APPENDIX D

PLANNING METHODOLOGY

Tucson Water used a scenario planning process to provide a framework for exploring the driving forces and critical uncertainties that will impact water-resource utilization over the next 50 years. Scenario planning provides organizational flexibility by planning for multiple futures (scenarios). Instead of relying on what is known and certain when preparing for the future, scenario planning emphasizes the critical uncertainties. The ability to address future uncertainty will determine the success of any long-range planning effort.

The task of developing sustainable sources of supply in arid, rapidly growing areas has to address a wide range of variables many of which have a high degree of uncertainty. Communities can grow faster or slower than expected, regulations will change, and public sentiment can shift. Tucson Water applied the scenario planning process to address how best to maximize utilization of the Utility’s most abundant renewable water supplies: Colorado River water and locally generated municipal effluent.

The planning process was applied to the water resources currently owned and/or controlled by the City of Tucson in order to define how far these supplies can carry the Utility into the future. It is necessary for the City of Tucson to establish a foundation upon which to build a flexible water-resource portfolio for the future. This planning process identifies supply scenarios based on the current water-resource portfolio and also indicates where supplies may fail to meet projected water demands. Understanding how far existing supplies can be used to meet future demands will help the community in its decision-making process regarding demand management issues as well as the uncertainties associated with acquiring additional water supplies.

PLANNING FOR MULTIPLE FUTURES

The concept of scenario planning gained widespread popularity among private businesses in the 1990s after publication of *The Art of the Long View* by Peter Schwartz (1991). There are many scenario planning methods currently advocated; Tucson Water adapted the Schwartz model to serve its needs. Scenario planning provides organizational flexibility by planning for multiple, equally possible futures (i.e. scenarios). Each future is a unique combination of the identified critical uncertainties. Descriptions of each possible future are developed and provide the basis for identifying and sequencing various projects and programs that would be implemented to realize them. The resulting series of chronologically ordered projects and programs is referred to as the pathway to each future.

Scenario planning is superior to the more one-dimensional planning approach when there are many planning uncertainties. Under the scenario planning approach, each possible future is considered equally likely to occur to maintain a multi-dimensional view of the future. The process involves building pathways to each possible future. However, the overall objective is to identify the common elements that lie on these different pathways. These are the programs and projects (i.e. elements) that are common to the identified futures as shown on Figure D-1.

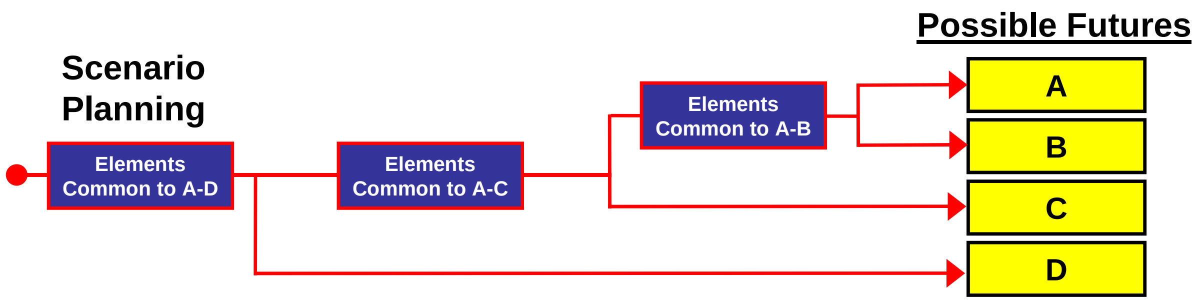

Figure D-1: The Scenario Planning Approach.

By following the path of common elements, capital investments can be directed toward projects that apply to multiple futures providing confidence that the decisions made today will remain viable in future years. As the planning environment changes over time, the scenario planning process is revisited to establish a new baseline of data and assumptions that will again be used to reassess and develop a new range of possible futures. This multi-dimensional approach is the essence of scenario planning.

