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The Water

Don't spit into the well water—you'll need to drink it later.
—Russian proverb

There is no water in this city, spread along the largest river in Europe. What a joke.
—Television newscast reporting on contaminated drinking water in the Russian city of Volgograd

The Soviet Union faced two major problems with water resources, one natural, one humanmade. Although the Eurasian region is blessed with ample amounts of rain and snow feeding its great rivers and lakes, the bulk of its water resources are located in relatively undeveloped regions of Siberia—in the basins of rivers that carry the water north and even farther away from the areas where it is needed most. Three-quarters of the region's population and 70 percent of its industry enjoy ready access to only 16 percent of total available water resources. Seasonal variations exacerbate the distribution problem as meltwater combines with heavy rainfalls in spring and early summer to cause flooding. Autumn and winter in Eurasia tend to be dry, with runoff stopping completely during the long winter freeze. The region is also noted for great variations in precipitation from year to year, rendering agricultural output unpredictable. To overcome these challenges of nature, engineers dammed, diked, drained, and diverted water resources in an effort to work the Soviet Union into a single hydrographic network.

Where and when water was available, resources were squandered through poor allocation, misuse, and severe pollution. According to a 1990 government survey of 10,000 citizens living in ecologically depressed regions, water pollution was the problem that troubled people the most.[1] Given the fact that many bodies of water cross the borders of newly independent states, the Soviet legacy of these two issues—the distribution and degradation of water resources—could prove to be one of the most contentious environmental problems of the post-Soviet era.

WATER DIVERSIONS AND WATER USE

In 1988, a total of more than 80,000 enterprises, associations, farms, and urban water utilities drew off 365 cubic kilometers (365 billion cubic meters) of water, about 8 percent of the annual renewable supply. (The term *water withdrawal* means water physically abstracted, the majority of which returns to the water table.) In 1987, water withdrawals in the Soviet Union equaled about 3.3 cubic meters of water per person per day. For comparison, following are the rates in other countries during the same time period: Bulgaria, 2.3 cubic meters of water per person per day; Hungary, 1.9; Czechoslovakia, 0.9; and the United States, 6.4.[2] Water withdrawals by economic sector are presented in Table 3.1; included for comparison are data for the United States.

The volume of water used by the economy was actually much greater, but the Soviet government expended hundreds of millions of rubles annually during the 1970s and 1980s to develop recirculating supply systems. Between 1980 and 1988, the volume of water recycled by industry increased 42 percent, reaching 72 percent of all water used. In turn, water use dipped slightly during this period, while the economy grew.[3] Despite these efforts, however, water usage remained inefficient by interna-

TABLE 3.1 Water withdrawals for the national economy in the Soviet Union and the United States

	Soviet Union (1988)		*United States[a] (1985)*	
Purpose	*Cubic Kilometers*	*Percentage of Total*	*Cubic Kilometers*	*Percentage of Total*
Industry[b]	140.2	38.4	289.8	52.6
Irrigation	194.5	53.3	189.3	34.3
Public supply	24.5	6.7	55.1	10.0
Other	5.7	1.6	17.0	3.1
Total	364.9	100.0	551.2	100.0

[a]Includes salt and fresh water.

[b]Includes water used by the agroindustrial complex for purposes other than irrigation and water used by power plants.

Sources: USSR Goskompriroda, *Sostoyanie prirodnoi sredy v SSSR v 1988 g.* (Moscow: VINITI, 1989), p. 43; U.S. Bureau of the Census, *Statistical Abstract of the United States: 1989* (Washington, DC: Government Printing Office, 1989), p. 198.

tional standards. To produce one ton of steel, the average Soviet factory required 270 cubic meters of water; the average in West Germany was 180 cubic meters.[4] To produce one ton of pulp, the Baikal Pulp and Paper Combine (an efficient plant, by Soviet standards) used 375 tons of water and discharged 231 kilograms of mineral salts (sodium sulfate) in its effluent. The corresponding figures for pulp production in the United States were 250 tons and 64 kilograms, respectively.[5] The more water used to produce a measure of output, the greater the resources that must be expended to ensure its purity before returning it to the environment.

A second concern related to the issue of water use and efficiency is water consumption—the volume of water abstracted but not returned ultimately to the local water table. Although improvements such as recirculating water supply systems improved the efficiency of water use, the economy continued to consume a large volume of water. Of the total amount of water withdrawn in 1988, 182 cubic kilometers, or 50 percent, was irretrievably lost.[6] The U.S. economy withdrew significantly more water from the environment, but a much larger proportion was returned; in 1985, water consumption was 127 cubic kilometers, or just 23 percent of withdrawals.[7]

Heavy water consumption, not use, frequently led to environmentally disruptive decreases in the levels of many rivers and lakes. By the 1980s, water flows throughout the Soviet Union were reduced by 2.5 percent, and in the southern regions of the country by an average of about 14 percent.[8] Water consumption has deprived the Volga of 5 percent of its historic flows, flows in the Dnieper have been reduced by 19 percent, and supplies of water feeding the basins of the rivers Don and Kuban have been reduced by one-third. Even in water-rich Siberia, the Tom, Ishim, and Chulym rivers have been in "a strained condition," according to USSR Goskompriroda.[9] The agricultural sector traditionally has consumed the most water; in parched regions under extensive irrigation, such as Central Asia and Kazakhstan, on average one-quarter of the annual supplies of water are not returned to the local water table.[10] The Aral Sea is an extreme case: Consumption of water drawn from the Amu Darya and Syr Darya rivers, which feed the Aral Sea, is almost complete. What water still flows in those rivers is largely agricultural runoff laden with fertilizer and pesticides; in some years, water from neither river has reached the Aral Sea.

One reason efficiency remained low and consumption high is that water often was diverted unintentionally. Fourteen percent of the water pumped out of ground- and surface-water resources in 1988 (50.6 cubic kilometers) was lost in transmission between source and end user—a volume equivalent to sacrificing almost all the water that flows down the

Dnieper River in a year. Ninety-two percent of all water lost in the national economy occurred in the agricultural sector from irrigation systems that often were crudely constructed and poorly maintained.[11]

For a region of great seasonal and geographical disparities in the distribution of water, the expansion of irrigation systems has played a central role in boosting agricultural output. In the 1970s and 1980s, the area of land under irrigation doubled to include a total of 21 million hectares.[12] By the late 1980s, almost one-third of all agricultural production, in terms of ruble value, came from irrigated land; grown on irrigated land were all cotton and rice produced in the Soviet Union, three-quarters of the vegetables, half the fruit, and 30 percent of the corn.[13] The benefits of irrigation, however, have cost the environment dearly. In the haste to boost irrigation, the Ministry of Land Reclamation and Water Resources frequently dug channels directly in the soil or sand, often without adequate lining or covering. More than half of irrigation systems consist of simple unlined furrows, and as a result, seepage has averaged almost 20 percent.[14] In Georgia, 78 percent of all channels are unlined and uncovered, and water losses in the republic are as high as 40–60 percent.[15] Of the 180,000 kilometers of irrigation canals in Central Asia, 15,000—only 8 percent—have linings.[16] Seepage from the Karakum Canal (for which water has been diverted from its course into the Aral Sea) has inundated the Turkmenistan capital of Ashkhabad; to prevent flooding, the authorities have had to drill 150 wells to pump the water out of the city.[17] Sergei Zalygin, who is not only one of Russia's foremost literary figures and environmentalists but also a water resources engineer, has estimated that 25 million hectares of land not intended for irrigation are virtually swamped by misdirected water supplies.[18]

Although the total area of irrigated land and the volume of water used in the entire former Soviet Union have been roughly comparable to figures for the United States, the distribution of available resources has been very uneven, and the distribution and application have been ineffective and often damaging. In addition to spawning leaks, Soviet irrigation networks frequently have no means with which to regulate the water supply. Of the 7,000 sources feeding the irrigation systems of Georgia, only 18 percent are metered.[19] About 40 percent of irrigated land (7.7 million hectares in 1988) has been equipped with more water-efficient sprinkler systems; the remaining 60 percent is watered using simple furrows.[20] Sprinkler systems are used almost universally in the Baltic states, Ukraine, Belarus, and Moldova (regions with only small irrigation systems), but they are largely absent elsewhere. Turkmenistan and Uzbekistan, two of the republics with the largest share of irrigated land, have scarcely a sprinkler system between them.[21] High-efficiency sprinkler systems and slow-drip technologies have not been exploited.[22] In the end, according to Zalygin, a mere 20–30 percent of water withdrawn ultimately reaches the crops for which it is intended.[23]

A U.S. researcher, Michael Rozengurt, has pointed out that crops in Central Asia and Kazakhstan may receive between 4 and 6 times the amount of water they require.[24] Half of the 2.3 million hectares of farmland in Ukraine are reported to be overwatered.[25] According to a study by the Soviet statistical agency, of the farms surveyed that had established norms for irrigation, 44 percent were found to be applying too much water to their crops to the extent of a total of 100 million cubic meters.[26] Overwatering encourages erosion, and 10 percent of all irrigated land already has been affected.[27] In addition, excessive irrigation promotes the leaching of nutrients, minerals, and agricultural chemicals, which eventually contaminate ground and surface water resources. Finally, the swamping of irrigated land in southern regions has promoted the return of malaria, a disease Soviet authorities had considered eradicated.[28]

Just as it rapidly developed irrigation systems, the Soviet government aggressively expanded its network of hydroelectric power stations in order to meet the economy's growing demand for electricity following World War II. Dam building was a pet project of Lenin's and evolved into a grand effort. Under the "Great Volga'' scheme initiated under Stalin, the Volga River (often referred to as the "main street of Russia'') and its tributaries were dammed up with 34 large and small hydroelectric power stations.[29] In the 1950s, thousands of aspiring young Communists answered the call of the Komsomol, the Leninist youth league, and flocked to the wilds of Siberia to help build the Bratsk dam. Great pride was exhibited in the construction of the world's tallest dam—Tajikistan's Nurek and the most powerful hydroelectric station, then the Krasnoyarsk. At the close of the 1980s, there were about 210 large- or medium-sized hydroelectric stations in the Soviet Union.[30]

The government's hydroelectric program claimed 62,000 square kilometers of land in the former Soviet Union—an area equal in size to West Virginia—a result, in part, of numerous dams being built in lowlands.[31] Before the dam-building program, it took one month for water to travel the course of the Volga; by the 1980s, the trip had been slowed to a year and a half.[32] "The Volga has virtually ceased to be a river,'' laments Aleksei Yablokov. "[I]t has become a chain of reservoirs.''[33] In 1988, the Soviet environmental agency reported that the USSR Ministry of Land Reclamation and Water Resources and the USSR Ministry of Power Engineering and Electrification—the dams' builders—did not ensure the proper preparation of lands inundated by the reservoirs. As a result, Siberia's Bratsk, Krasnoyarsk, and Ust-Ilimsk reservoirs had accumulated 3.6 million cubic meters of wood debris. The subsequent decay of the wood raised the concentration of phenols to as much as 10 times established norms.[34] Because lowlands surrounding the reservoirs were not stabilized or protected, they became subject to flooding and erosion, which eventually fills the reservoirs with silt, diminishing their capacity and useful lifetime.

