Section 9
Development of Water and Wastewater Alternatives

This section will identify and evaluate water and wastewater alternatives based on prioritized options in previous sections. As a first step, water and wastewater alternatives are developed independently and a prioritization process is carried out in order to eliminate those that do not warrant additional consideration.

Once water and wastewater alternatives have been independently identified they will be combined in Section 12 to form global alternatives. Global alternatives are then developed and evaluated in order to finally obtain the recommended alternative. Because of this, the description of alternatives will be detailed in Section 12, where investment and operation and maintenance costs and dimensions for different works included in each alternative will be presented. In said section the alternatives will be evaluated and the preferred alternative selected.

Last, Section 14 will present in greater detail the preferred alternative, including the elaboration of an investment program for the planning period (20 years) and the stages in which the works will have to be implemented.

The identification of alternatives was carried out by taking into consideration alternative evaluation criteria established by CESPT in the BTC, which is described in Section 12.2 and used for the evaluation of alternatives. Said criteria includes: cost, level of environmental impact, implementation and performance risk level, ratio between the amount of underground water extracted and artificial recharge of the aquifer with high quality water, reduction of wastewater discharges into transboundary bodies of water, efficient management of waste sludges and the percentage of reused effluent.

9.1 Water Alternatives

The water sources that offer a major potential for solving the projected deficit for Tijuana and Playas de Rosarito are identified and prioritized in Section 7, as well as the most adequate water plant options for each source. The prioritized potential sources are:

Â Río Colorado

Â Seawater desalination

Â Indirect potable use of the effluent

Based on these three potential water sources, the following 9 water alternatives were identified:

Alternative A – Optimize the use of the Colorado River
As part of this alternative, 100 percent of the water supply necessary to satisfy the projected deficit would come from the Colorado River, which would require the construction of a new aqueduct, a storage dam, and water plant infrastructure.

The main advantages of this alternative are its relatively simple operation and the sustainable nature of the source. On the other hand, the cost of constructing the aqueduct and water plants would be relatively high. Likewise, the works implementation period would be long (the aqueduct would start operating in the year 2012), therefore short and medium term needs would not be satisfied.

Dependence on only one water source to basically satisfy the total demand, considering that currently this source constitutes 94 percent of the supply, would not comply with the criteria established by the CESPT in the matter of sources diversification and promotion of water reuse.

Alternative B – Optimize Seawater Desalination
Under this alternative, the projected deficit would only be satisfied with the desalination of seawater, which represents an inexhaustible water source in the study area. The construction of a desalination plant would increase the diversity of sources and reduce CESPT's dependency on the Colorado River. Likewise, the desalination would have low conduction requirements, differently from river water. Last, seawater availability would not be subject to draughts as is the case of the river.

However, desalination presents some important challenges. First, the construction and operation and maintenance costs will be high. The desalination technology is relatively complex and Mexico has little experience in this type of plants. Last, the requirements established by the corresponding authorities for disposal of brine, product of the water plant process could increase the cost of this alternative even more.

The operation of the desalination plant, as well as the aqueduct, will have considerable energy requirements.

Alternative C.1 – Desalination of Seawater for Costal Zones and Additional Water from the Colorado River
The two previous alternatives can be combined to create this alternative, which has a desalinating plant as well as an aqueduct. The combination of these sources will allow the optimization of the use of one or another source depending on the seasonal conditions of the system. The disadvantages of this alternative are similar to the combination of the disadvantages of the two previous alternatives: high investment and maintenance costs, high electric energy requirements, brine disposal and continuity in the use of the river as a main source.

Alternative C.2 – Desalination of seawater for coastal zones and indirect potable use
As part of this alternative the construction of a seawater desalination plant is proposed to supply the coastal zone, while the supply for the Tijuana River basin zone would increase through indirect potable reuse. This alternative allows the diversification of water sources, because there would be two new sources besides current sources (Colorado River and wells) and promote the use of sustainable sources.

