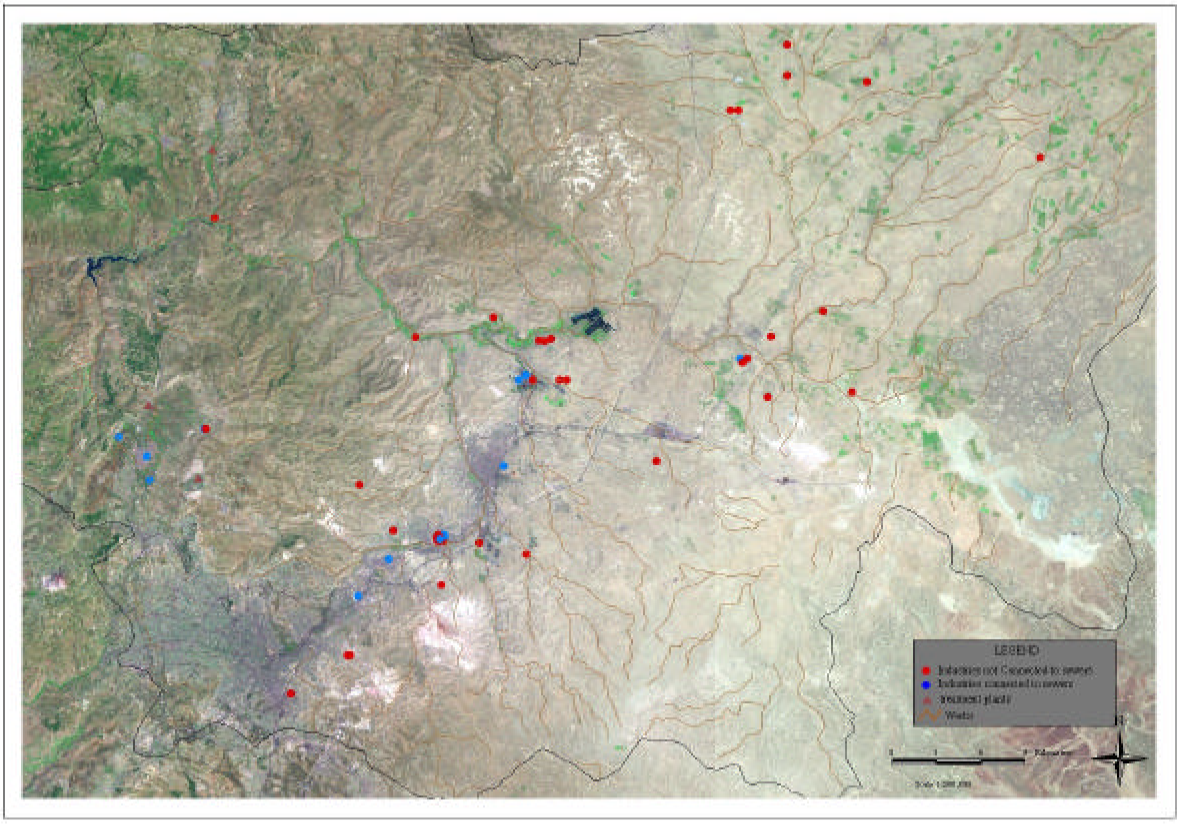
MINISTRY OF WATER AND IRRIGATION
Water Resource Policy Support



Dischargers in the Amman-Zarqa Basin (partial listing)

Controlling Harmful Discharges in the Amman-Zarqa Basin

WATER REUSE COMPONENT

JUNE 2001

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Executive Summary

This report summarizes results of two related Work Plan Activities: control of harmful industrial discharges (Activity 4.3), and the accompanying industrial wastewater discharge regulations (Activity 4.6). These activities target protecting the reuse potential of reclaimed water in the Amman-Zarqa basin. Existing discharges and regulations were investigated, and approaches for improving the regulations are proposed.

Effects, successes and shortcomings of existing industrial discharge regulations were discussed with staff at WAJ labs and the MWI. These regulations are Jordanian Standard (JS) 202/1991, addressing discharges to surface waters (and groundwater recharge and irrigation); and the regulation controlling discharges to municipal systems. In general, WAJ and MWI staff consider the regulations to have achieved successes. For example, enforcement has taken place -- some industrial dischargers were closed about a year and a half ago, and a number of pretreatment facilities have been upgraded. However, some facilities in need of upgrading cannot afford to do so. The overall level of industrialization is considered low, and there appears to be more concern about future industrial discharges than existing ones.

Other issues were noted during discussions with government staff. Use of industrial discharges for irrigation was mentioned as being of concern due to potential contamination of surface and ground waters with compounds not listed in the regulations. Illegal dumping of hazardous liquids (including aqueous discharges, pretreatment sludges and other hazardous wastes) was also cited as a potential problem for both surface waters and wastewater treatment facilities. Wastewaters from slaughterhouses, food, and dairy operations that are discharged to the municipal sewerage system were noted as often violating discharge standards; however it is understood that these discharges can (and should) be accounted for in design planning for the new As Samra reclamation plant.

A committee consisting of WAJ laboratory staff and others are currently reviewing the discharge regulations and preparing recommendations for modifications. Regulations in other regions (such as those of US EPA) are being used for comparisons. These considerations appear to be focusing mainly on modifying some of the numerical values listed in the regulations.

WAJ laboratories are beginning to focus on industrial wastewater discharges. Staffing and equipment shortages were noted during discussions. However, Royal Scientific Society laboratories do some of the analyses. In additon, recommendations below include considering some degree of self-monitoring and reporting on the part of industry. It will be helpful for planning to include examining roles and responsibilities among the various entities, to minimize cost while maximizing effectiveness of enforcement efforts.

Available data indicate that the reuse potential of reclaimed water is probably not at present being negatively impacted by industrial or commercial discharges. However, the present regulatory framework does not appear to be fully adequate for assessing and preventing problems that could be caused by compounds such as

toxic organics. In order to fully evaluate the effects of industrial discharges, the relevant standards should include, in addition to the existing parameters, some organic toxic compounds. Some compounds (and classes of compounds) of potential concern are on the EPA priority pollutants list and lists of compounds inhibitory to biological treatment (see Appendix C).

A number of recommendations are made for strengthening regulatory approaches. These approaches would not have to be done all at once; many can be made applicable to new dischargers and phased in as needed for existing industries. One main focus of the recommendations is on detailed evaluations and regulation based on the characteristics of each discharge.

Developing water quality standards for receiving bodies (such as Wadi Zarqa and the King Tallal Reservoir) can have a number of benefits. Water quality standards are developed from water quality criteria and other considerations, including designated uses and antidegradation approaches. In addition to water quality criteria, other useful information for setting water quality standards includes baseline data, lists of priority pollutants (see Appendix C), and information on known discharges. These standards could initially be set up as non-binding guidelines outside of legal frameworks. Water quality standards are among the data used for setting discharge limits, and for assessing environmental impacts of existing and proposed discharges to surface waters.

Jordanian Standard 202/1991 (Appendix A) has both general requirements and lists of discharge limits. The requirements that there should not be "negative effects" are excellent goals. However, such statements usually are not usually very effective because they are non-specific and difficult to prove. Protecting surface waters, particularly with future growth and industrialization, can be better assured by incorporating industry-specific aspects into regulations.

Surface discharge regulations can be strengthened by requiring written approval for discharging (as is the case for discharges to municipal wastewater systems). It is suggested that this approval be in the form of a permit written for each facility. Discharge limits and monitoring requirements would be set by considering water quality standards in the receiving stream(s), the specific industrial processes in use, wastewater characteristics, and pollution control technologies appropriate for those processes. (Still, it is useful to have discharge limits for commonly encountered constituents such as pH extremes, for example.) Permit applications would also include submitting for approval plans and specifications for pollution control facilities, along with providing a full chemical inventory, mass flow diagrams, and spill control procedures. Various guidance documents exist for helping with evaluating this information and for setting discharge limits. Note that the regulations can include statements regarding safeguarding proprietary information, to avoid hesitancy on the part of dischargers who might argue that processes in use are trade secrets.

Other recommendations for regulating surface discharges include, at the discretion of the permitting authority, requiring sampling sites and flow meters, and performing flow-proportional composite sampling. For many industries, self-monitoring and reporting can be considered as a regulatory option (with appropriate checks by regulators). Industries could hire out the laboratory work, saving government funds.

Project activity included reviewing reports of the Water Quality Improvement and Conservation Project (WQIC) and other studies to identify industrial sewer connection that could negatively impact on the reuse potential of reclaimed water. (The US EPA categorical pretreatment standards are also useful for assessing industrial discharges and pretreatment requirements -- see, for example, http://www4.law.cornell.edu/cfr, -> Title 40 -> Chapter 1 -> Subchapter N.) A list of these connections was drawn up based on flow rates and possible presence of harmful constituents.

Heavy metals and other constituents passing through the current As Samra system do not appear to have significant impact on reuse approaches under consideration. However, as noted by Shiekh (2000), dissolved solids and sodium levels are on the verge on creating a small decrease in yield of some crops. Other compounds of potential concern and which might pass through the treatment plant can be detected as part of the pretreatment program, as discussed below.

Chloride levels and possible presence of unknown compounds of concern could be potentially inhibitory to nitrification facilities. If nitrification is being considered for As Samra, then a more detailed literature review and further sampling and testing of plant influent (to include flow proportional composite sampling) should be conducted. If this detailed examination indicates the possibility of inhibition, then it will be prudent to consider developing as a component of process design a bench-scale treatability testing program at As Samra.

Facilities using or manufacturing toxic chemicals that are discharged, or could be spilled or otherwise reach the wastewater collection system, are of potential concern. Resulting problems include possible poisoning or inhibition of biological treatment systems, pass-through of harmful constituents, or interference with beneficial reuse of sludges. Effects of compounds on biological treatment applies to connected industries and to those that discharge into holding tanks for removal by tankers trucks. If illegal dumping is occurring, either to municipal wastewater systems or to wadis, there could be negative impacts on water reuse in the basin. Interference with beneficial reuse of sludge solids may not be problematic if non-food crops such as cotton or flax are grown. Such sludge uses should be explored in a Sludge Management Plan. As a result, it is prudent not to allow industries to connect to the sewer system without having a pretreatment plant at the industry site. The type of pretreatment plant and its size should be approved by the regulatory authority. A guideline document could be prepared for each type of industry explaining the type of treatment (most applicable or best available technology) suitable for such an industry. Industries that can show that their wastewater is of no potential threat to the wastewater treatment plant or to the potential reuse of wastewater can be exempted from having a pretreatment plant

In order to control the disposal of industrial wastewater that are hauled by tanker trucks, industries with access to the sewer system should be required to connect. This will prevent the illegal dumping of such wastewater through tanks in the wadis and sewer system without treatment. In case the industry is far away from the sewer system, the regulations governing the disposal of industrial wastewater to wadis, which should include the complete treatment of their wastewater.

Recommendations for strengthening the wastewater discharge regulation are similar to those for discharges to surface waters. The application process in the regulation is an excellent component, and could be developed into a permitting program. Thus, a permit would be set up for each discharger, renewable at specified time intervals or when discharge conditions change. As for discharges of wastes to surface waters, it is useful to have standards for commonly encountered constituents. However, especially for large, new, or industries using or producing toxic chemicals (including toxic organics), it is important to examine and specify requirements for individual dischargers. The US EPA's categorical pretreatment list and accompanying standards (see Appendix E), and the priority pollutants list (see Appendix C) are useful information sources for incorporating these aspects into pretreatment regulations.

Other suggestions for strengthening the municipal discharge regulation include setting up a pretreatment program with a small staff. These staff would coordinate sampling, testing, permit-writing, and enforcement. One goal of a pretreatment program is to work with industrial dischargers to help them come into compliance. Enforcement should be exercised where there are real problems and where there is no cooperation on the part of an industry.