Hydroelectric stations accounted for almost one-fifth of Soviet generating capacity and produced 13.5 percent of the electricity consumed, roughly the same share as the nuclear power industry.[35] Because many regions have suffered chronic energy shortages, energy managers are often forced to rely on hydroelectric power to cover gaps in supply, especially when demand peaks during the winter heating season. Water stocks are thus depleted during the winter and can only be replenished in the spring, when rivers rise with melting snow and heavy rainfall. The resulting cycle, which runs counter to the natural cycle of heavy spring flow and low winter flow, has wrought havoc with the aquatic systems of the rivers downstream; reproduction and migration patterns of fish have been disturbed. Planners expected winter flows to double along the Volga south of Volgograd because of the operation of the massive Volga-Kamsk hydroelectric power station. Power shortages in the region have forced the plant to work overtime, and flows during the winter are actually three or more times their natural level.[36]

Many dams in the Soviet Union were constructed without fish ladders, and those that do exist are ineffective. Commenting on the performance of fish ladders at the Volgograd hydroelectric power station, which was completed in 1958, Vladimir I. Luk'yanenko, a laboratory director at the USSR Academy of Science Institute of Inland Waters Biology, wrote:

> Regrettably, this is the only apparatus [along the Volga] that allows something "to pass.'' But only "something.'' The effectiveness of its operation is extraordinarily low—on the order of thousandths of a percent of the number of spawning sturgeon . . . that reach the dam. However, in actuality, the passing of even this infinitesimal portion of these reproducers has been nullified as a result of the subsequent construction of the Saratov (Balakovo) hydroelectric station and the rise of the Saratov reservoir, the hydrological regime of which is not compatible with the natural reproduction pattern of the passing fish. It is true that in the dam of this hydroelectric station a fish ladder has been built, but its performance is of a symbolic nature.[37]

In addition to obstructing migration routes, the dams have inundated valuable wetlands above but allowed those below to dry out, particularly during the spawning season in spring. Damming the Volga has reduced the spawning grounds for some species of sturgeon from an estimated 3,000–4,000 hectares to only 400 hectares—all located in the one remaining zone of relatively undisturbed riverbed between Volgograd and the river delta on the Caspian. Spawning grounds for beluga have been decimated completely. The construction and operation of the Tsimlyansk and Nevinnomyssk dams on the rivers Don and Kuban also have disrupted reproduction cycles and have completely destroyed the spawning grounds of beluga and 80 percent of the spawning grounds for other species of sturgeon.[38]

In 1990, however, the spring floods returned to the lower Volga after more than 20 years' absence. Fearing a complete and irreversible loss of aquatic life in the lower reaches of the river, concerned citizens in the "tens of thousands," with the backing of the RSFSR State Committee for the Protection of Nature, convinced both the Volgograd and Astrakhan oblast soviets to change the operating cycle of the Volgograd hydroelectric station—not a trivial demand. To make the change possible, the USSR Ministry of Power and the Russian Ministry of Land Reclamation and Water Resources agreed, after months of negotiation, to reduce electricity demand during peak hours and days by 20 percent; a 10 percent reduction was expected to be achieved through economies, and the remainder by rescheduling operations of local industries to the weekends.[39]

WATER RESOURCES MANAGEMENT POLICY RECONSIDERED

The vast schemes to harness water resources epitomized one of the core tenets of Soviet development: to overcome the imperfections of nature and to tame it for the benefit of society. As illustrated in the preceding section, projects often were praised more for their daring and scale than for their practicality or effectiveness. Ultimately, ecological concerns were eclipsed by planners' and engineers' ambitions. Such preoccupations resulted in projects that were designed and approved based on "concepts lacking reliable methodological foundations," according to one Soviet specialist.[40]

One of the most important factors influencing the direction of water resources development was the absence of market-based prices. Despite large capital investments made by the state to build dams and irrigation networks, water was supplied to industrial consumers at virtually no cost and to farms for free, leading to its widespread abuse by both industry and agriculture. Similarly, the absence of market pricing of electric power hampered decisionmaking with regard to the development and operation of hydroelectric facilities. Many Soviet officials recognized the need to raise the price of water and electricity, but their efforts were repeatedly stymied.[41]

The problems in the management of water resources also could be tied to the narrow institutional interests of the principal government agencies involved—the most important being the Ministry of Reclamation and Water Resources. To maintain its large budget and staff, the agency, with the help of in-house research institutes, continually advocated new projects, regardless of their merit. The environmental effects of such projects largely were irrelevant. Although reorganized several times over the 1980s, the ministry remained concerned solely with moving water—the more the better. Issues such as water quality or agricultural output were not its concern.

This cavalier approach to economics and the environment eventually caught up with the ministry. In August 1986, a nascent environmental movement won its first major victory when the government elected to scrap grandiose plans to divert water from the Russian north down to the Aral and Caspian seas. In addition to reversing the flow of the Irtysh River, the project entailed construction of a 2,200-kilometer navigable channel, dubbed "Sibaral," across the Kazakh steppe. This "project of the century" had been in the planning stage since the 1950s, and over 120 agencies were involved in its elaboration and assessment.[42] Opposing the project was an alliance of environmentalists like engineer / writer Sergei Zalygin and Russian nationalists such as writers Valentin Rasputin and Vladimir Soloukhin.

The reappraisal of the water diversion also turned on economic factors as the Gorbachev administration sought to reverse traditional Soviet policy of channeling investment into lengthy and costly new development projects. During the Tenth Five-Year Plan (1976–1981), for example, the overall cost of improving a hectare of land in Ukraine increased by over 20 percent, but agricultural productivity increased by just 8.6 percent.[43] Across the country, the area of new land coming under irrigation each year fell throughout the 1970s and 1980s; between 1986 and 1988, new capacity dropped by over a third.[44] Commissioning of new hydroelectric plants also slowed by 50 percent over this period.[45] In March 1990, an expert commission of the USSR State Planning Committee recommended canceling the nine-year-old Volga-Don-2 canal project.[46] The 65-kilometer canal, then under construction for five years at a cost of billions of rubles, was to divert water from the Volga north of Volgograd toward the Don, which had been depleted by withdrawals for other uses. The commission instead recommended the refurbishing of existing irrigation systems at lesser cost.

In the wake of the Sibaral decision, opposition to development projects exploded all across the Soviet Union. A constellation of similar economic, environmental, and ethnic considerations led the all-Union and republican governments to vote to cancel or postpone work on the Danube-Dnieper and Volga-Chogray canals as well as the Daugavpils, Rogun, Turukhansk, and Katun hydroelectric projects.

The increasing cost of bringing new marginal lands under irrigation and damming more remote rivers will limit even the smallest of projects in the future, as the newly independent regions move their economies to market relations and governments are faced with hard budget constraints. Nevertheless, many water industry officials remain undaunted by the new challenges to their prerogatives.

WATER POLLUTION AND POLLUTION CONTROL

In terms of fiscal outlays, improved water quality and water conservation were the highest environmental priorities of the Soviet regime; between 1976 and 1988, the government allocated over 22 billion rubles for such purposes—approximately 75 percent of all spending on environmental protection.[47] Total wastewater treatment capacity in the USSR increased by 53 percent between 1980 and 1988. In 1980, 78 percent of cities and 47 percent of towns were served with some level of centralized sewerage; by 1988, the levels were 87 percent and 53 percent, respectively. Significant improvements in wastewater treatment were achieved in the Ukrainian city of Odessa, for example: Between 1985 and 1988, the municipality halved its emissions of untreated sewage into the Black Sea.[48]

Overall, however, the quantity of effluent generated increased more than fourfold during the 1970s and 1980s, and one estimate was that effluent production would increase by another 150 percent by the year 2000.[49] Despite the investments in improved treatment, capacity remained small, and most communities relied on only primary, mechanical systems.[50] Over one-quarter of treatment systems surveyed at the end of the 1980s were overtaxed, and one-fifth operated with worn-out or outdated technology.[51] In Tallinn, the capital of Estonia, wastewater treatment equipment was forced to handle 10 times its designed capacity.[52] The result is that such systems release incompletely treated or raw sewage directly into the environment. In the provincial capital of Yaroslavl, an extremely overworked sewage treatment system spewed into the Volga River effluent containing organic compounds 5 times over the permitted maximum. In addition, the system released nitrogen and petrochemical compounds at a rate 20 to 40 times the permitted maximum, and concentrations of other pollutants reached more than 100 times the permitted maximum. In 1985, the city was forbidden to connect any more apartment blocks or enterprises to the sewage system until the plant's capacity had been expanded. The city ignored the order and offered the government assurances that new treatment capacity would come on line shortly; by 1988, it was apparent that it would not be ready before the mid-1990s.[53]

In 1989, one-third of all enterprises and utilities did not comply with wastewater standards.[54] In Moscow, 2,800 industrial enterprises were hooked up to the city's sewer system, but the wastes from over nine-tenths of them did not meet government norms.[55] In St. Petersburg, only 30 percent of the effluent flowing into the Neva River from this city of over 5 million inhabitants underwent any treatment at all.[56] As a result, each city spewed over 1 billion cubic meters of poorly treated sewage into their rivers in 1990.[57] At the end of the Soviet period, many cities still did not have even primary sewage treatment facilities—for example, Kaunas (1990 population 430,000) in Lithuania and the Russian port city of Murmansk (472,000). In Latvia, only 2 of 29 cities had wastewater treatment systems; the capital Riga (917,000) was able to treat less than 10 percent of its wastes according to norm.[58] Baku (1.8 million), the capital of Azerbaijan, also was equipped with only the most rudimentary system, and an upgrade was a decade behind schedule.

In 1988, urban sewage systems across the Soviet Union discharged 2.2 million cubic meters of raw and 10.7 million cubic meters of insufficiently treated sewage into the nation's waterways.[59] The republics with the most overtaxed municipal sewage treatment systems were Tajikistan, Belarus, Ukraine, Latvia, and Lithuania.[60] In addition, many industrial plants released untreated or improperly treated effluent directly into the environment—200 industrial enterprises were not connected to the St. Petersburg sewer system as of 1990[61]—bringing the total volume of effluent that did not meet sanitary norms to 32.6 million cubic meters in 1989, more than the annual throughput of the river Don. Between 1986 and 1989, the share of effluent adequately treated decreased sharply from 60 to 25 percent, a function of stricter treatment standards as well as deteriorating performance.[62] Even without this change in targets, the actual performance of treatment plants worsened, resulting in a 14 percent increase in pollutant emissions between 1988 and 1989.

Russia accounted for the major share of water pollution. In 1989, treatment facilities in the federation could process adequately just one-tenth of the wastewater produced, resulting in the release of 27.1 million cubic meters of raw or partially treated sewage into the environment—83 percent of the Soviet total. Ukraine accounted for about 9 percent of improperly treated wastewater emissions in the Soviet Union.[63] A breakdown of performance by republic is provided in Table 3.2. Table 3.3 indicates the types of contaminants released into the environment with wastewater.

Table 3.4 shows the destination of waterborne pollution. As it indicates, the region's topography tends to retain pollutants, mitigating the opportunity for nature to dilute and process pollution. Over 20 percent of former Soviet territory is composed of closed or nearly closed hydrological systems: Pollution from the Volga Basin collects in the northern Caspian Sea, and pollutants from the rivers Don and Kuban aggregate in the sea of Azov. Contaminants from the Danube, Dniester, South Bug, and Dnieper rivers are released into the northern Black Sea. A similar

TABLE 3.2 Performance of wastewater treatment as reported by republic, 1989

	Total Volume of Wastewater Requiring Treatment (millions of cubic meters)	*Percent Treated in Compliance with Norm*	*Percent Treated but Not Complying with Norm*	*Percent Remaining Untreated*
USSR average	43,564	25	51	24
Armenia	557	55	1	44
Azerbaijan	597	51	12	37
Belarus	994	93	7	0
Estonia	517	52	37	10
Georgia	626	49	9	42
Kazakhstan	591	43	48	9
Kyrgyzstan	180	78	17	6
Latvia	367	30	39	31
Lithuania	450	25	47	28
Moldova	298	37	48	39
Russia	30,633	11	61	28
Tajikistan	286	62	35	3
Turkmenistan	na[a]	na	na	na
Ukraine	6,706	57	36	7
Uzbekistan	762	65	8	27

[a] Not available.