The indirect potable reuse of highly treated effluent would be accomplished through advanced treatment of a portion of the secondary effluent from the treatment plants through a micro-filtering and reverse osmosis process to produce high quality water, which would be stored in the Abelardo L. Rodriguez Dam or recharged into the Tijuana River aquifer. Once it has been extracted from the dam or aquifer for potable use, the water would be treated once again through a conventional water plant process in the case of the dam, or with aquifer disinfection.

The exact point of recharge and extraction of the aquifer and the reservoir should be studied in detail in facilities planning phases. The hydrogeologic, geochemical and chemical (water quality) characteristics of the aquifer should also be studied in detail to determine the points and rates of recharge and extraction, as well as to guarantee that the quality of recharge water will not be degraded once in the aquifer as a result of the eventual groundwater contamination.

Aside from those concerning the desalinization of seawater, which were previously described under Alternative B, this alternative presents a series of additional disadvantages, the obstacles previously described under Alternative B, for the implementation of desalinization programs, plus its own indirect potable reuse program disadvantages, which mainly include potential difficulties from the political perspective and public acceptance. In addition, it would require robust control systems to reduce potential public health and environmental risks as much as possible, which were created by the reuse program. Nevertheless, the reuse program would require two treatment levels: the advanced treatment of the secondary effluent and potabilization before its distribution into the water system, in addition to effluent transfer requirements to the discharge sites, from these to the water plants and from the prior ones to the distribution system. In the country, experience with these types of projects is limited.

Alternative D – Maximize indirect potable reuse
Under this alternative, the projected deficit would be covered through the indirect use of the highly treated effluent, through the process described for the previous alternative.

The main advantages of this alternative are related to the CESPT interest in promoting reuse and to the sustainability criteria. On the other hand, as was previously

mentioned, the implementation of this alternative could be difficult from the political and public acceptance perspective.

Alternative E.1 – Indirect potable reuse of La Morita and Monte de los Olivos effluent from wastewater treatment plants and additional water from the Colorado River

The La Morita and Monte de los Olivos treatment plants will be built by CESPT, close to the Abelardo L. Rodriguez Dam, with Japanese credits. Under this plan, part of the secondary effluent from the plants would be additionally treated with micro-filtration and reverse osmosis in order to be discharged later into the dam, where it would be retained for a certain period of time before being extracted, potabilized and transferred to the distribution system. In addition, part of the projected deficit would be covered with additional water from the Colorado River.

Only reuse is proposed for this alternative through discharge into the dam and recharge of the aquifer is eliminated, given the distance that exists between the plants and potential recharge sites.

The main advantage that this alternative has is that it combines renewable sources and promotes sustainability. However, indirect potable reuse is limited to the La Morita and Monte de los Olivos plants, while the effluent from other plants would only be discharged into the ocean.

The disadvantages of this alternative are similar to those presented for additional exploitation of the river and indirect potable reuse presented previously: need for additional water rights, availability of water from the river in case of draughts, and public acceptance of reuse, among others.

Alternative E.2 – Indirect potable reuse of effluent from wastewater treatment plants La Morita and Monte de los Olivos and seawater desalination

This alternative is similar to the previous one, but this time indirect potable reuse is combined with the desalination plant instead of the river. The great attraction this alternative has consists of a greater diversification of water sources, since it would have input from the river similar to the current one, plus two new sources: desalinated seawater and indirect potable reuse.

Alternative F – Indirect potable reuse and seawater desalination

The only difference between this alternative and the previous one would consist in that the reuse would not be limited to the effluent from the La Morita and Monte de los Olivos treatment plants or to the discharge into the dam. Other plants considered in Section 8, such as the Alamar regional plant, would also have to be used for reuse.

Alternative G – Indirect potable reuse, seawater desalination and additional water from the Colorado River

Alternative G combines three prioritized water sources. Differently from other alternatives that combine three water sources, this one includes the construction of a

new aqueduct to increase the current supply from the Colorado River. It should be mentioned that even though this alternative has three additional water sources, while the others only include two, it does not represent the best option with the greatest diversity of sources, because it increases even more the use of the Colorado River, which currently contributes 94% of the supply.