Pretreatment regulation will benefit from requiring, at the regulators' discretion, the owner to install a sampling point outside the property; and a discharge flow meter. Sampling point and flow meter construction details can be specified in the municipal code. As for surface discharges, chemical inventories, industrial waste survey information, and plans and specifications for pollution control facilities should be submitted for approval. Portable, battery operated sampling equipment that can be installed in manholes and take 24-hour composite samples will be helpful for monitoring industrial dischargers.

Dissolved solids and heavy metals discharges were investigated. Current levels of TDS are on the verge of affecting agricultural reuse options. Available field data on TDS and heavy metals do not indicate problems for the wastewater treatment system. However, some discharges used for irrigation may be of concern in terms of ground water and surface water impacts. A more complete data set should be obtained, including a thorough evaluation of on-site industrial practices and waste discharges, with composite sampling and testing to characterize the discharges.

The chief sources of dissolved solids in wastewater are the potable water supplies. Many well sources have very high TDS levels. Further, potable water treatment, such as at the Zai Water Plant, can add significantly to dissolved solids levels. A new 45 MCM/yr reverse osmosis system serving Amman will reduce average TDS levels because reject from this system will be sent to the Dead Sea. Ion exchange brines can add to dissolved solids and sodium levels particularly when excess regenerant solutions are discharged.

A number of approaches can be considered for reducing TDS levels. It may be necessary to restrict some discharges of high TDS wastes, requiring evaporation ponds, for example. Discharges of reverse osmosis reject, cooling tower blowdown, and ion exchange regenerant wastewater, to wastewater collection systems may have to be prohibited. Ion exchange resins that use hydrogen ions instead of heavy metal cations merit investigation. Alternate chemical treatment approaches for potable water treatment at the Zai Water Plant should be studied, such as changing heavy metal cation compounds and replacing some coagulant with polyelectrolyte. Effects of these approaches can be examined by developing a mass balance on dissolved solids inputs, outputs, and sinks in the basin.

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I. INTRODUCTION

This report summarizes results of two related Work Plan Activities: control of harmful industrial discharges (Activity 4.3), and the accompanying wastewater (industrial) discharge regulations (Activity 4.6). Water reuse options in the Amman-Zarqa basin are being examined in detail, motivated in part by new water reclamation facilities under development. It is important to examine discharges that could interfere with reuse options, and to ensure that interference does not occur. As a component of these planning efforts, this report targets improving understanding and control of harmful discharges to surface waters and to municipal wastewater systems in the basin.

Regulations addressing harmful discharges have been in place in Jordan for some time. These regulations are Jordanian Standard 202/1991 (reproduced in Appendix A) governing industrial discharges to surface waters, and "Instructions for Commercial and Industrial Wastewater" (Appendix B) regulating discharges to municipal systems. Some aspects of these regulations are under review by a committee that includes staff from WAJ labs. Effects, successes, and needs for improving the regulations were discussed with WAJ and MWI staff. Recommendations for improving current regulatory approaches are included in this report.

Available information was examined on industrial discharges that could affect reclaimed water quality. Possible negative impacts include toxic effects on secondary treatment planned at As Samra. The existing level of industrial discharges is viewed by many as having little or no impact. However, as growth continues it will be important to ensure the effectiveness of approaches for preventing discharges (including accidental spills) of harmful constituents into municipal treatment systems and surface waters.

Discharges of total dissolved solids (TDS) and heavy metals are of concern because of potential negative impacts on agriculture and other reuse applications. Sources of TDS and heavy metals were investigated as a component of this project activity, and approaches are suggested for reducing their concentrations in wastewater.

At the start of this activity, discussions were held with staff at the WAJ labs and later at MWI regarding discharge regulations and their effectiveness. These discussions are summarized in the next section.

II. DISCUSSION OF EXISTING DISCHARGE REGULATIONS WITH MWI & WAJ STAFF

Effects, successes and shortcomings of industrial and commercial discharge regulations were discussed with concerned persons at WAJ labs and at the MWI. These regulations are Jordanian Standard 202/1991 governing industrial discharges to surface waters (reproduced in Appendix A), and "Instructions for Commercial and Industrial Wastewater," regulating discharges to municipal systems (Appendix B).

These discussions, summarized below, provide perspective on existing regulatory approaches and needs.

In general, these regulations are considered to have achieved successes. For example, there are reported to be 50% fewer violations of standards this year than last. While significant improvements have been made to some pretreatment facilities, it was noted that others do not work well due to financial constraints. It has been considered useful to have a consistent framework for monitoring and this approach is viewed as having prevented or reduced problematic discharges. Successes noted include the recent closure of a number of industrial dischargers violating the standards.

WAJ laboratories have been focusing for the most part on potable water issues, and are now turning greater attention to industrial discharges. They monitor and test about 200 factories, conducting monthly visits. Testing frequencies vary and some are considered to be too frequent, given current laboratory resources. Findings are summarized in reports at six-month intervals. Certain laboratory capabilities, such as testing for phenolic compounds and mercury are lacking, and a shortage of personnel and laboratory equipment to do this work was noted. However, the Royal Scientific Society laboratories do some of the testing.

The present level of industrialization is considered to be low, such that if discharge problems exist, they are relatively small in scale. As Samra influent and Wadi Zarqa data on-hand bear out this conclusion. However, because industrial development is growing, there is a need perceived on the part of WAJ and MWI staff for strengthening the regulations and accompanying harmful discharge control approaches to prevent environmental degradation, and to protect wastewater treatment facilities.

Use of industrial discharges for irrigation purposes (see Appendix A) was also mentioned as a concern. It was noted that such use may be appropriate under specific circumstances, but that irrigation with industrial wastewater, even following treatment, should be evaluated on a site-specific basis. Site specific considerations include potential for contamination of ground water and surface waters due to infiltration and runoff.

Other issues were noted during discussions. These issues include discharges of reject from reverse osmosis treatment systems producing potable water, and improper discharge (to sewers and wadis) of industrial wastewater and pretreatment sludges removed from industrial facilities by tanker trucks. Certain of these improper discharges may be toxic wastes. In addition, it was noted that while phenolic compounds are included in discharge regulations, other organic compounds that could be harmful are not mentioned.

One MWI staff member initially expressed the view that no industrial wastes, other than high B.O.D. food wastes (including dairy and beverage), should be allowed in municipal systems. This view was based on the potential for pass-through of harmful chemicals during water reclamation. However, during subsequent discussion of industry-specific regulatory approaches, such as the categorical pretreatment standards noted below, the MWI staff member indicated that perhaps such approaches would alleviate these concerns.

Wastewater from the Amman Municipality Slaughterhouse was noted as having a high COD and as a result is considered in violation of regulations. However, the discharge regulation permits paying a surcharge for COD values over 1500 mg/L. It was noted that such discharges should not be a problem once the new plant goes on line, because it should be designed to handle these wastes.

Build-up of chemical compounds in sludges is not generally considered to be a problem because there are at present no plans for reuse of biosolids. Lack of water that would accompany land application is sometimes cited as one reason for lack of interest in biosolids utilization, along with a bias against contact with such materials. However, some government statements do indicate that beneficial reuse should be practiced.

Due in part to concerns over industrial growth, a committee has been established to consider changes to the discharge regulations. This committee is using as a component of the review process regulations in place in other countries. It appears that present thinking is focusing mainly on modifying numerical values of a few discharge limits.

Discharges to surface waters are both direct and indirect. Direct discharges are readily recognized. Indirect discharges can result from land application of wastewaters (referred to in some summaries and regulations as “gardening” or “irrigation”), which can result in wastes reaching wadis by overland or subsurface flow. Assessing the surface discharge regulations includes taking account of surface water quality, as discussed in the next section.

III. JORDANIAN STANDARDS (JS) 202/1991

Jordanian Standard (JS) 202/1991 is reproduced in Appendix A. This regulation includes both general requirements and numerical discharge limits for industrial discharges to “rivers, wadis, and catchment areas,” industrial “reuse” for irrigation, artificial recharge, and discharge to the sea. JS 202/1991 was developed by the Department for Standards and Metrology in conjunction with governmental and other groups listed at the end of Appendix A.

One component of setting surface discharge limits is establishing water quality standards for receiving water bodies, such as Wadi Zarqa and the King Talal Reservoir. This approach includes acquiring baseline data on contaminants and pollution indicators, and setting up monitoring schemes to track effects of regulatory programs. Water quality criteria and other aspects of setting water quality standards for water bodies are discussed in the next section.

Water Quality Criteria and Standards

Water quality criteria represent the knowledge base about effects of constituents in water, such as the concentration at which a particular chemical affects a species or interferes with a designated use. For example, one often-cited criterion is that 4 mg/L is the minimum level of dissolved oxygen for survival of most fish species. Panels of experts have been assembled at different times to establish water quality criteria, published by bodies such as the World Health Organization.

Water quality criteria differ from water quality standards. However, criteria are one aspect of setting water quality standards for water bodies (or sections of water bodies, such as stream segments). For example, based on the dissolved oxygen criterion for fish, a dissolved oxygen level of 5 mg/L could be decided as the minimum allowable concentration, incorporating a 1 mg/L margin of safety into the standard-setting process. Standards are levels of quantifiable parameters used for regulatory purposes.

Other components of setting water quality standards include establishing the designated use(s) of the water, concentrations of constituents of concern, or levels of degradation that are deemed unacceptable. For example, it may be decided that a water body should meet certain standards for irrigation, for public contact, or other uses. Contaminant levels may be below the chosen water quality standards. When this is the case, it is not an opportunity to allow contaminant levels to rise -- anti-degradation requirements can be applied. Contaminant levels may also be greater than the water quality standards. In this case, plans can be made for addressing the problem, including setting discharge limits accordingly. Water quality standards, if not being met in a water body, become goals targeted by discharge limits and other mechanisms.

Note that in many countries (including the US), water quality standards are not being met in many water bodies. However, as noted above, water quality standards are useful targets, of great benefit in helping prevent environmental degradation. For example, a set of water quality standards, even if in the form of guidelines, are useful for preparing or evaluating environmental impact assessments of various projects.

Guidelines can also be useful under some circumstances. Guidelines are established by various bodies, from international organizations to local working groups. They basically are recommendations, representing the judgment or opinion of one or more experts and can be numerical or operational, or both. Guidelines can be helpful for setting water quality standards as well as discharge limits, but should be so applied with careful attention as to their applicability and the circumstances leading to their formulation. It may be useful initially in Jordan to set water quality standards as guidelines that are not binding or otherwise included in a legal framework. Then, as experienced is gained, water quality standards can be developed.

Discharge limits are measurable parameters used for regulatory purposes. They are set by considering a number of factors, including knowledge of water quality standards and results expected from applying pollution control technology to the discharge being examined. Discharge limits and approaches to setting them should be reviewed periodically as a component of examining whether water quality goals are being met. Setting discharge limits for individual dischargers can be a very useful, cost saving component of a regulatory program as discussed in the next section.

Recommendations for Regulations Governing Discharges to Surface Waters

JS 202/1991 has both general requirements and lists of discharge limits for various receiving bodies or reuse options. Recommended approaches for improving this regulation are discussed in this section.

The general requirements in JS 202/1991 that there shall be no "negative effects" and that discharges "shall not violate environmental balance in the affected area" are excellent goals. However, in practice such statements are not usually very effective because they are not specific and difficult to prove. t is more effective to set effluent limits based on knowledge of specific constituents and their potential for harm.

JS 202/1991 will benefit from an approach similar to one used for regulating wastewater discharges to municipal sewerage systems in Jordan: requiring written approval. In other words, industries should be prevented from discharging to the wadis, unless they have written approval (as is the case for discharges to municipal wastewater systems). It is suggested that this approval be in the form of a separate permit for each industrial facility. A permitting approach need not be a complex task. For example, permits could be required for new dischargers and phased in for existing ones. Permit applications and approval mechanisms can help ensure that industrial discharges and growth do not result in environmental degradation. Components of a permitting program include:

- Setting discharge limits based on the specific industrial processes involved, wastewater characteristics, and water quality standards (or guidelines) for the receiving water bodies. This approach includes considering pollution control technologies appropriate for the industrial processes, chemical feed-stocks and products. Wastewater characteristics of concern include flow rates and fluctuations, and accompanying chemical mass flow rates.