Source: USSR Goskompriroda, *Sostoyanie prirodnoi sredy i prirodookhrannaya deyatel'nost' v SSSR v 1989 godu* (Moscow: Institut Molodezhi, 1990), p. 99.

TABLE 3.3 Compounds released into surface waters, 1989 (metric tons)

Petroleum products	74,000
Suspended solids	2,236,000
Sulfates	20,953,000
Chlorides	19,189,000
Phosphates	65,689
Nitrates	240,056
Phenols	925
Surfactants	15,726
Copper	1,002
Iron	37, 435
Zinc	2,367
Nickel	915
Chromium	967
Mercury	1,978

Source: USSR Goskompriroda, *Sostoyanie prirodnoi sredy i prirodookhrannaya deyatel'nost' v SSSR v 1989 godu* (Moscow: Institut Molodezhi, 1990), p. 99.

situation exists with Lake Balkash in Kazakhstan, Lake Issyk-kul in Kyrgyzstan, and the Aral Sea.[64]

Remedial construction lagged far behind government targets as water pollution control projects were plagued by material shortages and bottlenecks. Essential materials and equipment proved difficult to procure, given the low priority and undeveloped nature of environmental protection industries. A lack of hard currency precluded the option of importing foreign technology. As a result, wastewater treatment facilities and enterprises were forced to build a large share of their own equipment. On a tour of Moscow's Kuryanovo wastewater treatment facility, for example, the plant's chief engineer, Fedor Dainenko, proudly pointed to huge agitators he had personally designed, adding that his enterprise built equipment for other facilities. Labor also was in short supply, particularly the specialists needed to elaborate the plans for the projects. The completion rate of planned treatment facilities averaged under 60 percent in 1988 (see Table 3.5). Some republics fared much worse: Plan fulfillment in 1988 for Kazakhstan was 1 percent, Azerbaijan 2 percent, and Georgia 12 percent.[65]

Installing water pollution control equipment was only one challenge; making it work properly was another. The quality of the latest Soviet wastewater treatment technology, when it could be procured, was not a significant obstacle. According to Soviet sources, the process efficiency of effluent treatment systems installed in the late 1970s was roughly equal

TABLE 3.4 Destination of untreated and partially treated effluent discharges, 1990

	Cubic Meters (millions)		Percent
Total USSR	33,564		100.0
Caspian Sea	12,458		37.1
Volga River		11,050[a]	
Kura River		371	
Other		1,037	
Sea of Azov	4,956		14.8
Don River		1,565	
Kuban River		1,704	
Other		1,687	
Baltic Sea	3,646		10.9
Neva River		1,592	
Lake Ladoga		390	
Other		1,664	
Yenisei River	3,160		9.4
Ob River	3,044		9.1
Black Sea	2,722		8.1
Dnieper River		1,945	
Other		777	
North Dvina River	839		2.5
Aral Sea	550		1.6
Syr Darya		276	
Amu Darya		75	
Other		199	
Amur River	543		1.6
Lake Baikal	192		0.6
Selenga River		81	
Other		111	
Lena River	143		0.4
Other	1,311		3.9

[a] Of the total volume of polluted effluents entering the Volga River basin, 4,700 million cubic meters are derived from the Oka River basin and 2,200 million cubic meters are from the Kama River basin.

Source: USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov* (Moscow: Informtsentr Goskomstata SSSR, 1991), pp. 76–77, 93.

to that in the United States, able to deal with about 90 percent of organic material and 10–40 percent of inorganic substances.[66] Rather, much of the problem lay in the application of available technology. This factor cannot be overemphasized with respect to the Soviet Union. Water purification systems tended to break down frequently because of poor

TABLE 3.5 Performance of water pollution control programs by ministry at all-Union level, 1988

	Discharges of Improperly Treated Effluent		*Treatment Capacity Installed*	
Ministry	*Volume (thousands of cubic meters)*	*Percentage Untreated*	*Plant Treatment Capacity (thousands of cubic meters per day)*	*Percentage of Planned Capacity*
Total USSR	28,434	28	5,196	59
Timber	2,718	15	185	79
Ferrous metallurgy	1,324	23	1,017	90
Petroleum refining and petrochemicals	1,251	16	742	105
Mineral fertilizer	1,104	30	207	74
Power engineering and electrification	1,097	69	48	41
Chemicals	959	27	25	13
Nonferrous metallurgy	629	38	98	83
Coal	574	25	102	45
Pharmaceuticals and microbiology	185	20	57	49
Construction materials	56	25	na	na
Other	18,537	29	2,714	na

[a] Not available.

Source: USSR Goskompriroda, *Sostoyanie prirodnoi sredy v SSSR v 1988 g.* (Moscow: VINITI, 1989), pp. 56–57, 142–143.

construction, improper maintenance, and operator error. At industrial enterprises, plant managers accorded environmental protection a low priority because the consequences of not fulfilling the plan or contracts were more grave than those for violating environmental norms. Management, therefore, was disinclined to halt production in order to construct, maintain, and repair pollution control equipment. The poor state of effluent treatment equipment was confirmed in a 1989 survey conducted by USSR Goskomstat: Urban systems were found to be working at 79 percent efficiency—in other words, 21 percent of effluent passing through the system was not being treated as specified. Treatment of industrial effluent fared much worse; only 42 percent of treated effluent was properly processed. The sectors that performed worst were pharmaceuticals (7 percent properly processed), coal (11 percent), light industry (29 percent), and timber and paper (38 percent).[67]

Goskomstat gave several reasons for this poor performance. First, many systems were overtaxed. In a quarter of the installations surveyed, the volume of effluent to be processed was too large, and almost a third of the systems were not suitably equipped to handle the types of effluent present. Second, a fifth of the equipment surveyed was worn out, much of it being more than twenty years old. To compound the problem, little money was spent on maintenance: in 1988, less than 500 million rubles were allocated for capital repairs of water pollution control equipment—a tenth the amount of money appropriated for investment in new water purification facilities.[68] Third, in 10 percent of the cases surveyed, the necessary equipment was missing or simply turned off. Finally, lack of essential treatment agents was a problem at 2 percent of the sites investigated. USSR Goskomstat concluded that “a significant number of enterprises’’ were plagued by two or more such problems simultaneously.

In consequence, breakdowns and malfunctions in sewage treatment facilities occurred frequently, according to media reports and personal interviews. On June 6 and 16, 1989, two releases of untreated sewage into the Oka River (a tributary of the Volga) occurred at the wastewater treatment plant in Orel, a provincial center 350 kilometers south of Moscow. On June 26, the river again was polluted when sludge from an overfilled holding tank flowed into the river. Despite widespread fish kills and complaints from citizens, local officials refused to acknowledge the accident or to warn the public of high bacteria levels in the river. On July 2, a fire at a pump substation forced the sewage plant to be shut down for two days; the result was the discharge of 150,000 cubic meters of untreated effluent into the Oka. Damage was assessed at 1.1 million rubles, and the river was closed to recreation in several neighboring oblasts. On January 22, 1990, a sewage collector in the same city burst because of settling ground and released another 40,000 cubic meters of waste into the Oka.[69]

In January 1990, workers at the Khimvolokno Production Association in Gomel oblast, Belarus, addressed an open letter published by *Pravda Ukrainy* to their comrades at the Slavyansk Chemical Production Association in Donetsk oblast, Ukraine. The Khimvolokno workers noted that in 1989 their enterprise was scheduled to receive from Slavyansk 13,000 tons of soda ash with which to treat their effluent, but only a third was delivered. “Not having received the soda,” the workers wrote, “our shop has been forced to dump untreated, aggressive industrial discharges into the Berezina River—a tributary of the Dnieper.” They added that they regretted their “barbaric pollution” of a region already reeling from the

Chernobyl accident, noting that their work collective had suffered the wrath of local environmental groups and had incurred fines of 89,000 rubles for the poisoning of fish.[70]

The previously mentioned Goskomstat study of wastewater treatment performance was concerned only with whether installed technology worked as intended; it did not investigate whether the processed effluent actually complied with government standards. As already illustrated, many urban authorities have either no treatment capacity or only primary effluent treatment systems, and even if all the effluent treatment equipment operated as well as it was intended to, the quality of installed technology is such that not all of the processed effluent would comply with existing environmental standards. If performance is to be improved, more modern technology and much greater sums of money are required—two things in short supply in the environmental budgets of the newly independent republics.

Unfortunately, the story and the data related here are not complete. First, data on water pollutants count only effluent passing through sewer mains. A factory that released its effluent (treated or untreated) directly into a local lake, for example, would not be included in the statistics. Underreporting due to this situation is most likely in the less developed regions of the former Soviet Union, most importantly, the Central Asian republics. This, in turn, would make the data reported in Table 3.1, for instance, look much less favorable. Second, in addition to the three categories of wastewater previously mentioned (treated, partially treated, and untreated), statisticians identify a fourth class of wastewater: water not polluted during use and that is released directly into the environment. An example is cooling water. Actually, such water often is contaminated in the process, due to equipment malfunctions, although it is not considered as such.[71] Third, figures for the output of tainted effluent do not include those for drainage systems for collecting storm runoff. In urban areas, storm runoff contains significant amounts of contaminants, such as petroleum products that accumulate on roads; in most cases, water from urban storm drains is not treated before being released or percolating down to the water table. Likewise, soil contamination, for example, in and around industrial sites can reach the water table. Fourth, illegal discharges as a result of accidents and malfunctions in treatment equipment are not included in the statistics.

Finally, officials are under great pressure to underreport. Sergei Pomogaev, co-chair of Delta, a St. Petersburg environmental group, described the situation in his city thus: When firms are hooked up to the city sewer authority, Vodokanal, they often underreport their emissions to avoid paying excessive fees. Vodokanal officials, on the other hand, often lack the resources to audit polluters, yet are faced with extra treatment burdens for which they are ultimately responsible. Moreover, Vodokanal relies on fees to cover half of its budget. Both sides strike a deal: Industries agree to report a certain volume of emissions for which they pay a fee, and Vodokanal and its officials are assured a steady income. "It's the greatest mafia ring'' in town, Pomogaev concludes.[72]

Agriculture, by virtue of its nature and scale, has presented an equally great if not greater pollution threat than that from industry or urban utilities. Agricultural runoff, which totaled an estimated 40 billion cubic meters in 1990,[73] often contains significant quantities of pesticides and fertilizers. Another problem has been poor storage facilities for agrochemicals that allow their contents to leach into the water table. The agricultural component of water pollution in Ukraine reportedly amounted to 45–48 percent in the 1980s.[74] One geographer estimated that 10–20 percent of the contaminants entering Lake Ladoga came from the region's agricultural operations, most notably 210 livestock farms located along major tributaries of the lake.[75] The extensive cutting of trees for timber denuded the land of cover in many regions, reducing the capacity of the soil to hold water and making it more susceptible to erosion. Irrigation exacerbated the leaching process, yet less than 2 percent of irrigation water was reclaimed to reduce surface water contamination.[76] The result has been the washing of a significant proportion of the topsoil down rivers and into lakes and coastal waters. Along with topsoil, erosion washes pesticides, fertilizers, salts, and organic matter, such as manure, which contains nitrites. One-third of the pesticides and fertilizers used leaches into the soil and water table; in the Russian Federation the rate of loss averages 40 percent, and in the central *chernozem* region and Tatarstan losses are as high as 50 percent.[77] In Ukraine alone, about 2.75 million tons of nitrogenous compounds, phosphates, and calcium enter the republic's waterways every year.[78]

