interests.

The primary responsibility – and legally binding obligation – of drainage basin authorities, which operate under the auspices of the Ministry of Agriculture, is to prevent damage from flooding. To this effect, they tend to focus their efforts on channelizing streams and ensuring that the water flows quickly through them. However, floods are a necessary element in freshwater aquatic ecosystems, fulfilling numerous ecological functions such as replenishing wetlands and dispersing seeds. While the drainage basins can be held liable for failing to prevent flood damage, they have no such obligation to implement specific rehabilitation projects. This creates a clear prioritization of incentives with water quality and ecosystem rehabilitation lower on the hierarchy. In addition to the conflict of interests, there is also a conflict of cultures, as drainage authorities have tended to seek engineering fixes to stream issues, rather than taking more ecologically based watershed approaches (State Comptroller 2011). Efforts to place the drainage authorities under the mandate of the Ministry of Environment, in order to change both the conflicts of culture and of interests, have been met with significant resistance (Darel 2011a).

5.5.2 Financial Obstacles

According to estimates by the Ministry of Environment, rehabilitation of the nation's streams will demand over $1 billion dollars, including an additional half billion dollars for upgrading sewage treatment facilities and another half billion for actual projects in and along the streams (Israel Ministry of Environment 2010; State Comptroller 2011). The average amount of funding allocated by the government for rehabilitation projects between 1998 and 2010, however, was only roughly $2.5 million, leading the Comptroller's office to declare that at the current pace, rehabilitation efforts would take a century to complete (State Comptroller 2011).

Many economic assessments have found the economic value of stream rehabilitation in Israel is quite high, often outweighing the costs (e.g., Yarkon Stream Authority 2002; Barak 2010). Yet much of the benefits are in the form of public goods and, therefore, do not necessarily generate revenues that can be used to fund the rehabilitation projects. Additional cases such as the Kishon, in which large industries with deep pockets can be coerced to foot the bill, are not foreseen. This leaves the government to appropriate the necessary funds. For streams in urban areas, some of the revenues can be raised through property taxes on areas expected to see an increase in property value; however, this is not likely to raise sufficient funds for all rehabilitation needs. Other economic policies to generate revenue, such as a dedicated tax on water consumption, have been resisted by various parties who maintain that water prices are already high and that such a tax would be regressive in nature.

A small abstraction levy which charges more for users to pump upstream than downstream, in an effort to incentivize letting water flow in natural channels, has been implemented by the Water Authority on a small scale. However, such a policy is effective primarily in areas such as the tributaries to the upper Jordan River, in which water still flows naturally from springs. Potential to utilize this policy in coastal streams is limited, as water tables too low to affect spring flows.

5.5.3 Obtaining Necessary Environmental Flows

Even if policymakers were to sort out regulatory and financial issues, several other challenges stand in the way of stream restoration in Israel. First and foremost, perhaps, are the scientific questions of what is needed to restore or rehabilitate rivers. Under pressure from the Water Commission (now the Water Authority) to detail the water needs of streams, an interagency team led by the Nature and Parks Authority and the Ministry of Environment, produced a policy brief entitled "Nature's Right to Water," detailing the minimum amounts of water necessary for ecologically functioning streams (Nature and Parks Authority and Ministry of Environment 2003). The report cited a need for over 600 mcm per year for nature reserves and coastal streams, and an additional 200 mcm per year for restoration of the Jordan River. This amount is above and beyond the amount of water flowing in the streams already. To put this quantity in perspective, it constitutes more than half of the annual renewable freshwater resources of the country.

Taking desalination costs as a shadow price, a "back of the envelope" calculation puts the annual expense of supplying such amounts at roughly half a billion dollars. Knowing that such a request would be summarily dismissed, the report specified that, because water could be captured downstream, net water needs for nature reserves and coastal streams (i.e., losses to evaporation and unrecoverable seepage) could be satisfied with only about 50 mcm.

While the policy document played an important role in pushing forward the debate on the water needs for nature, it is deeply problematic. First of all, the policy of encouraging capture of the streamflow downstream, while certainly better from an ecological perspective than capturing it upstream, and perhaps politically necessary in order to be taken seriously, inherently sacrifices flows into estuaries – deltas where fresh- and seawater mix. Estuaries are important habitats in and of themselves and often play an important role in ecological functioning upstream as well.