9.2 Prioritization of Water Alternatives

Once the 9 alternatives have been defined a prioritization is made in order to identify the alternatives that deserve a more detailed evaluation. A summary of the advantages and disadvantages related to each one of the 9 alternatives identified is shown in Table 9-1.

Table 9-1
Comparison of Water Alternatives

Alternative	Advantages	Disadvantages
Alternative A – Maximize river use	Á Renewable source Á Experience with this source Á Simple technology Á Less implementation risk	Á Requires new aqueduct with high investment costs, construction time and potential environmental impact Á Requires potabilization besides high transfer requirements Á Requires additional water rights Á Subject to availability of water from the river during draughts Á Transfer cost (pumping) Á Dependence on only one source Á Does not promote reuse
Alternative B – Maximizes seawater desalination	Á "Inexhaustible" water source Á Does not require additional water rights Á Low transfer requirements Á Water availability during draughts Á Source diversification	Á High investment and operation costs Á Requirements for management and disposal of brine Á Does not promote reuse Á Technology not used frequently in Mexico
Alternative C.1 – Seawater desalination for costal zones and additional water from the Colorado River	Á Desalination presents an inexhaustible source and the river a renewable source Á Potential for optimizing mixture of sources according to availability conditions (draughts), operation cost, etc. Á Source diversification	Á High investment, operation and maintenance costs Á Requirements for management and disposal of brine Á Does not promote reuse Á Requires additional water rights

Table 9-1
Comparison of Water Alternatives

Alternative	Advantages	Disadvantages
		Á Requires new aqueduct with high investment costs, construction time and potential environmental impact Á Desalination is limited to coastal zones
Alternative C.2 – Seawater desalination for costal zones and indirect potable reuse	Á More source diversification (Colorado River continues being used under current conditions) Á Desalination has an inexhaustible source Á Potential to optimize the mixture of sources according to availability conditions (draught), operation cost, etc. Á Does not require additional water rights Á Low risk during draughts Á Promotes water reuse (sustainability) Á Reduces requirements to move away wastewaters from the Tijuana River basin	Á The indirect potable reuse could have public acceptance problems Á Reuse could have greater risk to public health Á Requires two treatment systems: micro filtration and reverse osmosis plus potabilization prior distribution Á Requires extensive control systems Á Little experience in Mexico with this type of systems Á Potential accumulation of harmful substances resulting from recycling Á Considerable requirements for effluent management for reuse and for discharge of effluent not reused Á High investment and operation and maintenance costs Á Requirements for management and disposal of brine Á Desalination is limited to coastal zones

Table 9-1
Comparison of Water Alternatives

Alternative	Advantages	Disadvantages
Alternative D – Maximize direct potable reuse	Á Promotes water reuse (sustainability) Á Reduces requirements to move away wastewater from the Tijuana River basin Á Does not require additional water rights	Á The indirect potable reuse could have public acceptance problems Á Reuse could have greater public health risks Á Considerable emphasis on only one additional source Á Requires two treatment systems: micro filtration and reverse osmosis plus potabilization prior distribution Á Requires extensive control systems Á Little experience in Mexico with this type of systems Á Potential accumulation of harmful substances resulting from recycling Á Considerable requirements for effluent management, for reuse and for discharge of non reused effluent to the ocean
Alternative E.1 – Indirect potable reuse of effluent from La Morita and Monte de los Olivos wastewater treatment plants and additional water from the Colorado River	Á Combines renewable sources and promotes sustainability Á Reduces requirements to move away wastewaters from the Tijuana River basin	Á Limits the potential for reuse to the La Morita and Monte de los Olivos plants Á Requires additional water rights Á Requires new aqueduct with high investment costs, construction time and potential environmental impact Á The indirect potable reuse could have public acceptance problems Á Reuse could present greater public health risks