  Nevertheless, it is important to have in effect appropriate non-industry specific discharge limits such as the types of lists in Table 1 of JS 202/1991 (Appendix A). These listings may be modified in view of water quality standards discussed above, and other industry-specific considerations. Toxic chemicals other than the metals and (some) phenolics in JS 202/1991 should also be considered -- the US EPA Priority Pollutants list (see Appendix C) provides a useful perspective on many toxic compounds requiring scrutiny in discharges (and in water bodies). These listings are then used for establishing the parameters and limits (and monitoring frequencies) stated in an industry's permit. The list of monitored parameters should only include those organics that are expected to be present in the effluent of those industries present in the Amman Zarqa Basin. To reduce cost, the regulatory body could make the industries responsible for testing and reporting, and the regulatory body role would then become a verifying role.

A wide body of literature for most industries exists for helping with this standard-setting process. Nevertheless, permit applications should require very detailed and complete information.

- Requiring submittal for approval full design plans and specifications for pollution control facilities. Other information submitted for approval should include a full chemical inventory, process mass flow diagrams (in the form of a chemical waste survey), and spill control procedures. Regulations can include statements regarding safeguarding proprietary information, to avoid hesitancy on the part of dischargers who could argue that their processes are trade secrets. The timing specified in the regulation should be sufficient to allow these evaluations, feedback and approvals. This approval process can be made part of industrial licensing procedures, and should enhance industrial recruiting by increasing levels of interaction among all parties.

- Particularly for existing discharges, allowing the permit writer (and the authority signing the permit), to write time-lines into a permit, with dates for achieving specified milestones in developing treatment facilities and/or improving discharge quality. All permits should require renewal at specified frequencies (such as every five years) and when changes in processes and/or waste characteristics occur.

- Requirements that other regulations be followed, such as those addressing disposal of waste treatment sludges and hazardous wastes.

- Allowing the permit writer (and the authority signing the permit) to require monitoring and testing frequencies as considered necessary. (The regulation should still state minimum requirements, however.) The monitoring and testing requirements would be stated for each constituent of concern, depending upon factors such as chemicals in use and/or produced, the specific industrial and treatment processes, compliance history, and any other relevant factors. In addition, the regulation should state that, if considered necessary, sampling sites (with specified characteristics) be provided by the discharger.

  Monitoring requirements stated in JS 202/1991 appear to be far too frequent except in the case of serious violators. In practice, however, WAJ labs sample and test at more reasonable frequencies.

  Monitoring requirements and sampling locations should be stated in the permits. It may be important, for example, to require installation of up-gradient and down-gradient monitoring wells for checking whether harmful compounds from land application practices contaminate ground water supplies. Also, installation of flow meters, and flow-proportional compositing of samples should be required at the discretion of the permitting authority.

For many industries (especially new ones) it may be feasible for self-monitoring and reporting requirements to be a regulatory option (with appropriate sampling and testing checks by government laboratories). Industries could hire out the laboratory work directly; this approach could be a significant cost savings for government.

It is reported that WAJ labs are acquiring new space for analytical equipment to devote to monitoring tasks, and may be in need of additional analytical instrumentation. However, attention should be paid to preventing duplication of effort; instrumentation in place and being applied to water quality monitoring tasks, such as at the RSS labs and other existing or planned laboratories, should be taken into account. Recommendations above regarding dischargers doing at least some self-monitoring and reporting may also cut the workload.

The "reuse" aspects of JS 202/1991 for irrigation do not appear to be appropriate. Such land application approaches (with or without treatment) require site-specific and industry-specific evaluations to assess the potential for possible harmful effects. Some of these assessment approaches are outlined above; however, overland and subsurface transport of contaminants should receive detailed attention where harmful constituents are present.

Industrial (and commercial) wastewaters are also discharged to municipal wastewater collection and treatment systems. Protecting reuse options requires attention to preventing toxic discharges or spills, and comprehensive examination of dischargers, as discussed in the next section.

IV. IMPACTS OF INDUSTRIAL DICHARGES ON THE REUSE POTENTIAL OF RECLAIMED WATER

Irrigation is the chief focus of current water reuse planning in the Amman-Zarqa basin. In addition, industrial and municipal reuse approaches are being examined. As a component of the planning process, it is important to consider existing discharges that could negatively impact water reuse. Potential impacts of industrial and commercial discharges to municipal systems in the Amman-Zarqa basin are reviewed in this section.

Three effects usually are cited when considering possible problems caused by industrial discharges to municipal treatment systems. These effects are pass-through of harmful constituents, toxicity to secondary biomass, and accumulation of harmful constituents in sludges. Other problems such as wastes blocking collection systems or flammable materials are also of concern. The primary concerns with respect to water reuse are pass-through of constituents interfering with intended water reuse and toxic effects on microbial activity within treatment systems.

Sludges are not of direct concern in terms of water reclamation. However, effects of industrial discharges on sludge treatment, utilization, and disposal will be important aspects of a Sludge Management Plan, including possible beneficial reuse of biosolids. For example, suspended growth treatment systems such as activated sludge concentrate heavy metals in the biomass, part of which must be periodically removed as waste sludge. It will be important to consider such factors in requirements for both industrial discharges and for sludge utilization. Nevertheless, non-food crops such as cotton and flax can be grown on soils amended with biosolids containing heavy metals.

Influent and effluent heavy metals data for the current As Samra waste stabilization ponds indicate that heavy metals removal is occurring. For example, the data show copper removals varying from 30 to 90%, and zinc from zero to about 90%. The new treatment facilities at As Samra are likely to remove metals to as great or a greater extent than at present, concentrating metals in sludge wasted from the system. Such metals removals are incidental and are not designed into activated sludge unit operations. Nevertheless, so long as metals concentrations are below levels inhibitory to biological treatment, such removals will occur.

Examination of available discharge and Wadi Zarqa water quality data indicates that levels of heavy metals and other constituents passing through the current As Samra system do not have significant impact on reuse approaches under consideration. However, as noted by Shiekh (2000), dissolved solids and sodium levels are on the verge of creating a small decrease in yield of some crops. (Means for addressing TDS and sodium levels are discussed in a later section.) Other compounds of potential concern and which might pass through the treatment plant can be detected as part of the pretreatment program, as discussed below.

Toxic effects on biological treatment systems vary from inhibition of biological action to fully poisoning the biomass. Biomass (for example, activated sludge) poisoning is a catastrophic event, resulting from spills or dumping of slug doses of toxic compounds into wastewater systems. The result is elimination of secondary and following treatment steps including disinfection and filtration. One goal of a pretreatment program is to prevent such events.

Information on inhibition to activated sludge and nitrification systems is cited in the pretreatment Manual of Practice (WEF, 1994), sections of which are reproduced in Appendix C. Microorganisms can acclimate to some inhibitory compounds if concentrations are not too high. Acclimation depends on site specific conditions such as other waste constituents, and dominant and changing microbiological populations in the biomass. It is important that an industrial pretreatment program target these and other chemicals of concern, to prevent plant upsets.

To meet effluent ammonia limits, the new facilities at As Samra are likely to include nitrification. Nitrification can be inhibited by relatively low concentrations of some compounds (see Appendix C), and chloride ion at 180 mg/L is noted in one citation listed in Appendix C as inhibitory to nitrification. Chloride levels in As Samra influent are in the range of 300 - 400 mg/L. In addition, unknown constituents of concern could be present in the As Samra influent. Thus, it will be prudent to further examine chloride and the possibility of other potentially inhibitory constituents if nitrification facilities are being considered for the new As Samra reclamation plant. More detailed literature review and further sampling and testing of plant influent (to include flow proportional composite sampling and analysis of a broad range of constituents) are called for. If such detailed examinations suggest the possibility of inhibition, then it will be prudent to develop a bench-scale treatability testing program at As Samra.

Project activity included reviewing reports of the Water Quality Improvement and Conservation Project (WQIC) and other studies to identify industrial discharges likely to have impact on the reuse potential of reclaimed water. A listing of connected factories is shown in Appendix D.

Dischargers of high levels of oxygen consuming wastes, such as food, diary, slaughterhouses, and beverage facilities should not be of concern as long as reclamation facilities designs take into account these wastes, including their variability. Factors that must be taken into account include fluctuations (seasonal and diurnal) in flow and B.O.D., nitrogen and suspended solids. There may be need at some of these facilities for removing grease and other materials that could block collection system piping; however, such industries are not expected to discharge toxic or other constituents that could interfere with water reuse.

Facilities using or manufacturing toxic chemicals that are discharged, or could be spilled or otherwise reach the wastewater collection system, are of potential concern for water reuse. This concern applies both to industries listed in Appendix D, and to industries that are not connected that discharge into holding tanks for removal by tanker trucks. In some cases, the tanker trucks are permitted to discharge their contents to the municipal wastewater system. In other cases, they are not. However, it has been suggested that illegal dumping of prohibited wastes and pretreatment sludges may take place. If these practices are occurring, it will be important to step up enforcement mechanisms, including developing a chemical inventory system, for helping prevent discharges of compounds that could be toxic to the wastewater treatment system or otherwise interfere with water reuse.

The US EPA has a number of classifications useful for considering impacts of industrial dischargers to municipal systems. One of these is the Significant Industrial User designation, applied to industrial contributors that discharge 95 m^3/d (25,000 gpd) or more, are on the categorical pretreatment list (see Appendixes C and E) or which have been cited for repeat violations. A number of the facilities listed in Appendix D are classifiable as Significant Industrial Users on a volumetric basis and/or as a result of their being on the categorical pretreatment list. [In such cases, US EPA requires that the facilities file a report twice a year, detailing discharge monitoring results required by the facilities' discharge permits. Other specific requirements for categorical pretreatment contributors are listed in the EPA regulations (see, for example, http://www4.law.cornell.edu/cfr, -> Title 40 -> Chapter 1 -> Subchapter N).]

Based on the considerations listed above and on reviewing available information (including WQIC reports and Harza, 1997), a list of contributors likely to have the largest impact on the reuse potential of reclaimed water from As Samra was developed. This list is shown in Table 1.

Table 1. Preliminary List of Industrial Contributors Likely to Have the Largest Impact on the Reuse Potential of Reclaimed Water from As Samra

Facility
Amman Municipality Slaughterhouse
Jordan Tanning Co.
Hussein Thermal Power Station
Jordan Dairy Co., Ltd.
Jordan Worsted Mills
Eagle Distilleries Co.
Jordan Ice & Aerated Water Co.
ICA Company, Ltd.
Jordan Beer Co., Ltd
Arab Co. for Medicines
Clothes Factory
Arabic Chemical Detergent
Hikma Pharmaceuticals
Universal Modern Industries
Al_Issia Industrial and Trading
Ata Ali Factory
Raslan el-Ksih & Sons Co.
Middle East for Medicinal Industry

As discussed above, the food industries listed in Table 1 (including diary) are mainly of concern in terms of design and operation of new treatment facilities. These contributors nevertheless must be monitored (and/or do self-monitoring) to check on whether the waste strength remains at present levels.

The Table 1 list should be updated by pretreatment staff based on the categorical pretreatment standards listing (Appendix C and E), and examination of characteristics of each discharge as discussed above. For example, dischargers with toxic or inhibitory chemicals on-site which are discharged or which could be spilled into the wastewater collection system should be added to the list. Compounds that could also result in degradation of water quality standards or guidelines would also place a facility on the list.

As suggested above, means for strengthening existing pretreatment regulations include incorporating industry-specific considerations into the permit-setting process. This approach will be particularly useful for new or expanded facilities, as described in the next section.