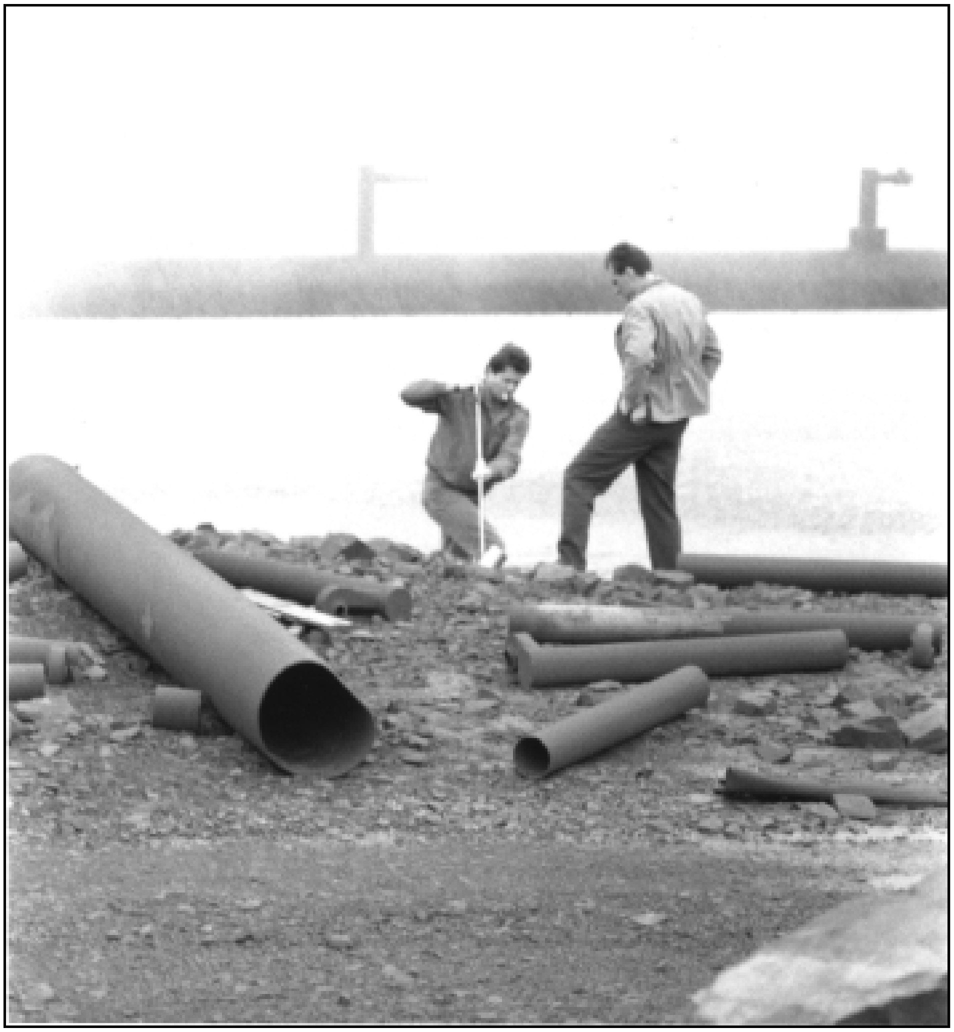
Although comprehensive data have not been published on the subject, groundwater contamination has become a major threat in many areas. As of the beginning of 1990, the USSR Ministry of Geology had discovered over 750 incidences of groundwater contamination across the Soviet Union, almost half of which had occurred as a result of toxics leaching into the soil from industrial waste stored on enterprise grounds. Serious cases of groundwater contamination have been discovered around the Ukrainian industrial cities of Krivoi Rog, Lisichansk, and northern Crimea as well as in the vicinity of Russia's Magnitogorsk.[79] The Astrakhan gas condensation complex, located in the vulnerable Volga delta, discharges effluent in such a polluted state that it must be diverted into huge evaporation ponds. The contaminants, nevertheless, have found their way into the ground. As a result, use of the land and water within a 25-kilometer radius of the plant has been prohibited.[80]

Thermal pollution from nuclear power plants also has had a serious effect on water resources. In 1989, *Sovetskaya Rossiya* published an article painting a dismal portrait of two lakes near the Tver (Kalinin) nuclear power station, located northwest of Moscow. Water from the lakes is used to cool the plant's two reactors; since the inauguration of the second generating block in 1986, the ambient temperature of the lakes has risen several degrees, thus killing off much of the native flora and fauna and altering the local climate. In winter, the lakes no longer freeze over, instead enveloping the surrounding region in a blanket of fog. In the words of the newspaper, the lakes are facing imminent catastrophe: If the situation is not reversed, they will become "lifeless, dirty, stinking puddles with deadly consequences for nature, people, and incidentally Kalinin nuclear power station itself." In 1988, the high temperature of the incoming water for cooling forced a reduction in the plant's energy output. To make matters worse, two more generating blocks are under construction.[81] Similar problems have been reported at Lake Druksiai, which serves the Ignalina nuclear power station in Lithuania.[82]

WATER QUALITY

Water quality standards were established for about 2,500 different substances in the Soviet Union[83] and, like those regarding air quality, were strict.[84] Strict standards did not ensure compliance, however. As one scientist, K. S. Losev, commented, they should not have remained "just a scientific achievement" but should have been translated into guidelines, regulations, and laws that provided for the attainment of these standards.[85] Instead, the setting of strict standards largely was an academic exercise; that industrial ministries and other powerful authorities permitted such standards to be set at all attested to the fact that there was little intention to enforce them.

The Soviet government did not begin systematic monitoring of water quality until 1975.[86] The conclusion from the testing of thousands of locations was that there remained few bodies of water not seriously tainted by economic development. Table 3.6 illustrates that few major river systems complied with basic water quality criteria. The data in the table are presented for rough comparison only, as these figures are annual averages and specific locations are not provided. For many rivers, conditions are likely to be much worse downstream from industrial and urban development. According to expert assessment, the most seriously polluted rivers were the Dniester, Danube, Don, and West Bug; also heavily polluted were the Volga, Kuban, Pechora, Yenisei, Lena, lower Amur, the rivers of Sakhalin Island, and rivers and lakes of the Kola Peninsula.[87] Common pollutants such as petroleum products, phenols, nitrogen compounds, heavy metals, organic substances, and sulfates in many waterways often exceeded the maximum by a factor of 10 and sometimes by a factor of 100.[88] In Estonia, 40 percent of lakes were declared to be in "unsatisfactory condition."[89]



Officials in Norilsk check a factory’s cooling system for signs of contamination. Photo: DJ Peterson.

Industrial wastes pour into the Ob from its headwaters on the Mongolian border from the mining and industrial regions of eastern Kazakhstan and the Kuznetsk Basin, the industrial centers of Chelyabinsk and Yekaterinburg, and the oil- and gas-producing region of Tyumen. In the winter of 1989–1990, vast sections of the Ob failed for the first time to freeze over: “Even Siberian frosts cannot freeze the hundreds of millions of cubic liters of polluted water annually discharged into the river," the Novosti Press Agency observed.[90]

TABLE 3.6 Mean annual concentration of pollutants for selected major rivers, 1990 (milligrams / liter)

River	*Biological Oxygen Demand*[a]	*Oil and Petroleum Products*	*Phenols*	*Surfactants*
Amu Darya	1.18	0.09	0.005	0.05
Amur	2.20	0.01	0.003	0.03
Angara	1.45	0.14	0.001	na[b]
Danube	3.13[c]	0.41	0.005	na
Daugava	2.16	0.06	0.003	0.03
Dnieper	3.11	0.04	0.003	na
Dniester	3.04	0.11	0.001	0.02
Don[d]	3.55	0.11	0.002	0.04
Irtysh	2.52	0.51	0.006	na
Kama	2.07	0.10	0.004	0.02[e]
Kuban	2.36	0.31	0.001	0.01
Lena	2.07	0.08	0.002	0.02
Neva[c]	1.90	0.09	0.000	0.00
Ob	2.93	0.54	0.006	0.01
Oka[c]	3.30	0.20	0.000	0.40
North Donets	4.01	0.23	0.006	na
North Dvina	2.46	0.03	0.000	0.01
Selenga[d]	1.47	0.09	0.000	na
South Bug	6.31	0.02	0.000	0.01
Syr Darya	1.75	0.04	0.002	0.02
Tobol	2.84	0.38	na	0.03
Tom	2.36	0.46	0.004	na
Ural	2.58	0.08	0.001[e]	na
Volga	2.24	0.21	0.002	0.04
West Bug	7.01	0.07[c]	0.003	0.08
Yenisei	na	0.41	0.005	na
Soviet Standard	3.00	0.05	0.001	0.1

[a] Biological Oxygen Demand is a measure of the quantity of suspended or dissolved organic matter.

[b] Not available.

[c] 1987.

[d] 1989.

[e] 1985.

Source: USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov* (Moscow: Informtsentr Goskomstata SSSR, 1991), pp. 102–103, 106.

As shown in Table 3.4, over 11 billion cubic meters of raw or partially treated municipal and industrial wastes were discharged into the Volga River in 1990—almost one third of all such documented wastes released into the environment in the Soviet Union.[91] Over 90 percent of the wastewater discharged into the Volga from Saratov oblast, Kalmykia, and Tatarstan did not meet government standards in the late 1980s.[92] As a result, ambient concentrations of phenols and petroleum products exceeded permitted norms by 8 to 9 times, and nitrogen and copper compounds were 3 to 4 times above norm. In the lower reaches of the river, the concentration of copper rose to as much as 15 times permitted limits.[93] The impoundment of the Volga by the extensive network of dams exacerbated problems by slowing down the river's flow and increasing the retention time of pollutants by between 8 and 10 times.[94] Fertilizers collected by the dams promoted algal blooms, which, combined with accumulation of silt, have choked the reservoirs.

Half of all coastal regions monitored by the Soviet government were classified as "polluted, very polluted, or extremely polluted." Included are the Azov, Caspian, and Black seas. Major pollutants include phenols, detergents, and heavy metals. High concentrations of petroleum products (primarily from offshore oil and gas extraction and shipping) were registered virtually everywhere: In the Baltic and White seas, concentrations were an average of 1.5–2.0 times the maximum permissible concentration; in sections of the Sea of Okhotsk, they reached 6 times the maximum. An estimate by UNESCO, the United Nations scientific branch, pegged the Baltic as the world's dirtiest sea; the Baltic's largest sources of pollution are the rivers feeding the Gulf of Riga. Jurmala, located on the southern coast of the gulf, once was one of the region's premier resorts, but beaches there have been closed repeatedly because of high levels of fecal coliform bacteria and other pollutants. Overworked sewage systems in resort and industrial regions on the Black Sea coast have forced medical authorities to ban swimming at beaches there too. In the waters around Yalta, the concentration of detergents doubled in the period from 1987 to 1988 and reached levels twice the sanitary norm. The bacteria count at beaches on the northeastern shores of the Black Sea often exceeded norms by a factor of up to 200.[95]

Ninety percent of the Black Sea has been declared dead. Every year, 7,600 tons of copper, 900 tons of petroleum products, 600 tons of lead, and 200 tons of detergents (to name just a few pollutants) flow into the Black Sea from municipal sewage systems alone. Extensive industrial development (particularly of ferrous metallurgy and chemicals) along the tributaries of the Black Sea and on its periphery are one problem. The