Table 9-1
Comparison of Water Alternatives

Alternative	Advantages	Disadvantages
Alternative E.2 – Indirect potable reuse of effluent from the La Morita and Monte de los Olivos wastewater treatment plants and seawater desalination	Á Advantages similar to Alternative C-2, but desalination is not limited to coastal zones	Á Disadvantages similar to Alternative C-2, but, reuse is limited to La Morita and Monte de los Olivos plants
Alternative F – Indirect potable reuse and seawater desalination	Á Advantages similar to Alternative E-2, but does not limit the reuse to the La Morita and Monte de los Olivos plants	Á Disadvantages similar to Alternative E-2, but desalination is limited to coastal zones
Alternative G – Indirect potable reuse of seawater and additional water from the Colorado River	Á All the sources are utilized Á Advantages similar to those previously described for each one of the sources, individually	Á Disadvantages similar to those previously described for each one of the sources, individually

Some of the alternatives are very similar and can be combined to reduce the number of alternatives to be developed, and therefore make better use of available resources to elaborate a master plan. For example, alternatives C.2 and E.2 include seawater desalination and indirect potable reuse. The only difference between these alternatives is that the first one limits the reuse to effluent from La Morita and Monte de los Olivos treatment plants. The creation of an alternative in which reuse and desalination can be evaluated without this type of limitations would tolerate a more detailed analysis of this type of combined sources, while the decision on service areas from each facility would later be taken into consideration in case this alternative s selected.

The following is an analysis of the merits for each alternative and it justifies which of them will be considered for the rest of the plan.

Alternative A presents an important limitation for its implementation because the construction time for the new Colorado River aqueduct will take at least 10 years. Since under this alternative the river would represent the only additional water source and considering that currently there is a deficit to satisfy the day's maximum demands, with its implementation the deficit could be maintained until the year 2013, which is unacceptable to comply with the CESPT goals. Therefore Alternative A will not be considered for the elaboration of alternatives, even though the option of constructing a new aqueduct will continue being analyzed as part of the other alternatives.

Alternative B does not present disadvantages that cannot be mitigated; as a result these alternatives will be kept for the elaboration of a more detailed analysis. The construction of a desalination plant would take much less time than the aqueduct, therefore the period during which there would be a deficit to satisfy the day's maximum demand would be considerably reduced. Likewise, this alternative would reduce CESPT's dependence on the Colorado River.

Alternative C.1 presents important advantages by combining desalination with the construction of a new aqueduct. Under this plan, the desalinating plant could be built at short term to eliminate the water deficit as soon as possible while the new aqueduct could start operating at medium or long term. However, it is contemplated that the desalination should not be limited to coastal zones for this level of analysis, but that this should be a decision that could be made later. This alternative will be maintained and will be evaluated later, but the service area in the desalinating plant will be open to the whole study area.

Similarly, Alternative C.2 has the great advantage of introducing new water sources (desalination and indirect potable reuse), which would contribute to the diversification of sources. However, this alternative also limits desalination to the coastal zones. On the other hand, Alternatives E.2 and F also include a combination of desalination and indirect potable use, which makes them very similar to C.2. However, Alternative E.2 limits indirect potable reuse to the La Morita and Monte de los Olivos plants effluent, while the other two alternatives leave open the possibility of reusing the effluent from any plant. The combination of these three alternatives into only one that combines desalination with reuse but that does not limit the service area of the works would be practical for the elaboration and evaluation of alternatives, therefore Alternatives C.2 and E.2 will be eliminated and only Alternative F will be kept.

Alternative D puts too much emphasis on indirect potable use, which, as was previously described, has the largest number of disadvantages from the three sources analyzed. The two main disadvantages for this option are the potential risks to public health and the probable lack of public acceptance. Public health risks would be reduced through the use of adequate technology and the implementation of control methods. However, any failure in treatment or quality control processes could have a considerable negative impact on users. Consequently, it is recommended that any water reuse program be accompanied by the implementation of programs to use other water sources. Therefore, indirect potable use will play an important role in water supply, but if necessary it could be omitted during emergency situations. Likewise, a considerable number of detailed studies are needed in order to continue with the design and construction of the necessary works for reuse. For that reason, the short-term implementation of this alternative, which is necessary to satisfy water deficit, would not be very practical. For these reasons, Alternative D will be eliminated and the indirect potable reuse option will be kept as part of the alternatives, in combination with other sources.