V. REGULATIONS GOVERNING DISCHARGES TO MUNICIPAL COLLECTION SYSTEMS

The regulation governing wastewater discharges is included in Appendix B. This document is entitled “Annex C, Instructions of the Commercial and Industrial Wastewater, Disposal through the Sewerage Project Network, (Issued According to the Water Authority Law No. 18, 1988).”

The discharge regulation covers many important aspects of protecting the wastewater collection and distribution system. Due to factors including concerns about industrial growth, a committee has been established to review the regulation. The review process includes examining sewer discharge requirements in other countries, including those of the US EPA, and other literature. However, it has been noted that the committee appears to be mainly considering minor numerical modifications to listed parameters.

The awkward structure and language of the US Code of Federal Regulation was discussed with personnel at WAJ labs, and as a result this activity included providing copies of the US pretreatment regulations, a model US EPA ordinance, and a draft ordinance developed recently for a US city. (Many other examples can be found on the internet.) Approaches in these sample materials are helpful for considering modifications to the discharge regulations, and aspects of these materials were used for developing recommendations discussed herein.

The current regulation refers to enforcement mechanisms in somewhat broad terms. For example, reference is made to the “director of the governate water directorate,” but the responsibilities of that office are not noted. It would be helpful to indicate the roles and responsibilities of the various authorities, including ministries, in a preamble.

The regulation requires obtaining written approval before connecting to municipal wastewater systems. Application forms are referred to, and are “subject to the approval of the Secretary General.” This process is an excellent component of the regulation and it is recommended that it be expanded upon, developing a permitting program similar to, but separate from, the one discussed above for surface discharges. Thus, a permit would be set up for each discharger, renewable at specified time intervals or when discharge conditions change.

The requirement of a written approval should be accompanied by a requirement of having a pretreatment plant before discharging to the sewer system. This is necessary, especially as more industries are expected in the future in Amman-Zarqa basin. The type of pretreatment plant and the size should be approved by the regulatory authority. A Guideline document could be prepared for each type of industry explaining the type of treatment suitable (most applicable or best available technology) for such an industry. This will ensure the removal of any harmful constituent that could have a negative effect on the treatment plant or the reuse potential of wastewater. In case the pretreatment plant was found to be effective in removing those harmful constituents, then the monitoring requirements may be relaxed.

Some industrial activities may not produce wastewater with constituents that may affect the performance of the wastewater treatment plant or the reuse potential of wastewater. They may also be of small scale that such effects are negligible. Therefore, industries that can show that their wastewater is of no potential threat to the environment or to the potential reuse of wastewater, and after being approved by the regulatory authority, can be exempted from having a pretreatment plant.

The requirement of the presence of a pretreatment plant at the industry site before discharging to the sewer system must be implemented for new and planned industries. Existing industries could be exempted from this requirement for a period of time, and can be phased in to comply with the new regulations.

Once the requirement of a pretreatment plant is implemented, then all industries with access to the sewer system should be forced to connect to the sewer system. This is important because the use of tanks to dispose of the wastewater of these industries is not controlled and very difficult to control. Therefore, the illegal dumping of wastewater through tanks in the wadis or sewer systems without treatment is prevented. In case the industry is far away from the sewer system, the industry should propose plans for the complete treatment of their wastewater. The plans should also be approved by the regulatory authority, as discussed in the previous section regarding discharges to surface waters.

As for discharges of wastes to surface waters, it is useful to have standards for commonly encountered constituents (pH, temperature, and other requirements in the existing regulation). However, especially for large, new, or industries using or producing toxic chemicals (including toxic organics), it is important also to examine and specify requirements for individual dischargers in the form of a permit. Considerations regarding new discharges, monitoring requirements and other factors are similar to those for discharges to surface waters.

For setting individual permit limits for new and/or existing dischargers, it will be useful to consider the US EPA categorical pretreatment standards for the industries listed in Appendix E. These standards have industry-specific limits for existing and new sources, with limits set based on known, workable technological approaches.

If categorical pretreatment standards are implemented, for example, then the existing industries in the Amman Zarqa basin can be divided into a number of major categories. For monitoring purposes WAJ laboratories have given alphabetical initials for different industrial categories. A number of these categories are shown below:

Alphabetical Initial	Type of Industry
A	dAiry product processing
C	Ceramics industries
D	soap and Detergent industries
F	Food processing industries
G	organic and inorganic chemicals, paints, petrochemicals, tanning, power plants, battery manufacturing, and oil refining
M	pharmaceuticals
I	metal manufacturing and finishing
T	Textile

Although there is no categorical differences between industries in the Jordanian standards regulating industrial wastewater discharges (Standard 202 and regulations controlling discharges to municipal systems), WAJ laboratories have divided the industries into categories that have mainly different monitoring frequencies. For some industries some of the parameter were not tested for, but for the majority, the same parameters were tested regardless of the type of industry. Heavy metals in wastewater from dairy product processing industries, and slaughterhouses along with battery manufacturing were measured, but at a lower frequency. It is suggested that these categories be built upon and the required monitoring parameters be different according to the type of industry.

The WAJ categorical division is a good starting point. However, the G category has a wide range of different industries and can be further divided into a number of subcategories. A portion of what the final suggested categorical listing of industries with different monitoring requirement and suggested pretreatment method is shown in Table 2. This table has to be expanded and the parameters be refined. A guideline document for each industrial category defining the suitable treatment units is necessary.

Whether categorical pretreatment standards are used or any other system, industries have to apply for a written permission to discharge to the sewer system. The applicant should be required to submit for approval all plans and specifications for their pollution control facilities. In addition, industrial waste survey material should be submitted by each discharger, giving a chemical inventory and showing water and mass flow rates, and spill control methods. This is different than the present regulation which states that control plans and specifications be provided “if available.” Slug discharges of potentially harmful compounds and high total mass discharges should also be prohibited. As for surface discharges, many of these requirements can be phased in for existing dischargers while being required for proposed or expanding dischargers.

In addition, flexibility in setting monitoring requirements should be a component of the regulations so that resources can be focused on facilities with problems. As suggested for discharges to surfaces, self-monitoring and reporting should be considered (with appropriate checks by regulatory authorities). Industries could hire out the laboratory work directly, making potential cost savings for government.

It will be useful to consider creating a pretreatment program as a component of implementing these suggestions. Such a program would have a small staff, with a pretreatment program coordinator in charge. The program would take responsibility for assembling the needed information on each discharger, and help coordinate permit-writing and enforcement. While self-monitoring and reporting is suggested, pretreatment program staff would coordinate sampling and verification efforts. A pretreatment program’s goals include working with dischargers to help them come into compliance. There should be a partnership approach to working with dischargers; of course, when there are serious problems or flouting of the regulations, enforcement action should be undertaken.

Table 2. Part of the suggested categorical listing of industries in the Amman-Zarqa basin.

Suggested categorical division	Parameters requiring testing
Food processing industries	BOD, COD, SS, pH, Oil & grease
Electroplating and metal finishing	Acids, metals, cyanide, toxic organics
Textile	COD, Cr, phenol, sulfide, dyes
Leather Tanning and Finishing	BOD, SS, TDS, Cr, Zn, Pb, Ni, Cu, Oil & Grease, sulfide, fecal coliforms, naphthalene, phenol, pentachlorophenol.
Pulp & Paper	pH, Alkalinity, H2S, Volatile solids, SS, COD, BOD, Oil & Grease, Pentachlorophenol, Trichlorophenol, PCBs, Color (dyes).
Petroleum Refineries	Oil & Grease, H2S, Mercaptans, Cr, Zn, Pb, Cu, NH4, F, Cresol, Phenol, Toluene, Benzene, Xylene, Alkalinity, pH, Thiosulfate, Combustible gas, other organosulfur compounds
Paint Formulating	BOD, COD, Oil & Grease, SS, Heavy metals (As, Cr,Cu, Cd, Ni, Zn, Pb, Hg), Organics (benzene, ethyl-benzene, methylene chloride, ethyl acetate, butyl acetate, xylene, naphthalene, di-n-butyl phthalate, tetrachloroethylene, toluene, carbon tetrachloride, di phthalate.

Laboratory equipment and testing methods are similar to those of the surface discharge sampling program. As noted above, laboratory equipment may be needed. However, current testing involving the RSS labs and possible requirements for some level self-monitoring and reporting needs to be factored into considering new laboratory equipment to avoid duplication of effort.

A pretreatment program will require sampling and testing equipment. For example, portable, programmable automatic samplers (battery operated) are helpful for taking composite samples of discharges. To facilitate such efforts the regulation should state that, if required, an approved, full access sampling point and flow metering must be provided by the discharger. The type and design of sampling points needs to be considered for the regulation.

Discharges of wastes containing high TDS levels are addressed in the discharge regulation, which places restrictions on wastes "causing an increase in … soluble salts." Thus, wastes contributing to high TDS levels in reclaimed water can be addressed in discharge permit requirements. Such wastes include connections by governmental units, such as reverse osmosis reject wastes, as discussed in the next section.

VI. DISSOLVED SOLIDS & HEAVY METALS CONSIDERATIONS

Project activity included addressing concerns regarding dissolved solids and heavy metals in waters of the Amman-Zarqa basin. As discussed above, heavy metals are not at present impacting negatively on water reuse options currently being planned. However, dissolved solids levels (currently at about 1200 mg/L in As Samra effluent) could approach levels affecting agricultural reuse options. Sources of these constituents and strategies for their reduction are discussed below.

Boron was also listed in the work plan as an element of concern in basin waters. Boron in the past has been problematic, impacting negatively on agricultural yields. However, as discussed by others, including Grattan (2000), boron concentrations have since 1991 dropped below levels of concern.

<u>Sources of Heavy Metals and TDS and Control Approaches</u>

Sources of water for potable treatment (usually called "raw" water supplies) have significant impact on municipal wastewater quality in the basin. As shown by Harza (1997), dissolved solids in potable water supplies is the major contributor (about 92%) of the total solids in wastewater. Hardness and TDS values in many ground water sources are high and increasing. However, some surface water sources such as the King Abdulla Canal (the raw water source for the Zai Water Plant) have much lower TDS values than the subsurface supplies serving Amman. As wastewater enters the As-Samra waste Stabilization ponds, the TDS concentration in the effluent increases as a result of evaporation. When the new As-Samra wastewater treatment plant is put online, the TDS value is expected to decrease as a result of decreased evaporation. In addition, a new 45 MCM per year reverse osmosis plant will soon be feeding potable water to the Amman area. Reject from this plant is to be routed to the Dead Sea, and it is reported that the product water will have a TDS level of about 250 mg/L.

TDS values in potable water systems generally do not result in consumer complaints below 1200 mg/L, although 650 mg/L is considered preferable (AWWA, 1999). If potable water is maintained well below 1200 mg/L, TDS values in reclaimed water may not reach harmful levels so long as discharges to municipal systems are controlled. Thus, there is a need for ensuring that discharges of TDS are kept low.

It is very difficult and expensive to control the TDS concentration in water supplies in Jordan. The natural increase in TDS concentration as a result of domestic activities is also hard to control. Therefore it is more reasonable to concentrate on other controllable sources to try to keep TDS concentrations at levels acceptable for water reuse activities. Some of these sources that could have an impact on TDS and/or heavy metals are discussed below. These sources can be summarized as follows:

1- Industrial processes.
2- Industries evaporating water and thus concentrating the salts in their water. This include industries using recirculating cooling towers.
3- Reverse Osmosis reject.
4- Ion exchange regeneration.
5- Water treatment plants.

Each of these sources is discussed below.

Industrial Processes

Available field data on sources of TDS and heavy metals are provided in Appendix F. The highest mass output of TDS is the Jordan Yeast Company, while the highest mass output for a connected industry is the Jordan Tanning Company.