Tucson Water applied the scenario planning process to assess how to best utilize its currently available water resources by maximizing the use of its most abundant renewable supplies: Colorado River water and municipal effluent. Integration of these two scenario planning assessments created a matrix of possible futures. Related futures were grouped together into four Families of Futures which in turn formed the basis for developing the recommended plan. A step-by-step description of the scenario planning process and how it was applied under each assessment are summarized in the following sections.

THE SCENARIO PLANNING ROAD MAP

Scenario planning can be approached in a number of ways. The steps of the scenario planning process utilized by Tucson Water in developing its long-range water-resource plan are summarized on Figure D-2. A step-by-step overview of the process is provided in this section. For detailed guidance regarding the process, refer to Schwartz (1991).

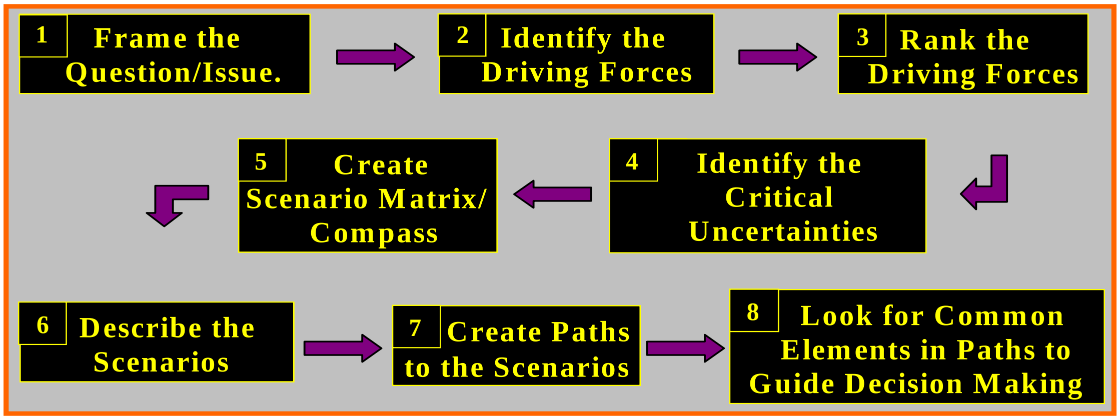

Figure D-2: The Scenario Planning Road Map (after Schwartz, 1991).

Step 1: Frame the Question/Issue

The initial step is to identify the central question or issue that will be assessed. This is accomplished by conducting a brainstorming session with the planning group to generate a list of important issues. The planning group then discusses the various issues to arrive at consensus agreement on the central issue that needs to be addressed.

Step 2: Identify the Driving Forces

A second brainstorming session is held to generate a list of driving forces that have a bearing on the central question. Many of the driving forces are related to the various questions identified in Step 1 while others become evident through the group's discussions. One key is to initially capture all ideas without trying to gauge their relative importance at this stage of the process. The planning group seeks to generate as complete a list as possible.

Step 3: Rank the Driving Forces

Once the list of driving forces is established, the planning group evaluates each one. The driving forces are ranked based upon their relative importance versus their relative uncertainty with respect to the central issue. Each driving force is plotted on a graph of these characteristics as shown on Figure D-3. The driving forces of greatest interest are those that are both very important and highly uncertain; this quadrant is marked by the star.

Step 4: Identify the Critical Uncertainties

By the end of Step 3, a number of driving forces have been identified that are both highly uncertain and critically important. The next task for the group is to review these forces to determine which ones will become the critical uncertainties used to frame the scenario matrix. This step forms the fundamental basis for the balance of the scenario planning assessment. In theory, almost any number of critical uncertainties could be identified and used. However, as the number of critical uncertainties increases, the number of resulting future scenarios increases exponentially. Therefore, the planning group must be careful to be selective and focus on things that are of the greatest importance and uncertainty. Trying to work with more than three critical uncertainties becomes difficult to manage.