Alternative E.1 includes indirect potable reuse in combination with the construction of a new aqueduct. However, the reuse option is limited to the effluent from the La Morita and Monte de los Olivos treatment plants. This alternative will be kept for the remainder of the evaluation, but the possibility of using any treatment plant will be kept open for the indirect potable reuse.

Alternative G combines three potential water sources and therefore will be used in the remainder of the evaluation.

Once this first level of prioritization has been elaborated, a short list was obtained with the following options:

- Alternative B – Maximize seawater desalination
- Alternative C – Seawater desalination and additional water from the Colorado River
- Alternative E – Indirect potable reuse and additional water from the Colorado River
- Alternative F – Indirect potable reuse and seawater desalination
- Alternative G – Indirect potable reuse, seawater desalination and additional water from the Colorado River

Afterwards, during a meeting of the BTC the idea of combining Alternatives C, E and G into one was presented and approved, which would include the three options for water sources. These three alternatives have in common the construction of the Colorado River aqueduct in combination with one of the other sources or both. Later, through the final selection of Alternative G, the implementation phases could be optimized, which at a given moment could exclude desalination options or indirect potable reuse and regress to Alternatives C or E.

Table 9-2 shows 3 prioritized water alternatives. In subsequent sections wastewater alternatives are identified and prioritized in order to combine later on the three prioritized water alternatives in order to create global alternatives.

Table 9-2
Prioritization of Water Alternatives

Alternative	Description
Alternative B	Maximize seawater desalination
Alternative F	Seawater desalination in combination with indirect potable reuse
Alternative G	Seawater desalination, additional water from the Colorado River and indirect potable use

9.3 Wastewater Alternatives

Different options for wastewater treatment were analyzed in Section 8 and, for the purpose of planning and estimating costs, conventional activated sludge is a good option. This technology is able to produce an effluent that would comply with the Mexican standards and with quality goals established for this project. This option allows the development of adequate cost estimates for planning purposes. In subsequent phases to the master plan the actual technology for the secondary treatment will need to be determined as part of a facilities plan.

Five wastewater alternatives were identified (4 alternatives plus the Public Law) taking into consideration different characteristics from the study area: topographic, location of service zones, potential effluent discharge sites and sites available for the construction of treatment plants, etc.

One of the basic assumptions of this master plan is the fact that there cannot be any raw wastewater discharges or from treated effluent into the Tijuana River or any other transboundary body of water, with the exception of the Pacific Ocean. As a result, any treatment plant taken into consideration should include the necessary infrastructure to discharge effluent into the ocean, either in Mexico or through its South Bay ocean outfall in San Diego, or for its reuse in Mexico. This requirement will impact infrastructure needs of any of the proposed alternatives.

All the alternatives include the base wastewater infrastructure described in Section 6: SBIWTR, San Antonio de los Buenos Plant, Rosarito plant and the four plants that will be built by CESPT with Japanese credit in La Morita, Monte de los Olivos, Tecolote-La Gloria and Rosarito II plants. Likewise, common treatment infrastructure will exist for all the alternatives that will provide service to communities located to the south of Playas de Rosarito (Puerto Nuevo, Popotla, La Misión and Mesa del Descanso) as described later.

The following is a description of five alternatives, as well as their main advantages and disadvantages.

Alternative A – United States Public Law Treatment Plant

The United States Public Law 106-457, Title VIII, entitled Tijuana River Valley Estuary and Beach Cleanup, dated November 6, 2000, is described in Section 8.7. It states that subject to the negotiation of a new treaty minute, the United States International Boundary and Water Commission (USIBWC) is authorized to take the necessary measures to provide secondary treatment in Mexico of up to 50 million gallons per day (mgd) (2,190 l/s) of: 1) 25 mgd (1,095 l/s) of advanced primary effluent of the South Bay International Wastewater Treatment Plant (SBIWTP) and 2) of additional wastewater generated in Mexico. Additionally, the Public Law plant could provide 25 additional mgd (1,095 l/s) of secondary treatment in Mexico subject to the results of the comprehensive plan. The secondary effluent from the Public Law facility could be reused in Mexico or the United States (after additional treatment) or discharged through the San Diego South Bay Ocean Outfall. Under the Public Law, the facility would be a privately constructed and owned wastewater treatment facility located in Mexico, which would then be financed under a twenty-year contract with the USIBWC. U.S. funds would be available for this contract.