Secondly, the quantities needed were calculated based on a dated methodology that failed to take into consideration important nuances in flow regimes that are vital to ecosystem health, such as the timing, duration, and rate of change of flows (Poff et al. 1997). The methodology is widely used because it is inexpensive and easy to implement (Katz 2006), yet it is unlikely to actually bring about restoration

of ecological functioning.[4] Furthermore, that method, like most other methods for determining ecological needs for streams, was based on how much water must be left in streams to avoid irreparable damage. It assumes a reasonable existing ecological integrity. Much less is known about how much flow must be returned to streams in order to overcome damage already inflicted by decades of dewatering and toxic discharges, as is the case in Israel. This is especially challenging in Israel, as no coastal stream is in good enough ecological health to serve as reference case and a basis for restoration plans.

While the exact quantities needed to rehabilitate streams are still unknown, it is clear that they are significant. In 2000 the government committed to allocating 50 mcm of water for nature preservation and rehabilitation. However, as of 2011, only 10 mcm was actually been allocated for such purposes, almost exclusively to the Yarkon stream. Policymakers still struggle with finding the needed waters. As Israel presently uses 100% of its renewable precipitation, until the country's desalination network grows appreciably, water for streams will have to come at the expense of other uses. Various government proposals call for treated wastewater – treated to the Inbar standards – to account for much of the future allocations for streamflows. Yet ecologists and environmental organizations argue that the standards are insufficient to bring about actual ecological restoration and that water at these standards may cause more harm than good (e.g., Gasith and Hershkovitz 2010; Stutolsky and Perlmutter 2012).

5.5.4 Water Quality

Additional improvements in water quality are still needed as well. The Inbar standards have already decreased the amount of pollutants and improved water quality in streams, from effluents, the primary point source of contamination. But many streams still suffer significant loadings from nonpoint source pollution from agricultural, urban storm water, or other non-discrete sources. In fact, the few studies that actually characterize the full profile of stream pollution suggest that nonpoint sources from runoff are the single greatest source of nutrients and other pollutants to the streams (Tal et al. 2010). Moreover, periodic treatment plant "failures" or accidents along the stream are not unknown and can cause considerable damage even when they occur far away from the stream but within the basin. Several such accidents have occurred in recent years resulting in massive fish kills and other water quality damages that literally wiped out years of rehabilitation efforts.

[4]The present criteria were proposed as a rule of thumb in the 1970s by Donald Tennet, an American hydrologist who examined rivers in the western USA and who himself has stated that many better, more sophisticated methods have been developed since then (Instream Flow Council 2002).

5.5.5 *Land Use*

Changes in land use within stream basins also complicate rehabilitation efforts. Development, especially in floodplains, decreases recharge areas and increases runoff, exacerbating floods and increasing the need for flood prevention, which, as stated, can contradict restoration goals. Furthermore, such development can prevent projects such as the reintroduction of meanders, which may be necessary for restoration of ecological functioning in streams. Proposals to establish funds to purchase land for purposes of stream restoration, including open spaces to preserve floodplains, have been put forward, but, to date, have not been implemented (State Comptroller 2011).

5.5.6 *Public Perception and Understanding*

Despite important shifts in policy that reflect a new appreciation of streams' value, significant rehabilitation will still require additional change in public opinion, both among policymakers and the public at large. Given national water shortages, many citizens still view water left instream as a luxury or a waste of precious resources. Editorials and declarations of politicians bemoaning the "wasted" water left to flow unexploited to the sea are still commonplace, as are calls for development of additional reservoirs to capture surface water flows.

In theory, the production of large quantities of desalinated water should reduce pressure on natural water resources; nonetheless, because of the high cost of desalination, many people object to desalinating seawater, for the seemingly "frivolous" purpose of allowing additional freshwater to run in streams. Similarly, theoretically, increasing standards for wastewater treatment can produce more water for instream flows. However, once sewage is treated to a high level, local authorities and utilities tend to see it as an economic resource that can be sold to farmers and are reluctant to release it without payment to streams. Indeed, for many years the Water Authority expected the Nature Reserves to "pay" for water – though the reserves had little ability of producing income to compete in a national market. Thus, both desalination and high-quality wastewater standards – which potentially could supply additional water to streams – may end up working against such allocations.

The Israeli public consistently expressed a desire for stream restoration, especially in urban areas. Still, it lacks the associated recreational culture. After living through decades of putrid conditions, stream-based recreation activities are minimal. Whole generations have grown up viewing streams as an environmental hazard, not a resource to be enjoyed. A recent study on public willingness to pay for stream-based recreation found that it was divided roughly equally between instream activities such as fishing and swimming, and off-stream activities, such as bike trails along the banks and picnic areas (Barak 2010). Yet much of the public is seemingly content with creation of recreational areas alongside of streams and still widely views the streams themselves as dangerous or as beyond repair.