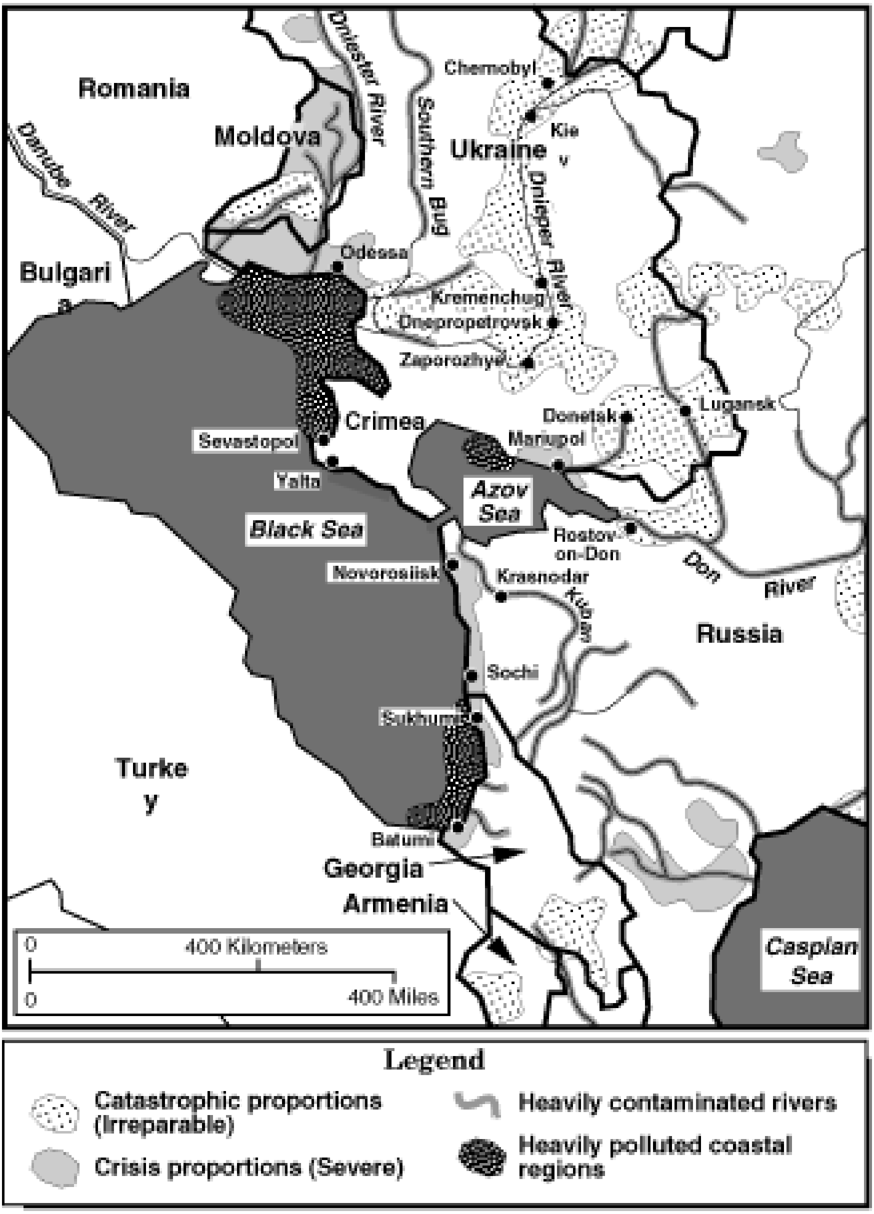
Dnieper, for instance, passes through the Ukrainian industrial heartland—cities like Kremenchug, Dnepropetrovsk, and Zaporozhye—picking up contaminants before emptying into the Black Sea east of Odessa, another major industrial center (see Map 3.1). These sources, combined with extensive naval operations, make the area in and around Odessa the most polluted part of the Black Sea. In 1988, concentrations of phenols were more than 30 times greater than the permitted sanitary norms, and levels of detergents were as much as 52 times the norm.[96] The Black Sea also suffers from severe pollution in the vicinities of Russia's Krasnodar region, which includes the port of Novorossiisk and the resort of Sochi, and of the Georgian industrial port cities of Batumi and Sukhumi.

The principal threat to sea life, however, is a stratum of dissolved hydrogen sulfide welling up from the sea bottom—an anoxic environment in which sea life cannot survive. Since 1935, the rate of ascent of the upper limits of the hydrogen sulfide layer has increased from 3 centimeters to 2 meters per year. Though the presence of hydrogen sulfide is a natural result of the currents present in the Black Sea and the fact that the basin is almost totally landlocked, the increase in hydrogen sulfide has been accelerated by the large volume of organic materials dumped into the Black Sea. Every year, 5,000 tons of nitrogen and phosphorous compounds are released into its basin from municipal sewage systems; in estuarine zones, agricultural runoff has caused the concentration of these compounds to surge to 30 to 50 times their levels in the 1960s.[97]

In a sense, the sea has been fertilized by the untreated sewage and agricultural runoff. The sewage provides ample bacteria, which multiply rapidly in the fertile waters during the long warm summers, depleting the dissolved oxygen. Concomitantly, the enriched waters promote algal blooms. When the algae die, they sink to the bottom, where they decompose slowly, thereby producing more hydrogen sulfide. Experts predict that at the present rate, the upper limit of the anoxic layer, now at a depth of 80 meters, will reach the surface in forty years. Others give the Black Sea just ten to fifteen more years of life.[98]

THE IMPACT ON FISHERIES

One simple measure of the effect of the discharge of effluent, damming, and desiccation of waterways is the state of the region's fisheries. Vladimir Luk'yanenko reports that in the period 1965–1980, 1,348 large-scale fish kills occurred in the Caspian Sea as a result of pollution incidents. During the 1980s, the number of such fish kills increased dramatically, totaling almost 500 in 1986–1987 alone. Between 1948 and 1983



Source: Institute of Geography, Russian Academy of Sciences.

Map 3.1. Environmental Degradation in the Black Sea Region, Late 1980s.

the annual fish catch from inland lakes and rivers decreased from 1 million tons to just 200,000 tons.[99] Before the initiation in the 1930s of the "Great Volga" scheme to develop the river's resources, fishers harvested over 600,000 tons of commercial fish every year; by the 1980s, the catch had been reduced to about one-tenth its previous size. Operation of hydroelectric power stations on the Volga reduced the annual catch in the Volga-Caspian watershed by 41,000 tons.[100] The varieties of fish being caught have also changed over time: Before World War II, sturgeon, perch, salmon, and other prime fish constituted 80 percent of the catch; by the end of the 1980s, 80 percent of the catch was made up of fish of low commercial value.[101]

Reports indicate that many of the fish caught are not fit for consumption. After the widespread appearance of disease among the population of sturgeon in the Volga and Caspian, the government commissioned a two-year study in 1988, which revealed not only disease in the muscles, kidneys, and reproductive organs of the fish but concentrations of pesticides sometimes exceeding maximum permissible levels by 2 to 5 times. Heavy metals, such as cadmium, nickel, mercury, lead, and copper, were also found at levels "far exceeding the maximum permissible concentrations for food products."[102]

The region's fish stocks are threatened not just by environmental factors but also by the aggressive policies of the fishing industry. In the late 1980s, the Soviet fish catch averaged over 11 million tons annually—a rate second only to Japan and achieved at the cost of overfishing.[103] Even where water pollution has not been a serious problem, fish stocks have plummeted. Between 3 and 4 million tons of fish per year were caught in the Barents Sea; of this, the Soviet Union took 1.0–1.5 million tons. By 1988, the Soviet Union's catch was a mere 250,000 tons, indicating that the sea was "on the verge of ruin" in the words of one geographer.[104] Whereas six- and seven-year-old cod were the largest age cohort caught in the years immediately after World War II, the greatest numbers of fish caught were three and four years old by the 1970s. By that time, cod over fifteen years of age had practically disappeared. According to USSR Goskompriroda chair Vorontsov, the Ministry of the Fish Industry persisted in its overfishing practices by blaming the catastrophic decline of fish stocks on pollution.[105]

The government attempted to reverse the trend of declining catches by restocking threatened species. In 1988, for example, over 1 billion fry (mostly salmon) were released into the wild. Their survival rate, not surprisingly, was low, given the impact of environmental degradation.[106]

TO DRINK OR NOT TO DRINK THE WATER?

In July 1989, the citizens of Bryansk were warned to boil water before drinking it; after a heavy rainstorm, the city's water had become contaminated with "harmful substances" that could not be removed effectively.[107] One of the causes of the contamination was the dumping of waste by local farms and enterprises, which had turned the Desna River into "a gutter." No explanation of how the contaminants had found their way into the water supply was offered in the media. In January 1990, bottlenecks in the rail transport system delayed the shipment of antibacterial agents necessary for the treatment of water for public supply destined for Tallinn, Riga, and St. Petersburg. In Tallinn, stocks had dwindled to that sufficient for two days, and residents faced the possibility of having to boil drinking water.[108] The protozoan parasite *Giardia,* which causes severe gastrointestinal distress, is endemic to the tap water of St. Petersburg and other major cities. Drinking water drawn from the Volga and its tributaries in Ryazan, Tver (formerly Kalinin), and Volgograd oblasts failed to meet public health standards even after treatment, the weekly journal *Glasnost'* reported in 1990.[109]

Such anecdotes attest to the fact that despite the high level of urbanization and industrialization achieved in the Soviet regime, the government ultimately could not ensure its citizens a reliably safe supply of drinking water. In the advanced industrial countries, water utilities have been able to spend significant resources on procuring clean water supplies while relying on new technologies to counter increasing water pollution. Constrained resources, government priorities, and limited technology precluded these options in the Soviet Union. As a result, environmental degradation and deterioration of drinking water are closely related. Most cities, like Bryansk, draw their drinking water from rivers and lakes subject to pollution: "There are already numerous unavoidable instances where [communities] are forced to use river water, the level of chemical and biological contamination of which resembles wastewater," wrote researchers in a 1991 article in the *Bulletin of the USSR Academy of Sciences.*[110] Then they must treat it as best they can. As a result of these problems and the publicity surrounding them, almost three-quarters of the population surveyed in late 1990 expressed concern about the quality of their drinking water.[111]

In 1988, the Soviet government conducted almost 4.5 million tests of the public water supply. According to official data, over one-tenth of the samples tested for bacteria content did not meet government health standards; in the republics of Azerbaijan, Turkmenistan, and Tajikistan, the failure rate was more than 20 percent.[112] The USSR Academy of Sciences reported that almost one-half of Soviet cities equipped with running water surveyed failed government tests for bacteria content, adding that high bacteria levels were responsible for the USSR's high rates of enteric illness and hepatitis.[113]

Of water samples tested for their chemical content, 18.4 percent nationwide failed to meet standards (see Table 3.7). Latvia had the worst record—one-third of all samples failed. Not far behind were Belarus, Turkmenistan, Azerbaijan, and Uzbekistan.[114] Health officials in Tatarstan have reported that of samples drawn from the water supply, 27 percent did not meet biological standards, and 31 percent failed tests for chemical indicators.[115]

Moscow enjoyed the reputation of having the best-quality drinking water in the former Soviet Union, but in the late 1980s, persistent rumors suggested otherwise. A series of reports in the media investigating these rumors and their potential implications for public health only served to increase people's apprehension further.[116] When asked about the quality of Moscow's drinking water sources, an oblast official responded: "There is nothing to be happy about." Despite the designation of sanitary buffers, many of the city's reservoirs were subject to considerable pollution from the surrounding territory, particularly livestock farms.[117]

TABLE 3.7 Reported noncompliance with drinking water standards in municipal water supply systems by republic, 1988 (percentages)

	Chemical Indicators	*Bacteriological Indicators*
USSR average	18.4	11.3
Armenia	5.3	10.9
Azerbaijan	31.4	21.8
Belarus	29.5	9.0
Estonia	12.2	13.6
Georgia	7.9	14.7
Kazakhstan	12.7	7.4
Kyrgyzstan	3.7	14.1
Latvia	33.4	8.1
Lithuania	22.3	5.1
Moldova	14.5	8.6
Russia	20.5	11.7
Tajikistan	21.5	21.7
Turkmenistan	27.5	23.4
Ukraine	13.1	9.9
Uzbekistan	25.9	14.7

Source: USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov v SSSR* (Moscow: Finansy i statistika, 1989), p. 36.