The Public Law Plant was analyzed in the master plan as a scenario in the implementation of alternatives, since the Public Law could be implemented under any of the master plan alternatives. For this reason, the comparison of wastewater

alternatives in terms of advantages and disadvantages is made for alternatives B through E only.

Alternative B – Treatment plant in the Alamar River zone
As part of this alternative, a plant for activated sludges will be built in the Alamar River zone, to treat raw wastewater in the study area, specifically in the Tijuana River basin. Besides the treatment plant, this Alternative would require the construction of wastewater conveyance infrastructure to the treatment plant, as well as the necessary infrastructure to transfer secondary effluent to the Pacific Ocean, either exclusively within Mexican territory or through the South Bay ocean outfall.

Alternative C – Treatment plants in the Alamar River zone and Coastal Zone
Under Alternative C, a treatment plant will also be built in the Alamar River zone, even though it has less capacity than that considered within the two previous Alternatives. Excess wastewater generated from the plant in the Alamar zone will be transferred outside of the Tijuana River basin for its later treatment at a plant located in the coastal zone and its discharge to the sea. At the same time, the coastal plant could provide service to the basins that drain into the ocean.

The needs for transferring raw wastewater will be greater in this Alternative than in prior alternatives, since part of the wastewater generated will have to be sent outside of the Tijuana River Basin. On the other hand, the needs for transferring treated effluent will be reduced, since it could be directly discharged into the sea.

Alternative D – Treatment plant in the Coastal Zone
Alternative D considers the construction of only one regional treatment plant located outside the Tijuana River Basin. Wastewater generated within said basin will be collected and concentrated at a lower point in the system, close to the border, to be sent later on to the new treatment plant. This Alternative would have a routine similar to the current one, in which the majority of the wastewater, with the exception of flows treated at La Morita and Monte de los Olivos plants, will be taken out of the basin for its treatment and disposal in the sea.

It is expected that wastewater transfer requirements would be greater for this Alternative than for prior ones, even though effluent transfer requirements will be minimum. The implementation of this alternative will considerably reduce the water reuse feasibility, since it would be required to transfer treated effluent back to the basin, where the majority of the potential users are located.

Alternative E – Treatment plant in the Alamar River zone and expansion of La Morita plant
As part of alternatives A and B (treatment plant in the Alamar River zone) wastewater is collected and transferred through collectors to a site close to the intersection of the Tijuana and Alamar rivers, where it is captured and pumped along the Alamar River to a more elevated point for its treatment. These transfer requirements contribute to

the construction and operation and maintenance costs (pumping) of these Alternatives.

The objective under Alternative E is to reduce the needs to transfer wastewater through the expansion of La Morita treatment plant, which is located at a more elevated point than the site where the pumping station for Alternatives A and B would be constructed. Water generated upstream or close to La Morita would be captured and transferred to this plant by gravity or relatively small pumping. On the other hand, water generated downstream from La Morita would flow by gravity to the pumping station located close to the intersection of the rivers in order to be transferred later to the Alamar plant.

In addition, the generation of additional effluent in La Morita would increase the

Table 9-3 Comparison of Wastewater Alternatives		
Alternative	**Advantages**	**Disadvantages**
Alternative E – Treatment plant in the Alamar River zone and expansion of La Morita Plant	Á The needs for pumping wastewater would be reduced Á The potential for indirect potable reuse would increase through the discharge of the Abelardo L. Rodriguez Dam Á Potential for non potable reuse in relatively close industrial zones	Á Need for a pumping station of considerable dimensions in the congested zone at the intersection of the Alamar and Tijuana Rivers

As was previously mentioned, these Alternatives will be combined with water Alternatives previously described in Section 12 to develop and evaluate global Alternatives. That section will include Alternatives' details with regards to dimensions, costs and other selection criteria.

9.5 Common Elements to all the Alternatives

The following is a description of water and wastewater Alternatives that have a series of common components. Section 12 includes a detailed description of improvement and expansion works for water and wastewater distribution systems, including dimensions and investment costs.