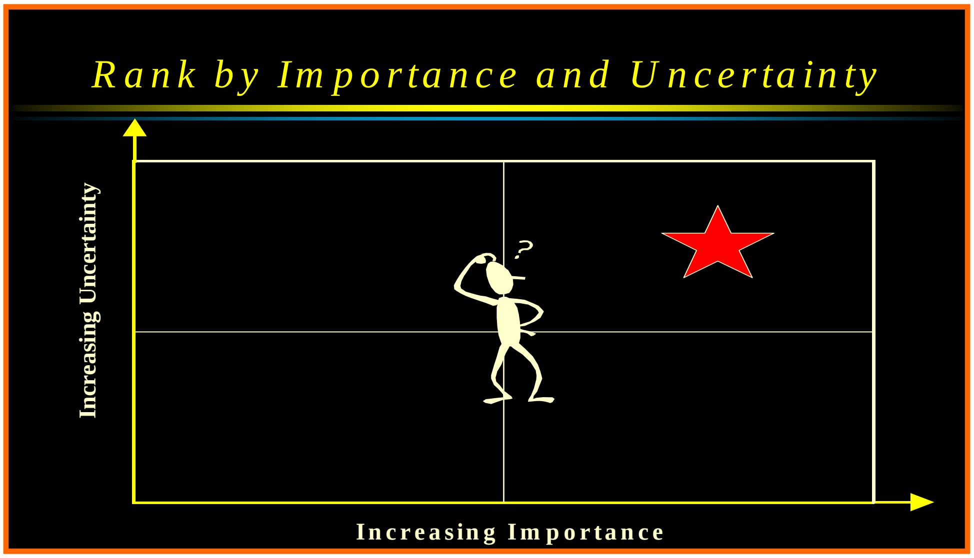

Figure D-3: Plotting the Driving Forces Assessing Their Importance and Uncertainty.

Step 5: Create the Scenario Matrix/Compass

Two or three critical uncertainties are used to create a matrix of possible futures. This is accomplished by identifying the polar extremes of each critical uncertainty. For example, a particular uncertainty could be answered by "yes" or "no" while another could be "aggressive" or "relaxed". The uncertainties are not viewed as representing a range or spectrum of relative values. They are instead viewed as end-point extremes. The critical uncertainties are then used to create a two- or three-dimensional matrix as shown on Figure D-4. The quadrants defined by the combinations of the critical uncertainties are the possible futures or scenarios to be assessed.

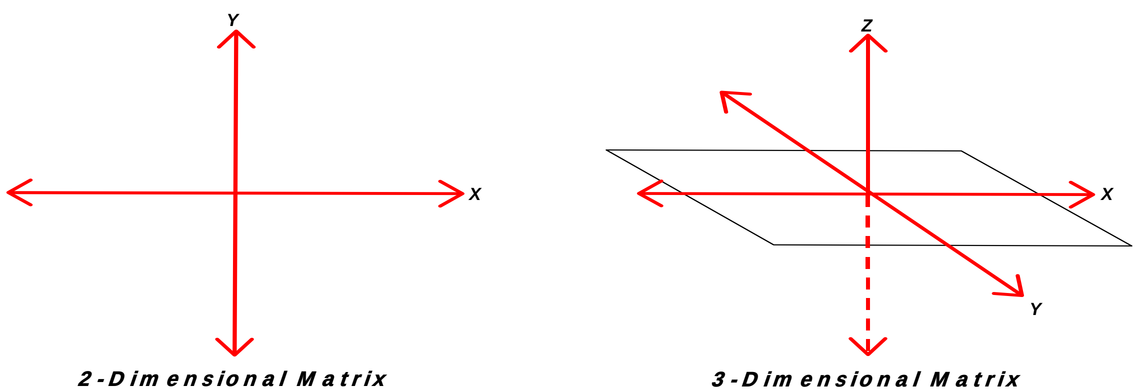

Figure D-4: Basic Scenario Matrix Types.