The total TDS mass discharge from the industries shown in Appendix F to Amman-Zarqa basin is about 6000 tons per year, with a flow of about 0.88 MCM per year. If all these industries are connected to the sewer system, then the increase in TDS concentration as a result of these industries would be around 100 mg/l, at the present effluent of about 60 MCM per year from As-Samra wastewater treatment plant. In order to more accurately evaluate the effects of industries on TDS concentrations, a more complete data set of industries discharging to the Amman-Zarqa basin should be obtained. This should include a thorough evaluation of on-site industrial practices and waste discharges, with composite sampling and testing.

Heavy metals outputs shown in Appendix F do not appear to be of concern in terms of the municipal wastewater system. However, some discharges to irrigation may have heavy metals and TDS levels impacting ground water quality.

As more industries in the Amman-Zarqa basin develop, the discharge of TDS and heavy metals will increase if no measures are taken to control these discharges. Therefore, it is necessary to implement the regulations mentioned above for industries disposing of their wastewater to the sewer system, or the environment. The increased use of both ion exchangers and reverse osmosis units in industries could also negatively impact the reuse potential of reclaimed wastewater due to higher salinity.

Cooling Towers

Cooling towers are used to reduce the temperature of the water that has been used for cooling to a lower temperature, so it can be used again for cooling. This is done by evaporating part of the water and recirculating the remaining colder part, which result in a higher TDS concentration in the cooling water. In order to limit the TDS value to a value that does not affect cooling efficiency, part of the cooling water having high TDS is discharged (blowndown), and replaced by lower TDS makeup water. TDS in blowdown water can reach values between 2 to 15 times the TDS concentration in the original water used for cooling (the ration is called cycles of concentration).

At the present time a number of industries, like the oil refinery and the power plant, are using well water with high TDS for cooling (more than 2000 mg/l). The amount of water discharged is about half of the water used for cooling but with twice the concentration of TDS. The oil refinery and the power plant are using this water for irrigation purposes at the industry site, in order to avoid the discharge of the water to the sewer system or the wadis. It should be noted that this type of application is not a solution to high TDS and eventually the TDS will reach either the surface water or the groundwater.

A number of solutions are proposed to decrease the discharge of TDS from industries using cooling towers:

1- Replace the current high TDS well water used for cooling with lower TDS water supplies. The new As-Samra reclaimed water will have lower (about half of those used by the power plant and the oil refinery) TDS values than the current well water used by a number of industries. For the same cycles of concentration, the concentration of TDS in the blowdown would be lower. For the same TDS in the blowdown, the quantity of water discharged would be lower.

2- Install evaporation ponds to evaporate the blowdown. This method would become more economically feasible if the cycles of concentrations are increased, so that the volume of blowdown would be smaller. For example if the cycles of concentration in the oil refinery are increased to 5 instead of 2, the volume of blowdown would be about one fourth of the original blowdown volume. If As-Samra reclaimed water is used 5 cycles of concentration could be possible after phosphorous removal. Details about the use of reclaimed water for cooling purposes can be found in "Identification and Pre-Feasibility Analysis of Non-Agricultural Reuse Options for Reclaimed Wastewater from As Samra" (MWI/ARD, 2001h).

3- Install thermal evaporation units.
These units use waste heat from facility processes to concentrate the brine through evaporation. The concentrate is then discharged into evaporation ponds, and the evaporated high quality water can be reused.

Reverse Osmosis

Effects of discharging reverse osmosis reject must be carefully considered in terms of effects on TDS values in receiving streams, and reclaimed water. Regarding use of membranes for potable water treatment, AWWA (1999) noted for systems in the US "Waste disposal is a more significant problem for any membrane plant than for a conventional water treatment plant because concentrate disposal is highly regulated by government agencies. A membrane plant can collect significant amounts of waste with high concentrations of many constituents including TDS and organics." This information suggests that great care should be taken in planning potable water facilities using reverse osmosis and other membrane technologies. Effects of discharges must be considered during early planning stages.

Reverse Osmosis units do not add TDS for the water per se, but it concentrate the TDS in one portion while leaving the other portion with lower TDS concentration. If both the desalinated water and the brine are returned to the sewer system, there would be no addition of TDS to the water, except for chemicals used for membrane cleaning and pre and post treatment. Slug discharges of brine should not be allowed, however.

Despite the fact that RO units, overall, do not add TDS to the water, the disposal of brine from RO units in industries should be carefully dealt with. This is because industrial processes using RO systems usually add TDS to the desalinated water, either through evaporation of part of the water used for cooling or boiler feed, or as process water. Properly managing the low volume and high TDS RO reject, is easier and more effective way of TDS management than managing high volume and relatively low TDS process water.

It should be noted, however, that the use of RO systems in industries can be utilized as a tool for reducing TDS in the water if the RO reject is prohibited from being discharged to the sewer system or to the wadis. This can be done through the use of evaporation ponds or thermal evaporation discussed earlier. In case a more relaxed approach is taken, then the industries should not be allowed to discharge water of higher salinity than water present in the sewer system or in the wadis.

Ion Exchangers

Ion exchange units are used mainly for the removal of hardness from water. In these units calcium and magnesium are exchanged for sodium. After exhaustion, concentrated sodium chloride solution is used for regeneration. Hardness ions and excess sodium end up in the regenerant wastewater. This ion exchange brine from softening units can add to TDS and sodium levels. Modes of operation of ion exchange units in homes and industries merit further investigation and alternatives should be examined. It may be economical to use resins which exchange hydrogen ions instead of sodium for hardness ions, for example. The following is an estimate of the effect of such units on sodium and TDS concentrations.

During hardness removal, for every mole of calcium or magnesium ions removed, two moles of sodium are added. In milligrams per liter, every 40 mg of calcium removed, 46 mg of sodium is added, while for every 24.3 mg magnesium removed, 46 mg of sodium is added. Therefore, hardness removal by itself adds salinity and sodium to water being softened by ion exchange. For a water with 200 mg/l as $CaCO_3$ hardness, a typical value of water in the Amman-Zarqa basin, the increase in sodium concentration would be about 90 mg/l, while TDS would increase by less than 20 mg/l. Above that, after exhaustion, the unit has to be regenerated through the addition of a concentrated solution of NaCl. The amount of regenerant used would define the extent of TDS increase caused by ion exchangers. As an example suppose that the hardness of a typical water in the Amman-Zarqa basin having a hardness of 200 mg/l as $CaCO_3$ has to be removed by sodium based ion exchange resins. If typical values of regeneration level and the corresponding hardness capacity for strong acid sodium based ion exchangers are used (Clifford, 1999), the increase in TDS due to regeneration would be as follows:

Regeneration Level (Kg NaCl/m^3 of resin)	Hardness capacity (eq. $CaCO_3$/L resin)	TDS increase (mg/L)
64	0.78	329
96	0.92	417
128	1.00	512
160	1.15	556
240	1.24	767
320	1.33	962

The above increase in TDS is calculated assuming that the regenerant wastewater is added to the softened water. As can be seen from the above table, the increase in TDS as a result of using ion exchangers is high. The increase is also dependent on the regeneration level. Therefore using a low regeneration level would lower the increase of TDS as a result of ion exchange softening. It is not known how much is the percentage of water being softened by ion exchangers and therefore the contribution of these systems on TDS is not known. A study to estimate the percentage of water being softened by sodium based ion exchangers is necessary.

The volume of regenerant used for ion exchange resins is small due to the high concentration of regenerant used. As higher regenerant concentration is used, smaller volumes of regenerant are required. In that case, evaporating ponds would be more economical as a method of brine disposal.

In order to reduce the increase in TDS concentration in water and the increase of sodium concentration, hydrogen ion exchange softening may be considered. This type of ion exchangers are hydrogen based weak-acid cation exchangers, because strong acid exchangers produce low pH waters, and there is a problem in acid regenerant disposal. These systems only remove temporary hardness. The pH of the product water has to be increased either by CO_2 stripping or by adding NaOH or $Ca(OH)_2$. The product water has also to be blended with raw water.

Another point to discuss is that ion exchange units remove hardness almost completely. In some cases, the complete removal of hardness is not necessary. Split treatment of part of the water or the use of weak acid hydrogen based ion exchangers is sufficient in these cases.

Ion exchange and reverse osmosis units are used at large industrial facilities, such as the oil refinery and power plant. These systems are necessary to produce high quality water for boilers, for example. In these cases, dissolved solids removed from wells are transferred to the wastewater collection system or, when used for irrigation, to surface and ground waters. These discharges and disposal methods should be further evaluated and where possible discharges of high TDS brines and reject should be stopped, requiring use of evaporation ponds, for example.

Water Treatment Plants

Potable water treatment increases TDS levels, and alternative chemical treatment approaches should be examined. For example, use of chlorine gas adds fewer dissolved solids than do hypochlorite systems. Other chemical compounds, including heavy metal coagulants and those used for pH adjustment should be investigated for minimizing dissolved solids addition during treatment. A carefully designed study should be developed at the Zai water treatment plant to examine treatment options. For the usual treatment practices used in water treatment plants, the impact on TDS concentration is usually not substantial.

These issues can be examined further by preparing a mass balance on dissolved solids in the Amman-Zarqa basin. Present and future proportions and quality of ground and surface water, and other sources, should be included along with existing discharges. The exercise will be complicated by factors such as industries doing land application of wastewaters, which may ultimately reach surface waters by horizontal subsurface flow. Targeting maintaining a maximum TDS value well below 1200 mg/L in the potable water system may be possible by operational approaches, including minimizing addition of dissolved solids during potable water production.

VII. CONCLUSIONS

As continuing urbanization and industrialization of the upper catchment of the Amman-Zarqa basin are taking place, the reuse potential of reclaimed water in the Amman-Zarqa basin and Jordan valley are at considerable risk. Industrial water discharges or sewer connections that could negatively impact the reuse potential of reclaimed water have been investigated. Existing relevant regulations were also investigated, and approaches for improving the regulations are proposed.

Available data indicate that the reuse potential of reclaimed water is probably not at present being negatively impacted by industrial or commercial discharges. Specifically, the following points can be made:

- Heavy metals and other monitored constituents discharged by the industries or passing through the current As Samra system do not appear to have significant impact on reuse approaches under consideration.

- The available monitoring data is not fully adequate for assessing and preventing problems that could be caused by compounds such as toxic organics. Some compounds (and classes of compounds) of potential concern are on the EPA priority pollutants list and lists of compounds inhibitory to biological treatment. Facilities using or manufacturing toxic chemicals that are discharged, or could be spilled or otherwise reach the wastewater collection system, are of potential concern. A list of these connections was drawn up based on flow rates and possible presence of harmful constituents. Resulting problems include possible poisoning or inhibition of biological treatment systems, pass-through of harmful constituents, or interference with beneficial reuse of sludges. Effects of compounds on biological treatment applies to connected industries and to those that discharge into holding tanks for removal by tankers trucks. If illegal dumping is occurring, either to municipal wastewater systems or to wadis, there could be negative impacts on water reuse in the basin. The US EPA categorical pretreatment standards are also useful for assessing industrial discharges and pretreatment requirements.

- Dissolved solids and sodium levels are on the verge of affecting agricultural reuse options. Chloride levels and possible presence of unknown compounds of concern could be potentially inhibitory to nitrification facilities. Available field data on TDS do not indicate problems for the wastewater treatment system. However, some discharges used for irrigation may be of concern in terms of ground water and surface water impacts. The chief sources of dissolved solids in wastewater are the potable water supplies. Many well sources have very high TDS levels. TDS levels could go down when a new 45 MCM/yr reverse osmosis system serving Amman starts operating because reject from this system will be sent to the Dead Sea. Ion exchange brines can add to dissolved solids and sodium levels particularly when excess regenerant solutions are discharged. Blowdown from cooling towers, used usually onsite for irrigation, is also high in TDS and can reach groundwater and surface water by infiltration and washout.