Expansion of water and wastewater distribution systems

As was seen in Section 6, currently (year 2002) 95% of the population in the study area has access to the water distribution system, while 87% has sewage service. The goal CESPT has is to slowly increase the water distribution system coverage in the next 5 years until it reaches 100% of the population in 2008. On the other hand, the sewage system will be expanded to reach 90% coverage in 2004, 95% in 2012 and 100% in the year 2023.

The expansion of the systems is considered common to all the Alternatives. Section 12 includes a cost estimate to expand the systems.

Cleaning, inspection and improvement of the sewage system

CESPT should continue with its sewage system cleaning, inspection and improvement programs, including main collectors and sub-collectors, manholes and secondary lines. The Healthy Tijuana improvement program that is currently being built should continue through other phases.

System improvement and leak reduction

In a manner similar to the programs that have been recommended for the sewage system, CESPT should implement similar programs to inspect and improve water distribution lines. The lines in need of repair not only represent a problem in loss of water (leaks), but also water contamination risks. Even though the physical loss rate in the Tijuana and Rosarito system are considered acceptable in comparison to the

national average (see Section 6), the additional reduction of leaks or maintaining the system in good status to prevent future leaks should be one of CESPT's goals.

New users hook-up program
Besides expanding the water and sewage distribution systems, a program should be established to promote the hook-up of new users in an orderly manner and in compliance with construction and installation guidelines for hook-ups (including meters) and wastewater discharges. This program should take into consideration technical and financial aspects, searching for high quality facilities but at the same time guaranteeing payment capability of this type of users.

The connection programs for new users to the potable water system should look not only to provide the service to persons who currently do not have it, but also reduce the number of irregular users, and with it be able to collect new rates. The new individual hook-ups to the sewage system, will contribute to the reduction of discharges into the environment or to the use of waste disposal alternatives of lesser quality.

Industrial and commercial discharge control program
The sewage and wastewater system in the city of Tijuana had in the year 2001 approximately 276,066 users, of which 254,763 were residential (92.2%), 17,941 commercial (6.5%), 2,335 industrial (0.9%) and 1,027 governmental (0.4%).

The City of Tijuana gathers an important amount of industrial and service facilities, some of which discharge wastewater used in their production processes to the sewage system, besides their discharges from restrooms. This type of discharges has the potential of including toxic, corrosive or explosive substances that could interfere with the operation and integrity of the collection, transfer and wastewater treatment system.

The most important potential impacts of uncontrolled industrial and commercial discharges are: the obstruction of the sewage system (greases and oils), the corrosion of sewage and wastewater structures, accumulation of explosive substances in the sewage system, presence of hazardous substances for the water company's operations' personnel, inhibition of biological processes in treatment plants, with resulting non-compliance in water quality limits for discharges and accumulation of hazardous substances in solid wastes at the plants.

It is evident that due to the risks that un-controlled industrial and commercial discharges offer to the integrity of the sewage and treatment system, to the safety of the water company's staff and the environment, the water company should have an adequate program to control discharges, as well as the jurisdiction and financial resources necessary for its implementation.

Pumping stations evaluation and improvement
The sewage system in the study area has important pumping requirements due to the topography of the zone, the location of the treatment plants and the restrictions that exist for waters flowing into the United States. Some of the stations are located in completely developed areas; therefore the nuisance (for example odors) and potential failures would have a considerable impact on the neighbors. Consequently, it is important that the pumping stations are in optimum conditions and that they have control devices to prevent wastewater spills during irregular situations. It is recommended that CESPT create an evaluation program for this type of facilities and that it carries out necessary improvement works.

Restroom facilities control program
It is recommended that CESPT create a program to control restroom facilities and to regulate this type of toilets and faucets that should be used in any new construction or replacement. Likewise, the connection of drains in the roofs of houses and buildings to the sewage system should be eliminated, which contribute to the problem of inflow of storm water into the system, as mentioned in the next section.