Step 6: Describe the Scenarios

Once the scenario matrix is created, the planning group must envision each of the possible futures identified. This begins with developing a description of each. This step is one of creativity and imagination. Each scenario must be framed and described to be unique and clearly understood by all participants. The group can prepare lists of characteristics which characterize each scenario and should identify the potential issues that must be managed or overcome given the uncertainties involved. This sets the stage to begin planning for the future.

Step 7: Create Paths to the Scenarios

Each characterized scenario is a future that could come to pass. The planning group plots a pathway to each of these futures based upon its specific characteristics and issues. The pathways include individual elements such as public, political, and research/technological programs as well as various construction projects that need to be sequenced over time to achieve the envisioned future. The pathways are developed independently from one another and are based solely on realizing each unique future. Nonetheless, similarities and overlaps do occur among the individual pathways developed. This commonality among the pathways is the essence of the final step.

Step 8: Identify the Common Elements

The ultimate result of the scenario planning process is the identification of common elements. These are projects and programs that are present on all or many of the individual scenario pathways. This commonality indicates that such projects and programs will be useful under a wide range of possible futures. As a result, such elements are more likely to be viable as the future unfolds.

SCENARIO PLANNING FOR *WATER PLAN: 2000-2050*

Many potential questions and issues were considered during Step 1 of the scenario planning process. After reviewing the list and noting that many of the identified issues were in fact small parts of something larger, the central over-riding issue readily became apparent. Tucson Water's central planning issue was to identify how best to utilize its most abundant renewable water resources: Colorado River water and municipal effluent. A scenario planning assessment of the Clearwater Program addressed how to maximize use of imported Colorado River water. An analogous but separate assessment evaluated how to maximize the Utility's use of locally generated municipal effluent.

The processes associated with the two scenario planning assessments are summarized in the following sections. These summaries are followed by a description of the process used to integrate these two assessments which resulted in a matrix of possible combined futures that formed the basis for the recommended plan.

Scenario Planning for the Clearwater Program

The Clearwater Program was developed to maximize Tucson Water's use of its Central Arizona Project allocation by blending Colorado River water with native ground water. However, this could be accomplished in a number of ways. After developing a list of driving forces, variables, and uncertainties associated with the central issue (Step 2 shown on Figure

D-5), they were individually ranked in terms of their relative importance and uncertainty (Step 3 shown on Figure D-6).