Despite the fact that present heavy metals levels are not high, these contaminants could buildup in the soil with time. Reject from reverse osmosis, ion exchange resins regeneration water, cooling tower blowdown, and saline wastewater from a number of industries are contributing to salinity of the water. Where possible, these discharges should not reach wadi Zarqa. In addition, as Jordan is expected to develop more industries in the future, the mass discharge is expected to be substantial. Therefore, more stringent regulations and enforcement are necessary to protect the reclaimed water from contaminants that could prevent it from being used for its intended reuse application. A number of recommendations are made for strengthening regulatory approaches. These approaches would not have to be done all at once; many can be made applicable to new dischargers and phased in as needed for existing industries. One main focus of the recommendations is on detailed evaluations and regulation based on the characteristics of each discharge. Specific actions that should be taken include:

- Developing water quality standards for receiving bodies (such as Wadi Zarqa and the King Talal Reservoir) can have a number of benefits. In addition to water quality criteria, other useful information for setting water quality standards includes baseline data, lists of priority pollutants, and information on known discharges. These standards could initially be set up as non-binding guidelines outside of legal frameworks. Water quality standards are among the data used for setting discharge limits, and for assessing environmental impacts of existing and proposed discharges to surface waters.

- Industries should be prevented from discharging to the wadis, unless they have written approval for discharging. It is suggested that this approval be in the form of a permit written for each facility. Discharge limits and monitoring requirements would be set by considering water quality standards in the receiving stream(s), the specific industrial processes in use, wastewater characteristics, and pollution control technologies appropriate for those processes. Permit applications would also include submitting for approval plans and specifications for pollution control facilities, along with providing a full chemical inventory, mass flow diagrams, and spill control procedures. Other recommendations for regulating surface discharges include, at the discretion of the permitting authority, requiring sampling sites and flow meters, and performing flow-proportional composite sampling. For many industries, self-monitoring and reporting can be considered as a regulatory option (with appropriate checks by regulators). Industries could hire out the laboratory work, saving government funds.

- The existing industrial standards should include, in addition to the existing parameters, some relevant toxic organics. The list should only include those organics that are expected to be present in the effluent of those industries present in the Amman Zarqa Basin. To reduce cost, the regulatory body could make the industries responsible for testing and reporting, and the regulatory body role would then become a verifying role.

- Industries should be prevented from discharging to the sewer system without having a pretreatment plant at the industry site. The type of pretreatment plant and the size should be approved by the regulatory authority. A Guideline document could be prepared for each type of industry explaining the type of treatment suitable (most applicable or best available technology) for such an industry.

- Industries with access to the sewer system should be forced to connect to the sewer system. This will prevent the illegal dumping of their wastewater through tanks in the wadis or sewer systems without treatment. In case the industry is far away from the sewer system, the industry should propose plans for the complete treatment of their wastewater. The plans should also be approved by the regulatory authority.

- Industries that can show that their wastewater is of no potential threat to the environment or to the potential reuse of wastewater, and after being approved by the regulatory authority, can be exempted from having a pretreatment plant.

- Existing industries could be exempted from the previous points for a period of time, and can be phased in to comply with the new regulations. New industries should comply from the start.

- Cooling water blowdown, reverse osmosis reject, and ion exchange regenerant wastewater may have to be prohibited from discharging to wastewater collection systems. Ion exchange units add substantial amounts of salts as a result of regeneration, unlike reverse osmosis units, and therefore ion exchange regenerant wastewater should be prevented from being disposed to the environment. It may also be necessary to restrict some discharges of high TDS wastes, requiring evaporation ponds, for example. The present use of brine water in irrigation at the plant site will cause TDS either to infiltrate into the groundwater or to be washed out to surface waters during rainy periods, and therefore should not be considered a solution to the problem.

- Other suggestions for strengthening the municipal discharge regulation include setting up a pretreatment program with a small staff. These staff would coordinate sampling, testing, permit-writing, and enforcement. One goal of a pretreatment program is to work with industrial dischargers to help them come into compliance. Enforcement should be exercised where there are real problems and where there is no cooperation on the part of an industry.

- Pretreatment regulation will benefit from requiring, at the regulators' discretion, the owner to install a sampling point outside the property; and a discharge flow meter. Sampling point and flow meter construction details can be specified in the municipal code. As for surface discharges, chemical inventories, industrial waste survey information, and plans and specifications for pollution control facilities should be submitted for approval. Portable, battery operated sampling equipment that can be installed in manholes and take 24-hour composite samples will be helpful for monitoring industrial dischargers.

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Appendixes

Appendix A. Jordanian Standard 202/1991
Appendix B. Regulation for Discharging to Municipal Wastewater Systems
Appendix C. Excerpts from Water Environment Federation (WEF), *Pretreatment of Industrial Wastes*, Manual of Practice No. FD-3, WEF, Alexandria, VA (1994).
Appendix D. List of Dischargers Connected to the Municipal Wastewater System
Appendix E. Categorical Pretreatment Industries (US EPA)
Appendix F. TDS and Heavy Metals Dischargers Summary

APPENDIX A
(Unofficial translation – Yasser Nazzal)

JS 202/ 1991

Water – Industrial Wastewater

Department for Standards and Metrology

Contents

1. Scope

This Jordanian Metrological Standard is concerned with the requirements that must be met in the effluent from industries that is discharged into surface water or used to recharge the groundwater or that treated effluent that is reused for irrigation purposes.

2. Definitions

Industrial wastewater effluent: Water that results from water use in some or all stages of manufacturing, cleaning, or cooling …etc., whether it is treated or untreated.

3. General Requirements

The following requirements must be met:

3-1 Industrial wastewater effluent must not have negative effects on the public environment in order to ensure safety and human health. In Addition, the discharge of industrial effluents must not have a negative effect on the social and economic development of the area or the water catchment (basin) that might become polluted.

3-2 The end use of the industrial wastewater defines the criteria or guidelines that must be achieved for the quality of industrial water shown in Table 1 with the further condition that such dischagres shall not violate the environmental balance in the affected area.

3-3 Industrial wastewater must not have a negative effect on the groundwater within the discharge area of the industrial wastewater effluent or the water basin that has a direct effect.

3-4 Industrial wastewater effluent discharged into wadis must not have a negative effect on the quality of surface water or aquatic life.

3-5 In case that the industrial wastewater effluent is used in any stage of manufacturing (cooling, cleaning, …etc) or in irrigation, it must not have any negative effect on the health and safety of the workers in the factory or the consumers of that product.

3-6 In case that the industrial wastewater effluent is reused for all type of irrigation, WHO guidelines and the marshal law belonged to wastewater and the instructions issued according to it, must be taken into consideration if it is mixed with the sewer water of the concerned factory.

3-7 In case that the industrial wastewater is linked to the public sewer network that belongs to Water Authority of Jordan (WAJ), it must meets the instructions of connection to the sewer network and any other related amendments.

4. Metrological Requirements

The industrial wastewater effluent must meet the metrological requirements (criteria) listed in Table 1 according to the end use. The considered results of these criteria depend upon:

1- Samples must be collected and representative, and paced according to the discharge quantity and taken during normal factory operation time. The number of samples must not be less than one sample a week in order to evaluate and study the water quality.

2- If rule No. 1 above is not met, samples must be taken at random times according to the quality and continuity of effluent discharge and at a rate not less than 3 samples/week, or more than this number, where possible.

3- Samples must be taken, kept and analyzed according to the Standard Methods for Water and Wastewater Examination issued by the American Society for Public Health and the American Federal Society for Water Research and Pollution Monitoring and its amendments, in addition to any other recognized methods of analysis if it is not available in the aforementioned references.

4- The general requirements and the detailed environmental impact assessment must be followed in order to define the allowable water quality discharged from the factory in that area, especially for those criteria that are not mentioned and do not have values in Table 1.

Table 1. Industrial Wastewater Reuse Criteria.

Parameter	The maximum allowable concentration limit (mg/L) +			
	Reuse for Irrigation +++	Artificial Recharge	Discharge to	
			Sea	Rivers, wadis, and catchment areas
BOD_5	-	50	-	50

COD	-	150	200	150
DO	1 ++	1 ++	5 ++	1 ++
TDS	2000 (2)	1500 (1)	-	3000 (1)
TSS	100 (3)	-	-	50
PH	6.5-8.4	6.5-9	5.5-9	6.5-9
Color	-	15	75	15
T^o	-	-	4	-
Oil & Grease	5	-	4	-
Phenol	0.002	0.002	1	0.002
Industrial Detergents	-	15	-	25
NO_3 – N	30	12 (4)	-	12 (4)
NH_4 – N	5	5	12	5
Total N	50	-	125	-
PO_4 – P	-	-	-	15
Cl^-	350	500	-	500
SO_4^{-2}	400	500	-	500
F	-	1.5	-	1.5
HCO_3^-	500	-	-	-
Na^{+1}	-	400	-	-
Mg^{+1}	-	-	-	-
Ca^{+2}	-	-	-	-
SAR	9	-	-	-
Al^{+3}	5	0.3	-	5
As	0.1	0.05	0.1	0.05
B	1 (5)	1	-	1
Total Cr	0.1	0.05	0.3	0.1
Cu	0.2	2	0.1	2
Fe	5	1	2	1
Mn	0.2	0.2	0.2	0.2
Ni	0.2	0.1	0.02	0.2
Pb	1	0.1	0.1	0.1
Se	0.02	0.05	0.02	0.02
Cd	0.01	0.02	0.07	0.01
Zn	2	15	-	15
CN	0.1	0.1	1	0.1
Hg	0.001	0.001	0.001	0.001
TCC (MPN/100 ml)	-	-	5000	-
TFCC (MPN/100 ml)	1000 (6)	1000 (6)	-	1000 (6)
Nematodes (Eggs/L)	< 1	-	-	< 1

+: The unit is mg/L unless otherwise indicated. The average monthly value is considered except for the highly toxic criteria.

++: The values of DO are the lower limit values.

+++ Depends on crop types, production quantity, irrigation method used, type of soil, climate and groundwater in the area.

(-): Means undefined, in order to define it, it depends on the metrological and general requirements.

Remarks on Table 1:

1- The allowable limit value depends on the concentration of TDS in water source supplying the industry as well as the water basin effected by this water.
2- The allowable limit value depends on the degree of restriction (unrestricted, low to moderate, and highly restricted).
3- The allowable limit value depends on the irrigation method used (drip, surface, or sprinkler).
4- The allowable limit value depends on the nitrate concentration in the effected water basin.
5- It might reach 30 mg/L.
6- The engineering average is considered.

5- Technical Terms

1- Bio-Oxygen Demand (BOD_5)
2- Chemical Oxygen Demand (COD)
3- Dissolved Oxygen (DO)
4- End Use
5- Faecal Coliforms
6- Grab samples
7- Intestinal Nematodes
8- Oil Content
9- Phenol
10- Suspended Solids (SS)
11- Total Dissolved Solids (TDS)

6- Technical References

1- Water Reuse and Recycling Technology
2- Water Quality Criteria for Discharge to the Arabian Gulf-Codes of Practice & Environmental Guidelines-Kuwait.
3- FAO Guidelines for Agriculture.
4- Jordanian Standard for Drinking Water No. 286/ 1988.
5- Regulations for Wastewater Reuse and Discharge- Sultanate of Oman, Ministry of and Environmental and Water Resources.
6- Recommended Water Quality for Reuse, KISR-Kuwait.
7- Reuse of Effluents, Methods of Wastewater Treatment and Safeguards, (WHO).