Separation of the sanitary and stormwater sewage systems
There are some points in the sewage system where there are direct inputs of stormwater into the sanitary sewage system. It is recommended that CESPT create a program to eliminate this type of interconnections and to slowly build an independent stormwater system.

The input of storm water into the sanitary system presents two important issues. First, together with the input of stormwater, sand and waste that could accumulate in the pipes enter the system (silt) and contribute to their deterioration. Second, stormwater uses part of the capacity of the lines and treatment plants, which sometimes results in spills, transporting sand to the plants and insufficient treatment.

Waste collection from septic tanks
Even though CESPT's goal is to provide sewage service to 100% of the population in the study area, this cannot be accomplished until the year 2023, according to projections in Section 6. Meanwhile, users lacking this service will continue using alternate systems for the disposal of sanitary (restroom) waste, such as septic tanks. CESPT could assist in reducing potential contamination, infection and nuisances, through the implementation of a program to collect waste accumulated in septic tanks.

Improvements to the operation and maintenance programs of treatment plants
The improvement of existing treatment plants and the construction of new plants, which will represent considerable expenses by CESPT, deserve the implementation of improvements to the operation and maintenance programs at the plants. Among other issues to consider is the creation of reserves and regular budgets for plants' maintenance. Budgets for maintenance (for example the replacement of damaged

parts or that meet their life cycle) should be created independently of the operating budgets (energy, chemical reactive, labor force).

Likewise, certification programs and continuous education programs should be established to certify operators, especially taking into consideration that each time more sophisticated technology will be available.

Water reuse for non-potable purposes (industrial, green areas)
As was mentioned in Section 7, it is considered that non-potable reuse will not be

Detailed studies are required to confirm the feasibility of this option. The geo-hydrological and geo-chemical characteristics of the aquifer should be evaluated to determine the recharge, transfer and extraction capacity, as well as chemical reactions that could take place. Likewise, it is necessary to know in detail the quality of water from the aquifer and the impact that it could have on recharge water. The fact that part of the Alamar River aquifer is located within the urban zone has the potential that the soil and waters from the aquifer might present a degree of contamination.

Study on the optimization of water plants
The El Florido and Abelardo L. Rodriguez water plants will continue operating under any of the alternatives developed, even though they might require improvement. A detailed study is recommended for the identification of rehabilitation works and optimization of both plants.

Study for the management of the Abelardo L. Rodriguez Dam basin
The Abelardo L. Rodriguez Dam will continue performing an important role in the future as a storage body for local runoff water and water imported from the Colorado River. Likewise, under some alternatives the dam will be used to store high quality effluent for indirect potable reuse.

The dam's basin is currently undeveloped, but it is expected that this area will be inhabited at medium term, specially considering the implementation of the Boulevard 2000 project. The basin's development has the potential of impacting runoff patterns towards the dam, as well as the quality of said runoffs and therefore the water stored in the dam.

It is very important that CESPT, in coordination with other authorized agencies, organize a program to control the growth in the basin and to control discharges.

Telemetry
The water distribution and sewage systems in the study area are relatively complex as a result of the topographic conditions and the way in which the systems have been built. The installation of telemetry systems would make it easy to operate the system; it would facilitate the prompt detection of problems and would help optimize the operation, which could result in energy and personnel savings.

Rate study
As part of the agreements recently signed between CESPT and the NADBank, the water company's rate structure has been evaluated and improvements have been proposed and implemented. However, the elaboration of a detailed analysis that analyzes among other things the advantages of implementing a charge for each one of the services provided by CESPT (water, sewage and wastewater) has been recommended and not only for the water service. Likewise, the possibility of organizing rate structures that stimulate water conservation and sanction high use should be considered.

Program to make readings more efficient

In 2001, approximately 33% of the hook-ups registered by CESPT were lacking measurement service, besides the existence of a considerable number of illegal hook-ups. Likewise, it is common for a considerable number of meters to be out of service or badly calibrated.

It is widely accepted that the installation of meters stimulates water conservation and allows income to be in agreement with the real cost of the system. In addition, there are technologies that facilitate the reading of meters, especially for larger users. It is recommended that CESPT strengthen its measurement programs.