In autumn 1989, the weekly *Nedelya* featured an article about Moscow's tap water with "To Drink or Not to Drink?" as the provocative title. It contended that Moscow's drinking water fell within the norms for public health, but noted that the city did not test for many toxic substances such as cadmium, chromium, and nickel.[118] Responding to the concern and denying any cover-up, Valerii Saikin, then mayor, announced at a meeting of the city council: "There are no secrets. The water in Moscow conforms with government standards." A *Pravda* reporter inquired into the matter and found the reality was quite different: The mayor was being truthful, admitted Aleksandr Lopatin, an official at the city's public health department, "not because there is no secrecy, but because there is nothing about which to be secretive. There is no data." Lopatin tersely explained why: "There is no equipment, no procedures, no reagents, [and] of course no hard currency with which all of this could be purchased abroad.''[119]

The plight of the Bashkirian capital of Ufa provides a clear—if extreme—example of the pollution threatening the public. In April 1990, over half of the city's 1.1 million residents were forced to go without running water for a fortnight because the municipal water system became contaminated with phenol. Rapidly melting snow from the previous month had brought with it this highly toxic compound, which had accumulated in the soil surrounding a petrochemical plant located at the edge of the city. The phenol leached into the soil initially as the result of "gross violations of production discipline" by plant personnel, according to a government commission that investigated the accident.[120] The phenol made its way into the Belaya River and then downstream to where the city's water is drawn off. At the height of the crisis, the concentration of phenol in the city's drinking water exceeded sanitary norms by 500,000 times.[121] On August 23, a new unit producing phenol acetone at the Ufa alcohol works exploded and sent out a plume of burning toxic gases, which necessitated the hospitalization of 110 people. According to TASS, "a blend of various chemical mixtures was washed by the foam of dozens of fire engines from the territory of the plant into the river Ufimka." Again, the water supply of two-thirds of the city's residents was shut off.[122] The following February, *Komsomol'skaya pravda* reported that the city was in a state of shock: Water samples tested during the phenol crisis the previous spring had revealed that "frightening quantities" of dioxins had been discovered in drinking water several days after the government had announced that the city's water supply was safe.[123]

The data presented here pertain only to the public water supply. Aside from the question of accuracy, evidence suggests that the problem of contaminated drinking water is far worse than officially reported.[124]

According to USSR Goskomstat, 15 percent of small towns and cities in the Soviet Union did not have running water at all in 1988[125] and therefore were subject to the uncertain quality of local ground- and surface-water supplies. Five million rural inhabitants of Uzbekistan did not have running water at the close of the 1980s, a problem so serious that the republic's president, Islom Karimov, signed a special decree in July 1990 ordering that the capacity of municipal water systems installed be quadrupled.[126] In many regions of Turkmenistan, such as Tashauz oblast along the lower reaches of the Amu Darya, up to 90 percent of inhabitants are forced to drink water from irrigation canals and ditches that often carry pesticide- and fertilizer-laden runoff.[127] In Tashauz, the bacteria count in the drinking water exceeded health standards by a factor of 10 times, reports revealed in 1990. Further, 70 percent of the population was reportedly ill, and the infant mortality rate had soared past 1 in every 10 live births, as the people were forced to drink the poisoned water.[128]

As the water supply in the former Soviet Union has become more contaminated with industrial, municipal, and agricultural pollution, it also has become more difficult and costly to purify. Unlike the United States, the Soviet government never expended significant resources to counter the rising impact of environmental degradation on drinking water supplies by building more sophisticated purification systems or by piping water from distant, albeit more pristine, sources. Now, the financial resources to effect an improvement have become even scarcer as the Soviet successor states slash public investment and confront the rigors of economic reform and upheaval. The disruption of traditional supply lines as a result of economic collapse and rising barriers to trade has further impaired the functioning of the region's shaky wastewater and drinking water treatment facilities. Unlike the sharp decrease in atmospheric emissions registered as a result of the economic downturn in 1991, the rate of water pollution remained unchanged.[129] In 1991, the Russian government reported substantially higher rates of dysentery and intestinal illnesses; in Siberia's Tom River basin, health officials reported sharp increases in gastroenteritis, hepatitis A, and bacterial dysentery as a result of maintenance problems in water purification systems.[130]

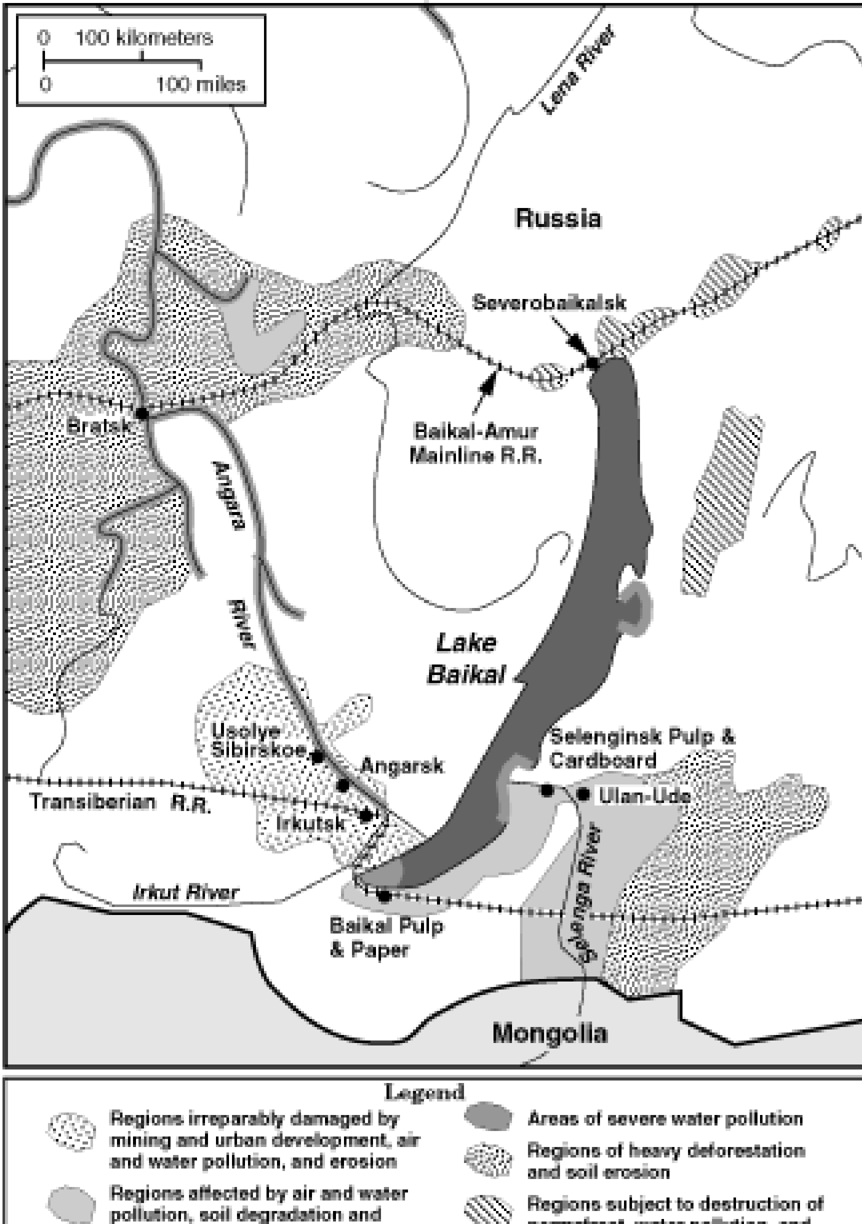
THE CASE OF LAKE BAIKAL

Unlike elsewhere, citizens of Irkutsk like to point out that it is still possible to drink the water from Lake Baikal directly, even though the lake has been threatened by industrial and agricultural development for over thirty years. Though Baikal now competes for attention with the catastrophes at Chernobyl and the Aral Sea, the damage to Baikal has been quite minimal in comparison. Nevertheless, its cultural and scientific value makes whatever damage the lake has sustained quite alarming and painful. Indeed, the fate of Baikal epitomizes the struggle to combat water pollution elsewhere.

Lake Baikal covers 31,500 square kilometers, making it larger than Belgium or the state of Maryland. It is fed by 336 rivers (the Selenga River flowing out of Mongolia provides over one-half of the inflow) covering a watershed area of 600,000 square kilometers, equivalent to the size of France or Ukraine. Baikal is the deepest continental body of water in the world (1,620 meters), making it the world's largest fresh-water lake. The lake is so large, in fact, that it accounts for about 80 percent of the reserve of surface fresh water in the former Soviet Union, or 20 percent of the entire world's reserve. Formed 25 million years ago, Lake Baikal is also the oldest fresh-water lake in the world. As a result of these conditions, more than two-thirds of the 2,400 different plants and animals living in the lake are found nowhere else in the world.

Baikal (see Map 3.2) is threatened by three types of pollution: industrial and municipal emissions, agricultural runoff, and airborne pollution. First, and most directly, it is affected by direct dumping of wastes from industrial plants and urban sewerage systems. There are three principal sources of direct water pollution in Baikal: the Baikal Pulp and Paper Combine (Russia's largest paper plant), the city of Ulan-Ude (located upstream from the lake on the Selenga River), and the Selenginsk Pulp and Cardboard Combine. In 1988, they were responsible for 40 percent, 30 percent, and 6 percent, respectively, of the polluted wastewater dumped into the Baikal basin.[131] Because of problems with the sewage system in Ulan-Ude, the city dumps almost 500 tons of nitrates into the water—70 percent of all nitrates entering the basin.[132] Baikal Pulp and Paper, the largest single polluter, emitted 32 million cubic meters of wastewater directly into Baikal in 1987.[133] The water near the plant registers above-norm levels of sulfates, chlorides, and suspended particles, and a 20-square-kilometer tract of lake bottom has been fouled.[134] In addition to these polluters, there are 100 smaller enterprises and settlements located around the lake that have no wastewater treatment capacity at all.[135] As a result, Baikal is threatened by large quantities of phenols, petroleum-based substances, detergents, suspended particulates, and other substances.

Second, the lake is affected by erosion and runoff from surrounding lands that have been denuded by agriculture, logging operations, and a high rate of tree loss due to illness. One researcher estimated that 60–70 percent of all pollution of Lake Baikal comes from agricultural sources;



Source: Institute of Geography, Russian Academy of Sciences.

Map 3.2. Environmental Degradation in Lake Baikal Region, Late 1980s

there are almost 700 agricultural and forestry enterprises located in the Baikal Basin.[136] In the post-World War II era, the Soviet government facilitated the rapid exploitation of the region's agricultural and forest resources with the expansion of traffic along the Trans-Siberian Railway to the south of Lake Baikal, and construction of the Baikal-Amur Mainline Railroad to the north. Although farmers in the vicinity of Lake Baikal heeded the laws of nature in the past with respect to their crops and livestock, the demands of central planners under Soviet rule changed farming practices in the region. As a result, the soil has tended to become compacted and prone to erosion because of overgrazing and the cultivation of pastureland.