7. Organizations That Participated in This Standard’s Amendments

1- The Ministry of Health (MOH)
2- The Ministry of Water and Irrigation (MWI)
3- The Ministry of Planning (MOP)
4- The Ministry of Municipality and Rural Development and Environment
5- The Ministry of Agriculture (MOA)
6- The Greater Amman Municipality (GAM)
7- The Royal Scientific Society (RSS)

8- The University of Jordan (UOJ)
9- The Industrial Cities Corporation/ Sahab
10 The Amman Industrial Chamber
11 Jordan Petroleum Refinery Company
12. Arab Company for Aluminum Manufacturing
12 Yeast Manufacturing Company

APPENDIX B

(Unofficial Translation)

Instructions for the Commercial and Industrial Wastewater

Disposal through the Sewerage Project Network

(Issued According to the Water Authority Law No. 18, 1988)

Article 1: The following expressions and words shall have the meanings designated for them below unless indicated otherwise by the context:

Authority: Concerned body within the water authority decided by the Secretary General.

Sec. Gen.: The Secretary General of the authority or whom he delegates the authority to.

Director: The director of the governorate water directorate.

Directorate: The governorate water directorate.

Sewage: Sewage water and liquid waste resulting from various water usages.

Industrial Wastewater: Waters resulting from the use of water in some or all the stages of manufacture, cleaning, cooling, or others whether treated or untreated.

Commercial Wastewater: Water resulting from the use of water in non-industrial fields which contain additional pollutants to the wastewater e.g.: wastewater from hospitals, Labs, fuel stations, slaughter houses, cattle and chicken farms …etc.

Person: Any individual, company, corporation or establishment with an incorporated entity.

Article 2: It is prohibited to dispose of industrial and commercial wastewater whether polluted or non-polluted through the sewerage network before getting a written approval from the authority according to these instructions.

Article 3: Any person is prohibited to dispose or allow the disposal of wastewater containing any of the following materials through the public network:

A. Any solids or liquids in quantities or sizes or chemical properties, that may obstruct the effluent in the sewerage project network or cause a public health hazard or cause the diffusion of bad odor or cause damage to the sewerage project or its workers, or clash with the O&M of the treated plants and the treatment process, or may result in treated water that may threaten public health and safety, e.g.: glass, ceramics, feathers, coal remains, sand, clay, metals, plastics, blood, hair, paperplates…etc.

B. Any solids, liquids or gasses containing toxic materials that may according to the authority, undermine or clash with the purification process, or may separately or as a result of reaction with other waste materials, cause a health hazard on humans, animals or plants.

C. Any material that may lead to:

1. The inability for treatment during the purification process.
2. The formation of materials that may precipitate, solidify or become glutineres at temperatures 0 – 40 ^{o}C.
3. Hindering the final usage of the treated water by causing an increase in the soluble salts, for instance.

D. Any petroleum products or any other flammable or explosive solids or liquids.

E. Any solids or liquids with a pH degree <5.5 or >9.5.

F. Liquid waste resulting from brick, marble and tiles factories and cement mixers, and any other liquid waste with suspended solids concentration exceeding 50 mg/l and a specific gravity exceeding 1.5 g/ cm^3.

G. Any liquid or vapor with a temperature in excess of 65 ^{o}C, and if it becomes evident for the authority that such liquids or vapors may at lower temperatures still cause damage to the wastewater project or any other damages, then the authority reserves the right for the prevention of their disposal.

H. Liquids containing oil, greases, or emulsified waste with a concentration in excess of 100 mg/l.

I. Any liquids or solids containing cyanide or its compounds with a concentration that may yield 1 mg/l of HCN.

J. Any liquids or solids containing phenol compounds in excess of 10 mg/l estimated as pure phenol.

K. Any liquids or solids containing sulfuric compounds with a concentration in excess of 10 mg/l estimated as Hydrogen Sulfate.

L. Chlorinated organic solvents.

M. Chemical cleaning compounds measured as MBAS with a concentration in excess of 40 mg/l.

N. Any liquids or solids containing heavy or toxic elements with a concentration at the disposal site in excess of the following values:

***Cr**	**5 mg/l**
***Cu**	**4.5 mg/l**
Sn	**10 mg/l**
Be	**5 mg/l**
***Ni**	**4 mg/l**
***Cd**	**1 mg/l**
As	**5 mg/l**
Ba	**10 mg/l**
***Pb**	**0.6 mg/l**
Mn	**10 mg/l**
***Ag**	**1 mg/l**
B	**5 mg/l**
***Hg**	**0.5 mg/l**
Fe	**50 mg/l**
Zn	**15 mg/l**
***Co**	**0.05 mg/l**
***Se**	**0.05 mg/l**
Li	**5 mg/l**
***V**	**0.1 mg/l**
Al	**5 mg/l**

- Provided the sum of these elements doesn't exceed 10 mg/l, with the authority reserving the right to amend the above limits should a Jordanian specification be issued to this effect.

O. Any radioactive substances or any industrial isotopes unless a permit is obtained from the Ministry of Energy.

Article 4: It is prohibited to dilute the pollutants in the industrial wastewater by means of mixing them with fresh waters to reach concentrations set herein.

Article 5: Approval application forms for connections with the wastewater project are applied by commercial and industrial institutions in accordance with article two of these instructions in writing which become subject to the approval of the Secretary General, provided these applications include the following details:

a. Industrial operations carried out which yield wastewater.
b. Substances and chemicals used in each operation and those resulting from these operations.
c. The quantity of water used and its sources as well as the quantity of water coming out after manufacture.
d. The physical, chemical and biological properties of the wastewater that is to be connected.
e. The technical details of the physical, chemical and biological operations of the pre treatment unit (if available).
f. Any information seen necessary by the authority to consider the application for the connection.
g. Preliminary approval is issued to connect the new factories according to the information provided in the application form. The approval is reconsidered six months after the start of manufacturing in light of the analysis results of the industrial wastewater of the factory. In the case of any connection conditions violations, the factory has to rectify the situation within a period to be specified by the authority. Otherwise the approval is considered void, a situation that will be reported by the authority to all parties concerned.

Article 6: Whoever obtains the final approval for wastewater disposal through the sewerage network is prohibited to dispose of any wastewater that differs in quality and/or quantity from what the approval was obtained for, in which case a new approval has to be obtained.

Article 7: The authority can demand that the wastewater be treated prior to and after approving its disposal through the sewerage network if its harm has been confirmed.

Article 8: a. It is stipulated that before getting the written approval, commercial and industrial institutions should present engineering drawings showing the method and specifications of the private pipe construction, as well as the inspection points that have to be within the factory borders in a convenient location near the main network.

b. Persons benefiting from this factory have to stick to these drawings after the authority approves them and their execution has to be at the expense of such persons under the supervision of the authority.

c. The authority has the right, for closer controls to collect and examine samples according to a timetable set and seen appropriate by the authority for each factory.

Article 9: The approval for the connection with the sewerage network is issued for the commercial and industrial institutions upon the recommendations of the connected party within the authority if the former sees no harm in connecting with the sewerage network.

Article 10: a. The Water Authority shall charge the commercial and industrial institutions fees for connecting their systems with the sewerage network according to a set tariff.

b. The fees for consumed water, that is subjected to the sewerage network services fees, are set as follows:

- Fees for water measured by meters for institutions that are supplied with water from the water authority systems.
- Fees for water measured by meters for institutions supplied with water from their own private wells.
- Institutions supplied with water by trucks have their fees set by the Secretary General according to a committee appointed by the Sec. General.
- The sum of fees for institutions supplied with water from more than one source.

Article 11: a. In addition to the fees collected as per article 10, the authority charges these institutions that need to dispose of wastewater with a COD concentration higher than the allowable limit (VIZ 155 mg/l). The additional fees cover the additional treatment required in this case.

b. Additional fees are set as follows:

$$k = 0.05 \times T \times \frac{(COD - 1500)}{1000}$$

Where: k = additional fees to cover the treatment expenses /JD

T= quantity of industrial wastewater during the cycle/ M^3

COD= average concentration of chemical oxygen requirement during the cycle/ mg/l.

c. Fees are calculated quarterly or as decided by the authority.

d. The concerned directorate issues the claims for additional fees.

e. To apply the additional fee equation, the mean value is considered to cover the treatment expenses quarterly.

Article 12: The authority has the right to seek technical assistance from any party concerning these instructions.

Article 13: 1. The authority has the right to terminate or suspend its approval for the period seen necessary in addition to the legal charges due to the following violations:

a. Violating these instructions or any other conditions set by the authority at the time of approval.
b. Obstructing inspection and monitoring by the authority staff.
c. Not abiding with any conditions or requirements set by the authority in order to protect the sewerage network.
d. Failing to pay the fees.

2. The authority has the right to coordinate with any party to bring to a stop any damage to the sewerage network due to any violation. Additionally the authority staff shall issue penalties and claim compensations from violators.

Article 14: These instructions shall come into effects as of the date of making them publicly known in the official newspaper. Institutions have to rectify their status to fit these instructions within three months from the above-mentioned date.

Article 15: The instructions for commercial and industrial wastewater disposal published in the official newspaper no. 3573 dated 17/9/1988 shall be considered void.

The Minister of Water and Irrigation
Dr. H. Al-Mulqi

APPENDIX C

(From WEF, 1994)

APPENDIX D

Factory	Flow	Flow
	m^3/d	MCM/YR
Amman Municipality Slaughter -House	800	0.292
Jordan Tanning Co. Ltd.	300	0.110
Hussain Thermal Station	250	0.091
Jordan dairy Co. Ltd.	170	0.062
The Jordan Worsted Mills Co . Ltd.	150	0.055
Eagle Distilleries Co.	150	0.055
Jordan ice&aerated water co.ltd.	110	0.040
ICA Company Ltd .	110	0.040
Jordan Beer Company	100	0.037
Arab Co. For Medicines /Salalem	86	0.031
Clothes Factory / Krematex	60	0.022
Arab Co. For Medicines /Beheira	56	0.020
Sweileh Sloughter-House	50	0.018
Arabic Chemical Detergents Industry Co .	50	0.018
Jabri Sweet Factory	50	0.018
jordan ice&aerated water co.ltd.	50	0.018
hikma pharmaceuticals.	40	0.015
arabin trade &food industries.co.ltd.	35	0.013
Jordan Valley food ind .co.	35	0.013
al_maraai est. for food industries .	30	0.011
Universal modern industries co.	30	0.011
Jordan Potato & Corn Chips Co.	30	0.011
al_issa industrial&trading co.	25	0.009
Ata Ali Factory	25	0.009
raslan el-kasih &sons co.	20	0.007
Jordan Ceramic Industries Co. Ltd.	20	0.007
Middle East for Medicinal Ind . Co.	15	0.005
sujab ice cream co.	15	0.005
Kasih Factories group for Food Stuff	15	0.005
Hammoudeh food industries co.	12	0.004
Al-Asrya Dairy Co .	12	0.004
Danish Jordanian Dairy Co. Ltd	12	0.004
Al-Morouj Co For Industrial Dairy Products	12	0.004
Belady Dairy Co.	12	0.004
Masoud Dairy Co.	12	0.004
Al-Sanabel Fresh Milk Dairy	12	0.004
Raei Dairy Factory Co .	12	0.004
Jordan jeans co.	10	0.004
National Clothing & Commerce Factory	10	0.004
Spinning & Weaving Co.	10	0.004
Bright Star Factory	10	0.004
Zaidan Factory	10	0.004
Arab Chemical Detergents Industries .	10	0.004
United Chemicals For Battaries Mfg .	3	0.001
Spartin Chemicals Co.	3	0.001
Arabic Fruit Juice Co .	2	0.001
Hashem Karaman Group For Trade & Industr	1	0.000
Shannak &demeri forf ood industries	0	0.000
Al-Khayam Ice Cream Factory	0	0.000
Jordan Polymers &Inter Chem Co.	0	0.000
International Co. for Optical & Hearing Aid Ind	0	0.000
United Co. For Vet. Med. Mfg.		