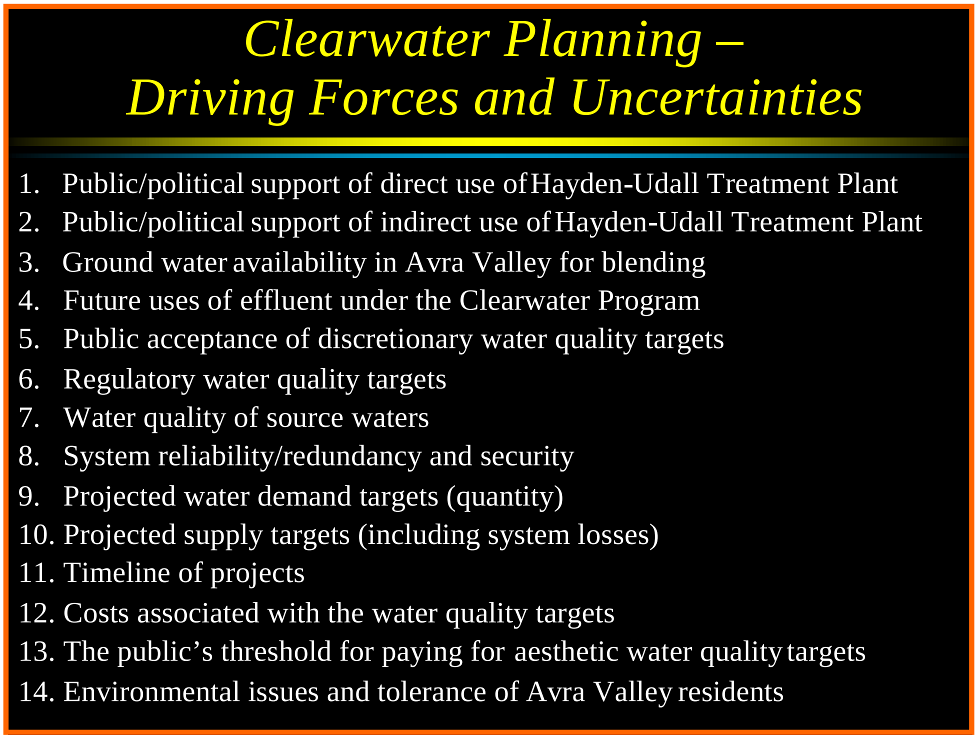

Figure D-5: Clearwater Driving Forces.

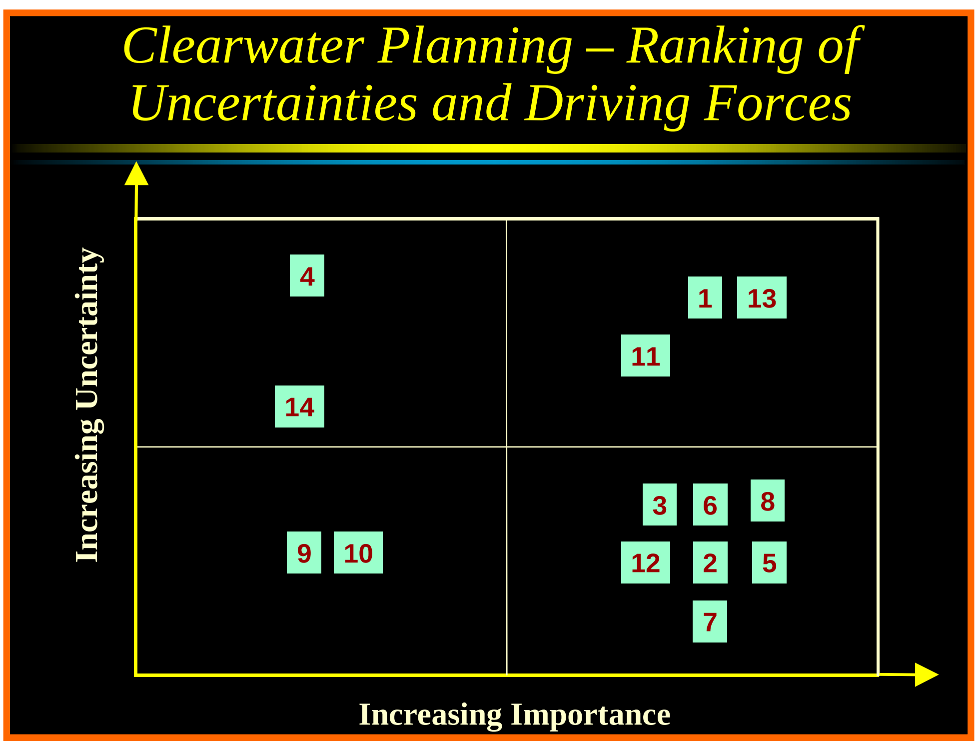

Figure D-6: Clearwater Ranking of Importance and Uncertainty.

The ranking process was followed by an assessment of those items identified as having the greatest importance and the highest uncertainty (Step 4). Of the three driving forces that were found to be both highly important and highly uncertain, #11 was determined to be more a result of the planning process than a critical driving force. Therefore, #1 and #13 were identified as the two most critical uncertainties and were further defined:

1. What is the public's threshold for paying for discretionary water-quality improvements to the Clearwater blend?

2. Will the public accept the use of the Hayden-Udall Treatment Plant for direct treatment of Colorado River water?

Under Step 5, these two critical uncertainties were then oriented on a two-dimensional matrix as shown on Figure D-7. The first is portrayed on the *x*-axis. The left side of this axis represents futures where the public would accept a blended water quality that meets EPA and ADEQ primary drinking water standards. The right side represents the public's willingness to pay for discretionary improvements above and beyond these standards. The second critical uncertainty is portrayed on the *y*-axis. The top of this axis addresses possible futures where the public would accept some direct treatment of Colorado River water at Tucson Water's potable treatment facility, the Hayden-Udall Treatment Plant. The bottom part of the axis represents futures where the public would require that all Colorado River water be recharged prior to use for potable supply.