Finally, Baikal has been threatened by large amounts of airborne pollutants passing over the lake. Although one does not usually associate air pollution with the eastern Siberia region, Lake Baikal suffers it acutely. Industrial plants situated along the Angara River to the west of Baikal churn out aluminum, wood and paper products, and chemicals. Cities such as Irkutsk, Angarsk, Usolye-Sibirskoe, Shelekhov, and Bratsk suffer high concentrations of formaldehyde, benzopyrene, nitrogen oxides, and particulates as well as other pollutants and ranked on the Soviet government's league table of cities with the worst air pollution in 1989. Industries in Angarsk, one of which is a large chemical plant relocated from Germany in the 1940s as part of war reparations, discharged over 430,000 tons of harmful airborne pollutants in 1988—38 percent more than industries in the city of Moscow.[137] These pollutants are then blown over the lake and its watershed by the prevailing winds. The interaction of these air- and waterborne forces has multiplied the negative effect on the region's ecosystem, which the forces of nature then concentrate on the lake.

In recognition of the lake's cultural and scientific significance, four joint Communist Party / government resolutions were passed between 1969 and 1987 to clean up and to protect Baikal.[138] The first three proved to be little more than statements of good intentions by the leadership, but the last was hailed by many environmentalists as a significant step forward. In the resolution, the government mandated the development of a long-range integrated plan for the development and protection of the entire Baikal Basin. It called for 162 projects to clean up the local environment between 1987 and 1995. These included the retooling of Baikal Pulp and Paper into an environmentally safe plant for producing furniture and the transferral of the pulp mill to a new location downstream. In the meantime, immediate measures were ordered to clean up the factory's wastes. The resolution also created a series of water protection zones in the regions adjacent to the lake that provided strict limits on, and in some areas prohibition of, development. Finally, a commission was appointed to oversee implementation of the resolution.

There have been some encouraging signs. In 1987, the Gusinoozerskii regional power plant located upstream on the Selenga River inaugurated a recirculating cooling system, which contributed in large measure to a 60 percent reduction in the total amount of wastewater being emitted into the Baikal Basin.[139] In 1988, production of pulp at Baikal Pulp and Paper was scaled back slightly, and the heavily polluting yeast operation was shut down, leading to a 17 percent decrease in the total volume of wastes emitted into the lake. As a result, biological indicators in the lake near the plant showed an improvement. Measures taken to rework the transport system in the region include a ban on the transport of timber by floating rafts and a reduction in shipping by 30 percent. Commercial logging operations in the vicinity immediately around the lake have been banned since 1988, and the number of forest fires in the region has been reduced.[140]

Nevertheless, other developments have shown that the environmentalists' successes have turned out to be Pyrrhic victories. The total volume of wastewater (most of which already met sanitary norms) being dumped into the Baikal Basin decreased and the volume of wastes being properly treated increased in the late 1980s, but the volume of untreated waste increased rapidly (see Table 3.8). Furthermore, although the concentration of pollutants in the immediate vicinity around Baikal Pulp and Paper fell, the levels of suspended particles, petroleum-based substances, and nitrogen compounds increased in other areas of the lake.[141] One of the most ominous signals that the lake was in trouble was the mass death of 6,000–7,000 of the lake's unique fresh-water seals in 1987

TABLE 3.8 Volume of improperly treated and untreated wastewater released in Lake Baikal watershed (millions of cubic meters)

	Improperly Treated	*Untreated*
1985	124	0
1986	66	0
1987[a]	104	3
1988	184	7
1989	183	15
1990	180	12

[a]Some of the increase after 1986 is attributable to a tightening of standards.

Sources: USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov v SSSR* (Moscow: Finansy i statistika, 1989), p. 133; USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov* (Moscow: Informtsentr Goskomstata SSSR, 1991), p. 220.

and 1988 from a mysterious virus.[142]

The retooling and transferral of Baikal Pulp and Paper originally was scheduled to take five years and be completed in 1993. After two years, only 15 million of the total 3 billion rubles allocated to the project had been spent, and workers had managed only to clear the site for the new plant at Ust-Ilimsk, down the Angara River.[143] The plant's management tried to sidestep the decree calling for the plant's closure by undertaking a crash program to build a pipeline that would divert wastewater away from the lake to the Irkut River, which releases into the Angara downstream. Only after strong public resistance was the pipeline abandoned.[144] Nevertheless, by late 1991, environmentalists doubted whether officials would be able to close the paper operation as planned, because the Russian economy faced severe paper shortages and unemployment: "There is a lot of concern that the factory won't close on schedule," said Vera Shlenova, an official of the Russian Society for the Protection of Nature. "After all, people are more worried about bread than about air or water."[145]

Notes

1. *Pravitel'stvennyi vestnik,* No. 24, 1991, p. 10.

2. USSR Goskomstat, *Okhrana okruzhayushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov v SSSR* (Moscow: Finansy i statistika, 1989), p. 63; U.S. Bureau of the Census, *Statistical Abstract of the United States: 1989* (Washington, DC: Government Printing Office, 1989), p. 198. The U.S. figure is for 1985.

3 . USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 62.

4. V. P Kukhar', "Nekotorye aktual'nye ekologicheskie problemy Ukrainskoi SSR," *Vestnik Akademii Nauk SSSR,* No. 11, 1988, p. 110.

5. V. V. Vorob'yev, "Problems of Lake Baikal in the Current Period," *Geografiya i prirodnye resursy,* No. 3, 1988, translated in *Soviet Geography,* No. 1, 1989, p. 40.

6. USSR Goskompriroda, *Sostoyanie prirodnoi sredy v SSSR v 1988 g.* (Moscow: VINITI, 1989), p. 47.

7. U.S. Bureau of the Census, *Statistical Abstract, 1989,* p. 98.

8. B. Babich et al., "Okhrana i ratsional'noe ispol'zovanie vodnykh resursov—krupnaya ekonomicheskaya problema," *Planovoe khozyaistvo,* No. 8, 1980, p. 97.

9. *Pravda,* August 11, 1989, p. 2; USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 66; USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* p. 42.

10. Michael A. Rozengurt, *Water Policy Mismanagement in the Southern USSR: The Ecological and Economical Impact,* report to the National Council for Soviet and East European Studies, November 1989, p. 55.

11. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* pp. 70–71.

12. USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1989 g.,* (Moscow: Finansy i statistika, 1990), p. 456; USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1970 g.* (Moscow: Finansy i statistika, 1971), p. 347.

13. USSR Goskomstat, *Sel'skoe khozyaistvo SSSR* (Moscow: Finansy i statistika, 1988), p. 213; V. Ivashchenko, "Intensifikatsiya zemledeliya—osnovnoi put' realizatsii prodovol'stvennoi programmy," *Planovoe khozyaistvo,* No. 8, 1986, p. 107. The share of agricultural production grown on irrigated land reached a peak in 1985 of 33.3 percent of the total. By 1987, the proportion had dropped to 31.9 percent, equal to the level of the late 1970s.

14. USSR Goskomstat, *Sbornik statisticheskikh materialov, 1989* (Moscow: Finansy i statistika, 1990), p. 142; USSR Goskompriroda, *Sostoyanie . . . v 1988 g.*, p. 145. Another source notes that three-quarters of irrigation channels lack cement linings, leading to a water loss rate of 40 percent. L. Vashchukov, "Uluchshit' sokhrannost' i ispol'zovanie zemel'nykh i vodnykh resursov strany," *Vestnik statistiki,* No. 7, 1988, p. 42.

15. *Zarya Vostoka,* May 4, 1989, p. 2. USSR Goskomstat reported that losses in Georgia averaged a third of supplies. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 108.

16. Grigorii Reznichenko, "I stakana chistoi vody ne pribavilos'," *Novyi mir,* No. 1, 1990, p. 204.

17. Rozengurt, *Water Policy Mismanagement,* pp. 48–49; K. S. Losev, "Sotsial'no-ekonomicheskie i ekologicheskie posledstviya ispol'zovaniya vody: Vozmozhnye puti razvitiya," *Izvestiya Akademii Nauk SSSR: Seriya geograficheskaya,* No. 6, 1988, p. 49.

18. *Izvestiya,* February 7, 1990, p. 3.

19. *Zarya Vostoka,* May 4, 1989, p. 2. A survey reported by USSR Goskomstat revealed that the demand for water-metering devices exceeded supply by 350 percent. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 109.

20. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 109.

21. Vashchukov, "Uluchshit'," p. 43.

22. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 109. The breakdown by republics for saturation irrigation using furrows is as follows: Turkmenistan 100 percent, Uzbekistan 99 percent, Azerbaijan 96 percent, Armenia 91 percent, and Georgia 88 percent. Another USSR Goskomstat source puts the use of furrows for irrigation as follows: Tajikistan 91 percent, Georgia 89 percent, Armenia 83 percent, and Uzbekistan 81 percent. Vashchukov, "Uluchshit'," pp. 43–44.

23. *Izvestiya,* February 7, 1990, p. 3. Rozengurt, writing about Central Asia and Kazakhstan in *Water Policy Mismanagement,* pegs efficiency there at 30–40 percent (p. 48).

24. Rozengurt, *Water Policy Mismanagement,* p. 47. Where the soil is very saline, particularly in regions affected by salt borne in wind off the Aral Sea's bed, farmers attempt to flush the salt out with applications of more water, thereby exacerbating the problem of overwatering. For more on this topic, see Chapter 4.

25. Kukhar', "Nekotorye," p. 109.

26. USSR Goskomstat, *Okhrana okruzhayushchei sredy*, p. 109. Of 656 agricultural enterprises surveyed, 82 percent had established guidelines for irrigation required, and over one-third of enterprises were found to be irrigating in excess of these guidelines.

27. A. N. Kashtanov, "Ekologizatsiya sel'skogo khozyaistva," *Vestnik Akademii Nauk SSSR*, No. 11, 1988, p. 58.

28. USSR Goskompriroda, *Sostoyanie prirodnoi sredy i prirodookhrannaya deyatel'nost' v SSSR v 1989 godu* (Moscow: Institut Molodezhi, 1990), p. 6.

29. Vladimir I. Luk'yanenko, "Vliyanie gidrostroitel'stva na vosproizvodstvo promyslovykh ryb," *Vestnik Akademii Nauk SSSR,* No. 12, 1989, p. 52.

30. Rozengurt, *Water Policy Mismanagement,* p. 10.

31. N. A. Lopatin, "The Development, Effectiveness, and Prospects of Hydroelectric Power," *Energetik,* No. 6, 1990, in JPRS–UEA–90–038, p. 115.

32. Aleksei Yablokov, presentation at conference on Democratic Federalism and Environmental Crisis in the Republics of the Former Soviet Union, Moscow, August 1991.

33. *Kul'tura,* No. 12, 1991, p. 3, translated in JPRS–TEN–92–003, p. 54.

34. USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* p. 58.

35. USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1988 g.* (Moscow Finansy i statistika, 1989), p. 379.

36. D. Ya. Ratkovich, "O probleme vodoobespecheniya strany s uchetom trebovanii po okruzhayushchei sredy," *Vodnye resursy,* No. 5, 1989, p. 7.

37. Luk'yanenko, "Vliyanie gidrostroitel'stva," p. 52.

38. Ibid., pp. 52–53.

39. TASS, April 5, 1990; I*zvestiya,* January 7, 1990, p. 1.

40. Ratkovich, "O probleme," p. 6.

41. I*zvestiya,* February 7, 1990, p. 3.

42. Robert G. Darst, Jr., "Environmentalism in the USSR: The Opposition to the River Diversion Projects," *Soviet Economy,* Vol. 4, No. 3, 1988, pp. 223–252.

43. Kukhar', "Nekotorye," p. 109.

44. USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1988 g.,* p. 445.

45. Lopatin, "Development, Effectiveness and Prospects," p. 115.

46. I*zvestiya,* March 26, 1990, p. 2.

47. USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1988 g.,* p. 252; see also Kukhar', "Nekotorye," p. 107.

48. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* pp. 14, 35.