APPENDIX E

SUBCHAPTER N--EFFLUENT GUIDELINES AND STANDARDS

(www4.law.cornell.edu/cfr, -> Title 40 -> Chapter 1 -> Subchapter N)

Part

- PART 400. [RESERVED]
- 401--GENERAL PROVISIONS
- PART 402. [RESERVED]
- 403--GENERAL PRETREATMENT REGULATIONS FOR EXISTING AND NEW SOURCES OF POLLUTION
- 405--DAIRY PRODUCTS PROCESSING POINT SOURCE CATEGORY.
- 406--GRAIN MILLS POINT SOURCE CATEGORY
- PART 407. CANNED AND PRESERVED FRUITS AND VEGETABLES PROCESSING POINT SOURCE CATEGORY
- PART 408. CANNED AND PRESERVED SEAFOOD PROCESSING POINT SOURCE CATEGORY
- 409--SUGAR PROCESSING POINT SOURCE CATEGORY
- 410--TEXTILE MILLS POINT SOURCE CATEGORY
- 411--CEMENT MANUFACTURING POINT SOURCE CATEGORY
- 412--FEEDLOTS POINT SOURCE CATEGORY
- 413--ELECTROPLATING POINT SOURCE CATEGORY
- 414--ORGANIC CHEMICALS, PLASTICS, AND SYNTHETIC FIBERS
- 415--INORGANIC CHEMICALS MANUFACTURING POINT SOURCE CATEGORY
- PART 416. [RESERVED]
- 417--SOAP AND DETERGENT MANUFACTURING POINT SOURCE CATEGORY
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- 434--COAL MINING POINT SOURCE CATEGORY BPT, BAT, BCT LIMITATIONS AND NEW SOURCE PERFORMANCE STANDARDS
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- 443--EFFLUENT LIMITATIONS GUIDELINES FOR EXISTING SOURCES AND STANDARDS OF PERFORMANCE AND PRETREATMENT STANDARDS FOR NEW SOURCES FOR THE PAVING AND ROOFING MATERIALS (TARS AND ASPHALT) POINT SOURCE CATEGORY
- 446--PAINT FORMULATING POINT SOURCE CATEGORY
- 447--INK FORMULATING POINT SOURCE CATEGORY
- 454--GUM AND WOOD CHEMICALS MANUFACTURING POINT SOURCE CATEGORY
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- 457--EXPLOSIVES MANUFACTURING POINT SOURCE CATEGORY
- 458--CARBON BLACK MANUFACTURING POINT SOURCE CATEGORY
- 459--PHOTOGRAPHIC POINT SOURCE CATEGORY
- 460--HOSPITAL POINT SOURCE CATEGORY
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- 463--PLASTICS MOLDING AND FORMING POINT SOURCE CATEGORY
- 464--METAL MOLDING AND CASTING POINT SOURCE CATEGORY
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- 468--COPPER FORMING POINT SOURCE CATEGORY
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- 471--NONFERROUS METALS FORMING AND METAL POWDERS POINT SOURCE CATEGORY

APPENDIX F

No	Factory	Location	Quantity (m3/day)	Discharged to	TDS (mg/l)	TDS (Kg/d)	AZ basin
1	Kamel Azar For Soab Factory	Irbid	Stoped now	-	1442		no
2	Masoud Dairy Co.	Al Hashemiah, Zarqa	12	Irrigation	1808	22	yes
3	Unium Co.	Urainbah, Amman	40	Irrigation	1041	42	no
4	Pepsi Cola Co./Irbed	Al Ramtha, Irbid	50	Irrigation	2182	109	no
5	Middle East Co. For Food Mfg.	Al Jeazah, Amman	50	Irrigation	2636	132	no
6	Dar Al-Dawa'	Naur, Amman	200	Irrigation	982	196	no
7	Poultry Slughter-House	Al Dhlail, Zarqa	200	Irrigation	1421	284	yes
8	Miller Beer Co.	Al Jeazah, Amman	800	Irrigation	995	796	no
9	J. Petroleum Refinary/Domastic	Al Hashemiah, Zarqa	800	Irrigation	1807	1446	yes
10	Tomato Juice Factory / Arda	Der Ala, Al Ghore	2200 (in summer)	Irrigation	660	1452	no
11	Jordan Yeast Co.	Al Rusaifah, Zarqa	500	Irrigation	17349	8675	yes
12	Hadeal Factory For Juice	Ain Al Basha, Salt	0.2	Public sewer	601	0	yes
13	ICA Company Ltd.	Rusaifah, Zarqa	110	Public sewer	1415	156	yes
14	Jordanian dairy Co. Ltd.	Awjan St, Zarqa	170	Public sewer	1617	275	yes
15	Eagle Distileries Co.	Old Zarqa	150	Public sewer	3832	575	yes
16	Jordan Tanning Co. Ltd.	Zarqa	300	Public sewer	14272	4282	yes
17	National Iron &Steel Co.	Zarqa	0	recycling	1830	0	yes
18	Al-Mosely Factory For Ceramec	Sahab, Amman	80	recycling	666	53	no
19	Hussein Steel Factory	Al Ish Valley, Zarqa	40	recycling	1712	68	yes
20	Medmak Factory for Vet.Medicin	Al Ramtha, Irbid	0.1	Tank	2700	0	no
21	Delux Pants Factory /Qastal	Al Qastal, Amman	2	Tank	3168	6	no

No	Factory	Location	Quantity (m3/day)	Discharged to	TDS (mg/l)	TDS (Kg/d)	AZ basin
22	Disinfection & detergant Fact.	Salt	5	Tank	4580	23	no
23	Al-Kawthar Dairy Co.	Al Khaldiah Mafraq	12	Tank	2564	31	yes
24	Aggricultural Mafraq Co.	Al Za'atary, Mafraq	40	Tank	1046	42	yes
25	Intermediate Petrochmicals Ind	Al Ish Valley, Zarqa	11	Tank	5026	55	yes
26	Selpho chemicals Co.	Al Ish Valley, Zarqa	10	Tank	25299	253	yes
27	Aread Co. For Oil & Deterget	Sahab, Amman	30	Tank	9766	293	no
28	United Co. for Chem & Oil Ind.	Al Jeazah, Amman	30	Tank	19290	579	no
29	Middle East For Textile Co.	Al Ish Valley, Zarqa	60	Used by Al	3533	212	yes

Summary table of Heavy Metals for industrial effluent

Factory	Quantity *(m3/day)*	Discharged to	Year	Fe	Fe	Mn	Mn	Cu	Cu	Zn	Zn	Cr	Cr	Ni	Ni	Pb	Pb	AZ Basin
				mg/l	***Kg/d***	*mg/l*	***Kg/d***	*mg/l*	***Kg/d***	*mg/l*	***Kg/d***	*mg/l*	***Kg/d***	*mg/l*	***Kg/d***	*mg/l*	***Kg/d***	
Unium Co.	40	Irrigation	99	0.28	0.0112	0.06	0.0024	0.08	0.0032	0.25	0.01	0.04	0.0016	0.05	0.002	0.15	0.006	No
Middle East Co. For Food Mfg.	50	Irrigation	99	_	0		0	0.19	0.0095	0.26	0.013	0.01	0.0005	0.345	0.01725			No
PepsiCola Co.Irbed	50	Irrigation	00	0.2375	0.011875	0.16	0.008	0.0925	0.0046	0.28	0.014	0.0225	0.0011	0.0825	0.004125	0.48775	0.024	No
Dar Al Dawa'	200	Irrigation	00	0.495	0.099	0.22	0.044	0.01	0.002	1.075	0.215	0.025	0.005	0.115	0.023	0.055	0.011	No
Poultry Slughter House	200	Irrigation	00	0.13	0.026	0.15	0.03	0.01	0.002	0.15	0.03	0.01	0.002	0.01	0.002	0.03	0.006	Yes
Jordan Yeast Co.	500	Irrigation	00	5.3	2.65	0.28	0.14	0.14	0.07	0.7	0.35	0.24	0.12	0.49	0.245	0.48	0.24	Yes
J. Petroleum Refinary.Domastic	800	Irrigation	98	0.395	0.316	0.036	0.0288	0.016	0.0128	0.206	0.165	0.023	0.0184		0		0	Yes
Miller Beer Co.	800	Irrigation	00	0.21	0.165	0.03	0.0213	0.01	0.008	0.66	0.531	0.01	0.0107	0.07	0.056	0.08	0.062	No
Tomato Paste Factory	2200 (in summer)	Irrigation	96	2.41	5.302	0.05	0.11	0.1	0.22	0	0	0.12	0.264	0.28	0.616	0.02	0.044	No
ICA Company Ltd.	110	Public sewer	99	0.08	0.0088	0.03	0.0033	0.03	0.0033	0.17	0.019	0.085	0.0094	0.045	0.00495	0.035	0.00385	Yes
Eagle Distileries Co.	150	Public sewer	00	0.32	0.048	0.01	0.0015	0.01	0.0015	0.34	0.051	0.01	0.0015	0.01	0.0015	0.02	0.003	Yes
Jordanian dairy Co. Ltd.	170	Public sewer	99	0.38	0.0646	0.06	0.0102	0.11	0.0187	0.75	0.128	0.14	0.0238	0	0	0.25	0.0425	Yes
Jordan Tanning Co. Ltd.	300	Public sewer	99	1.05	0.315	0.1225	0.0368	0.105	0.0315	1.82	0.546	0.295	0.0885	0.325	0.0975	0.25	0.075	Yes
National Iron &Steel Co.	0	recycling	00	0.06	0	0.23	0	0.03	0	0.22	0	0.01	0	0.19	0	0.001	0	Yes
Hussein Steel Factory	40	recycling	00	0.39	0.0156	0.39	0.0156	0.05	0.002	0.31	0.012	0.02	0.0008	0.22	0.0088	0.04	0.0016	Yes
Al-Mosely Factory For Ceramec	80	recycling	00	0.25	0.02	0.01	0.0008	0.01	0.0008	1.02	0.082	0.01	0.0008	0.1	0.008	0.09	0.0072	No
Medmak Factory for Vet.Medicin	0.1	Tank	00	0.23	0.000023	0.03	3E-06	0.04	4E-06	0.15	2E-05	0.01	1E-06	0.02	0.000002	0.11	0.000011	No
Delux Pants Factory /Qastal	2	Tank	00	0.66	0.00132	0.01	2E-05	0.01	2E-05	0.66	0.001	0.03	6E-05	0.43	0.00086	0.06	0.00012	No
Disinfection & detergant Fact.	5	Tank	99	0.42	0.0021	0.86	0.0043	0.34	0.0017	0.73	0.004	0.12	0.0006	0.05	0.00025	0.03	0.00015	No
Selpho chemicals Co.	10	Tank	00	3.65	0.0365	0.275	0.0028	0.135	0.0014	1.47	0.015	0.175	0.0018	0.295	0.00295	0.375	0.00375	Yes
Intermediate Petrochmicals Ind	11	Tank	99	0.17	0.00187	0.06	0.0007	0.15	0.0017	0.25	0.003	0.15	0.0017	0.23	0.00253	0.1	0.0011	Yes
Aread Co. For Oil & Deterget	30	Tank	00	1.82	0.0546	0.05	0.0015	0.13	0.0039	0.51	0.015	0.04	0.0012	0.02	0.0006	0.03	0.0009	No
United Co. for Chem & Oil Ind.	30	Tank	99	0.7	0.021	0.06	0.0018	0.22	0.0066	0.51	0.015	0.86	0.0258	0.31	0.0093	0.09	0.0027	No
Aggricultural Mafraq Co.	40	Tank	00	0.12	0.0048	0.01	0.0004	0.02	0.0008	0.32	0.013	0.04	0.0016	0.1	0.004	0.01	0.0004	Yes
Middle East For Textile Co.	60	Used by Al	00	0.12	0.0074	0.12	0.007	0.02	0.0012	0.34	0.02	0.04	0.0024	0.15	0.009	0.05	0.0032	Yes
Kamel Azar For Soab Factory	Stopped now	_	99	0.565		0.09		0.125		0.96		5.31		0.045		2.65		No