Case in point, one of the more developed stream rehabilitation projects is for the Alexander, along the country's Mediterranean coast. Its "restoration plan" won an international prize. The parks along its banks and the rare soft-back, giant turtles (*Trionychoidea*) which live in its estuarial sections attract thousands of tourists each year. And yet, despite over a decade of "rehabilitation," the Alexander Stream is still a toxic canal having experienced little meaningful improvement in terms of biological and chemical indicators (Tal et al. 2010). It may be economically rational to begin with the inexpensive "low hanging fruit" of development of recreation along stream banks. Yet there is concern that many rehabilitation efforts will end there and not continue on toward comprehensive ecological rehabilitation of the streams and their ecosystems (State Comptroller 2011).

5.5.7 Necessity of Transboundary Efforts

Given that 12 streams originate in the West Bank and that Jordan River system is shared with Jordan, Lebanon, Syria, and the West Bank, restoration efforts are dependent on policies outside Israel's boundaries, as well as international policy and diplomacy. In terms of water quantity, the challenge is to convince those upstream to forego water so that it can flow downstream – a considerable hurdle given existing political tensions, regional water scarcity issues, and attitudes that tend to see ecological goals as luxury items. But there is some empirical basis for optimism regarding cooperation in transboundary restoration efforts. In a recent public opinion survey, Palestinians reported a higher willingness to pay for restored streams than did the richer Israeli public (Abramson et al. 2010). Furthermore, several Jordanian policymakers, including members of parliament, publicly supported rehabilitation of the lower Jordan River.

In terms of quality, the most immediate challenges needed to improve water quality in transboundary streams involve improved treatment of urban wastewater and policies to abate nonpoint discharges, especially from agricultural sources. Given the costs of building and operating high-quality wastewater treatment facilities, and the limited economic capacity of Israel's neighbors, especially the Palestinians, they are unlikely to be built without substantial assistance from international donors.

5.5.8 Climate Change

Finally, the cloud of climate change casts additional shadows over the potential efficacy of any rehabilitation efforts. Already facing chronic water scarcity,[5] the

[5]Chronic water scarcity is commonly defined by water managers as renewable water supplies of less than 500 mcm per capita per year (based on the Falkenmark index. For a comparison of water

region is experiencing a measurable negative trend in precipitation. This includes longer periods between rainfall events, increasing storm intensity, and more extended droughts; trends that are expected to continue into the future (e.g., Alpert et al. 2008). Various models predict decreases in precipitation of between 10 and 30% by mid-century and by up to 50% by 2080.

5.6 Conclusions

Stream rehabilitation is a prolonged process that requires considerable stamina on the part of society and decision makers, even under ideal circumstances. After more than half a century of overwithdrawals, contamination, and neglect, rehabilitation in Israel requires a considerable investment in removing pollution sources, landscaping, and infrastructure. Not less important is a change in public perception of streams and an understanding of their importance to the country. Israel is home to streams that literally flow through the heritage and traditions of four major religions, providing both spiritual and economic (touristic) reasons to pursue a new deal for its streams. Offering pilgrims from around the world, the opportunity to hold Baptism ceremonies in the River Jordan as Jesus did in days of old is not just good business; it also constitutes an ethical responsibility that goes along with being a steward of a holy land.

In water scarce regions, a surfeit of water must become available to release anew to the nature reserves and parks as part of a process that meets the competing demands for agricultural irrigation and rising consumer consumption. Hence, one can argue that Israel's streams' time has finally come. The advent of massive desalination is changing the perspectives of the general Israeli public as well as the country's robust environmental movement about water resources. For Israel's beleaguered surface waters, it offers an opportunity and a fresh lease on life.

Israel's attitudes toward its streams have changed significantly over the course of the country's short history. Once viewed primarily as a convenient means for evacuating sewage, with little inherent value, streams are now increasingly recognized as a beneficial asset to local communities and the nation as a whole. For an increasingly urban country, they can provide "green ways" and parks that allow crowded citizens and visitors to enjoy some direct connection with nature and the historic countryside. Laws have been amended, rehabilitation plans developed, and some preliminary projects initiated. The challenges to meaningful rehabilitation of the country's streams, however, remain numerous and formidable. The pervasiveness of past neglect makes it a long-term, expensive prospect. But it appears that the country has turned a corner and that lip service has finally

poverty indices, see Lawrence et al. (2002)). Between 1990 and 2010, Israel's renewable rate was less than 200 mcm/cap/year (Weinberger et al. 2012). Even with massive desalination and wastewater reuse included, this amount was less than 300 mcm/cap/year.

begun to be replaced by actual commitments. If the country can stay the course and implement the many rehabilitation master plans, the outlook for the future of Israel's streams is hopeful.

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