49. *Pravda,* August 11, 1989, p. 2.

50. L. I. Globa et al., "Kachestvo pit'yevoi vody: proekt, kotoryi predstoit realizovat'," *Vestnik Akademii Nauk SSSR,* No. 4, 1991.

51. *Vestnik statistiki,* No. 6, 1990, p. 43.

52. Toomas Frei, minister of environment, in S*ovetskaya Estoniya,* December 2, 1990, p. 3.

53. Fedor Morgun, "Ekologiya v sisteme planirovaniya," *Planovoe khozyaistvo,* No. 2, 1989, p. 62.

54. USSR Goskompriroda, *Sostoyanie . . . v 1989 godu,* p. 222.

55. *Moskovskaya pravda,* July 5, 1989, p. 2.

56. *Ekologiya i my,* No. 1, 1990, p. 2.
57. *Vestnik statistiki,* No. 11, 1991, p. 64.
58. Radio Riga, cited in Radio Free Europe/Radio Liberty Daily Report, August 9, 1991.
59. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 34.
60. *Vestnik statistiki,* No. 6, 1990, p. 43.
61. *Ekologiya i my,* No. 1, 1990, p. 2.
62. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 30; USSR Goskompriroda, *Sostoyanie . . . v 1989 godu,* p. 99.
63. USSR Goskompriroda, *Sostoyanie . . . v 1989 godu,* p. 99.
64. A. K. Kuchushev and N. M. Matveev, "Sokhranit' zdorov'e zemli," *Vestnik Akademii Nauk SSSR,* No. 3, 1990, p. 34.
65. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 139.
66. B. Babich et al., "Okhrana," p. 99. See also Vladimir Luk'yanenko, "O general'noi kontseptsii okhrany vodoemov ot zagryaznenii," *Vestnik Akademii Nauk SSSR,* No. 12, 1989. For comparison, the process efficiency of a conventional activated-sludge process system in the United States rates at between 85 and 95 percent efficiency in treating organic matter. Metcalf and Eddy, Inc., *Wastewater Engineering: Treatment, Disposal, Reuse* (New York: McGraw-Hill, 1979), p. 484.
67. USSR Goskomstat, *Press-vypusk,* No. 79, February 23, 1990.
68. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 9.
69. *Izvestiya,* July 15, 1989, p. 6, and February 9, 1990, p. 2; *Ekho planety,* No. 31, 1989, p. 18; and *Trud,* March 1, 1990, p. 1.
70. *Pravda Ukrainy,* January 18, 1990, p. 2.
71. Boris N. Laskorin and Vladimir I. Luk'yanenko, "O kachestve vody Volgo-Kaspiiskogo basseina," *Vestnik Akademii Nauk SSSR,* No. 10, 1990, pp. 17–18.
72. Sergei Pomogaev, personal communication, St. Petersburg, June 1991.
73. *Vestnik statistiki,* No. 11, 1991, p. 64.
74. V. Tregobchuk, "Economics and the Environment," *Pod znamenem Leninizma,* No. 4, 1990, translated in JPRS-UPA-90-019, p. 79.
75. M. G. Sofer, "O vode zhivoi i mertvoi," *Energiya: Ekonomika, tekhnika, ekologiya,* No. 7, 1988, pp. 35–36; *Trud,* July 30, 1989, p. 3.
76. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 75.
77. Losev, "Sotsial'no-ekonomicheskie," p. 46; Kashtanov, "Ekologizatsiya," p. 57. According to research by USSR Goskompriroda, 200,000 tons of pesticides leach into waterways annually in Russia. Sergei Bobylev, professor of economics, Moscow State University, "APK: Ekologizatsiya ili krizis?" unpublished manuscript, 1991, p. 10.
78. N. N. Prikhod'ko, "Osnovnye napravleniya okhrany malykh rek Ukrainskoi SSR ot zaileniya i zagrazneniya agrokhimikatami," *Vodnye resursy,* No. 2, 1989, p. 147.
79. *Vestnik statistiki,* No. 11, 1990, p. 64.
80. Rozengurt, *Water Policy Mismanagement,* p. 43.
81. *Sovetskaya Rossiya,* July 14, 1989, p. 4.
82. Kaunas Economics Institute, "Urgent Ecological Problems in Lithuania," briefing submitted to the Lithuanian Council of Ministers, November 1988.

83. Losev, "Sotsial'no-ekonomicheskie," p. 48. The number of compounds for which norms have been established grew rapidly: from 13 in 1940 to 70 in 1960 and to 500 in 1980.

84. Although existing pollution standards are generally adequate for guaranteeing human health, they may not be strict enough to protect other wildlife. USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* p. 163.

85. Losev, "Sotsial'no-ekonomicheskie," p. 48.

86. M. I. Biritskii et al., "O pervichnom uchete ispol'zovaniya vod," *Vodnye resursy,* No. 4, 1989, p. 173. Responsibility for monitoring was split between three agencies at the all-Union level: the USSR State Committee for Hydrometeorology (surface waters such as lakes, reservoirs, and rivers), the USSR Ministry of Geology (underground water reserves), and the USSR Ministry of Water Resources Construction (water use and effluent discharge).

87. USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* p. 48; Bobylev, "APK," p. 9.

88. Bobylev, "APK," p. 9; USSR Goskompriroda, *Sostoyanie . . . v 1989 godu,* p. 39.

89. K. K. Rebane, "Severo-vostok Estonii: Bolevaya tochka sostoyaniya okruzhayushchei sredy," *Izvestiya Akademii Nauk SSSR,* No. 11, 1988, p. 155.

90. Novosti Press Agency, April 2, 1990.

91. USSR Goskomstat, *Press-vypusk,* No. 226, June 7, 1990. When agricultural runoff (particularly from the rice fields of the southern Volga region) is added, the total rises to 20 cubic kilometers, or almost half of all wastewater produced in the former Soviet Union. B. N. Profir'yev, "Ekonomicheskie i organizatsonnogo-upravlencheskie problemmy ekologicheskoi politiki v SSSR," *Izvestiya Akademii Nauk SSSR, Seriya ekonomicheskaya,* No. 3, 1990, p. 22.

92. "Ekologicheskaya obstanovka v respublike,"*Kommunist Tatarii,* no author, No. 3, 1990, p. 54.

93. USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* p. 48. See also Vladimir M. Kotlyakov et al., "O degradatsii vodnykh i zemel'nykh resursov na Russkoi ravnine," *Vestnik Akademii Nauk SSSR,* No. 12, 1989.

94. Rozengurt, *Water Policy Mismanagement,* p. 42.

95. USSR Goskompriroda, *Sostoyanie . . . v 1988 g.,* pp. 39–40, 51–52, 121.

96. Ibid., pp. 120–121.

97. Ibid., p. 121; *Izvestiya,* November 27, 1990, p. 3.

98. *Trud,* October 6, 1989, p. 4.

99. Luk'yanenko, "O general'noi kontseptsii," pp. 77–78.

100. Luk'yanenko, "Vliyanie gidrostroitel'stva," pp. 52, 57.

101. Kuchushev and Matveev, "Sokhranit' zdorov'e zemli," p. 35.

102. Vladimir I. Luk'yanenko, "A Toxicological Crisis in the Bodies of Water," *Rybnoe khozyaistvo,* No. 6, 1990, translated in JPRS-TEN-90-011, p. 55. See also Laskorin and Luk'yanenko, "O kachestve vody."

103. *Izvestiya,* November 13, 1990, p. 7.

104. Gennadii G. Matishov, "More na grani opustosheniya," *Priroda,* No. 3, 1990, p. 30.

105. Mikhail Dubrovskii, "Zashchita Vorontsova," *Poisk,* No. 28, 1989, p. 4.

106. Kuchushev and Matveev, "Sokhranit' zdorov'e zemli," p. 35.

107. *Sotsialisticheskaya industriya,* July 11, 1989, p. 4.

108. Helsinki Radio, January 9, 1990, translated in FBIS–SOV–90–007, p. 89.

109. *Glasnost',* cited by Novosti Press Agency, October 22, 1990.

110. L. I. Globa et al., *Vestnik Akademii Nauk SSSR,* No. 4, 1991, pp. 35, 37.

111. *Vestnik statistiki,* No. 11, 1991, p. 61.

112. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 36.

113. Yu. A. Rakhmanin, Academy of Medical Sciences Institute of General and Municipal Hygiene, cited in Globa et al., *Vestnik Akademii Nauk SSSR,* p. 36. The difference in reporting may be because water supplies in the major cities, which tend to have better treatment facilities, are likely to be tested more often.

114. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 36.

115. "Ekologicheskaya obstanovka v respublike," pp. 54–55.

116. See, for example, *Sovetskaya Rossiya,* May 24, 1989, p. 2; *Trud,* November 30, 1989, p. 2; and *Rabochaya tribuna,* July 27, 1990, p. 3.

117. Boris P. Namestnikov, prosecutor, Moscow oblast, cited in *Moskovskaya pravda,* August 8, 1991, p. 2.

118. *Nedelya,* No. 42, 1989, p. 5.

119. *Pravda,* May 13, 1990, p. 2.

120. *Izvestiya,* April 30, 1990, p. 2.

121. TASS, March 30, 1990.

122. Radio Moscow, August 23, 1990; TASS, August 24, 1990. Both reports are translated in FBIS-SOV-90-165, p. 88.

123. *Komsomol'skaya pravda,* February 21, 1991, p. 2.

124. On this point, the weekly *Glasnost'* issued a pessimistic assessment in December 1990 alleging that as much as two-thirds of the water supply in Russia did not meet health standards. *Glasnost',* cited by Novosti Press Agency, October 22, 1990.

125. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 14.

126. Radio Moscow, July 30, 1990.

127. *Turkmenskaya iskra,* April 27, 1990, p. 2.

128. *Izvestiya,* November 19, 1990, p. 1; *Meditsinskaya gazeta,* May 23, 1990. According to the latter newspaper, over 70 percent of the tests of the water in the city of Khiva near Urgench on the lower Amu Darya failed health standards for chemical content alone.

129. *Ekonomika i zhizn',* No. 6, 1992, p. 13.

130. US Centers for Disease Control, "Public Health Assessment—Russian Federation, 1992," *Morbidity and Mortality Weekly Report,* February 14, 1992, pp. 1–2.

131. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* p. 133.

132. *Vestnik statistiki,* No. 8, 1989, p. 57.

133. USSR Goskomstat, *Narodnoe khozyaistvo SSSR v 1987 g.* (Moscow: Finansy i statistika, 1988), pp. 574–575.

134. USSR Goskompriroda, *Sostoyanie . . . 1988 g.,* p. 126.

135. *Izvestiya,* May 4, 1989, p. 2.

136. Ibid.

137. USSR Goskomstat, *Okhrana okruzhayushchei sredy,* pp. 22–23.

138. The four resolutions were dated January 21, 1969; June 16, 1971; July 21, 1977; and April 13, 1987.

139. USSR Goskomstat, *Narodnoe khozyaiastvo SSSR v 1987 g.,* p. 574. It should be pointed out that although the new system, on paper, greatly reduced the volume of effluent labeled "wastewater" being dumped into Baikal, the discharges were relatively clean to begin with, and therefore this change did not contribute to a significant lowering of the level of pollutants entering the Baikal basin.

140. *Vestnik statistiki,* No. 8, 1989, p. 57.

141. Ibid., p. 56.

142. *Nash Baikal,* No. 3, 1990.

143. *Izvestiya,* May 4, 1989, p. 2. An environmental impact study indicated that the development of another large industrial complex in Ust-Ilimsk would further aggravate already serious environmental problems there.

144. *Literaturnaya gazeta,* No. 1, 1988.

145. *Los Angeles Times,* October 27, 1991, p. A5.