The resulting four quadrants shown on Figure D-7 correspond to four equally possible futures (I, II, III, and IV). The four futures represent the range of possibility associated with the water-resource management goal of maximizing Tucson Water's use of its Central Arizona Project allocation through the Clearwater Program.

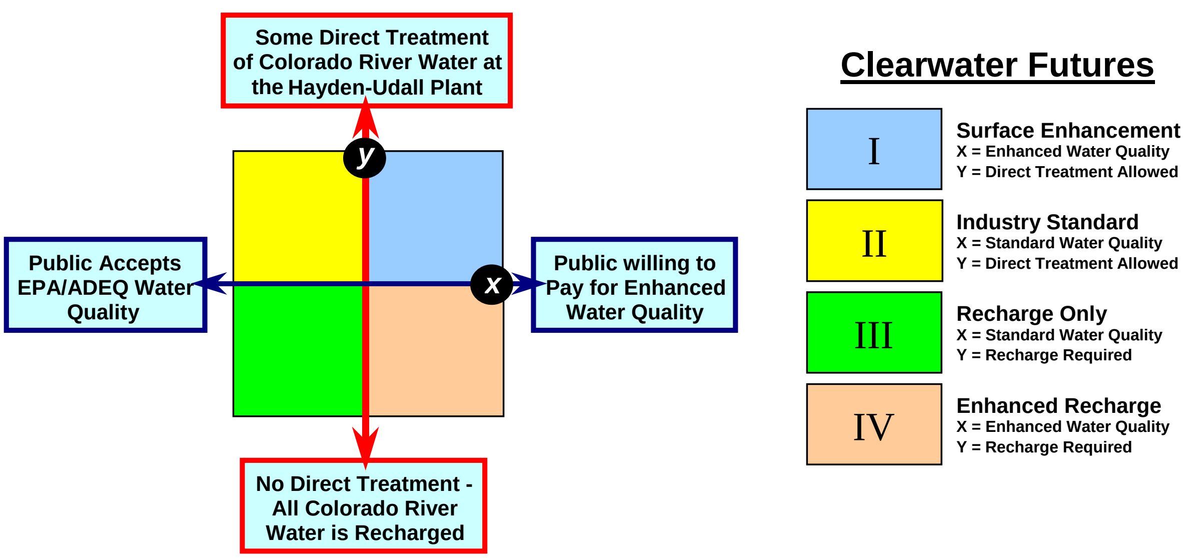

Figure D-7: The Four Scenario Planning Futures Developed for the Clearwater Program.

The objective of Step 6 was to characterize each of the four Clearwater futures. The task was to clearly distinguish each unique future from the others so that independent pathways could be developed to each. The descriptions included defining characteristics and significant issues associated with each future. The characteristics and issues of each were socio-political, technical, logistical, environmental, and economic to mention a few.

Under Step 7, pathways were developed to each of the four futures and these are schematically depicted on Figure D-8. The four pathways consist of the appropriate project and program elements that have been sequentially ordered to realize each of the four futures. These elements were selected from a common pool of potential programs and projects that could become part of the Clearwater Program.

The objective of Step 8 was to identify the elements that were common to all four pathways and the critical decision points where the pathways branch off from one another over time. Five elements that are common to all pathways prior to the first critical decision point were identified and are shown on Figure D-8. The first critical decision centers on whether the Hayden-Udall Treatment Plant can be used for direct treatment or whether all Colorado River water must be recharged and subsequently recovered prior to use.

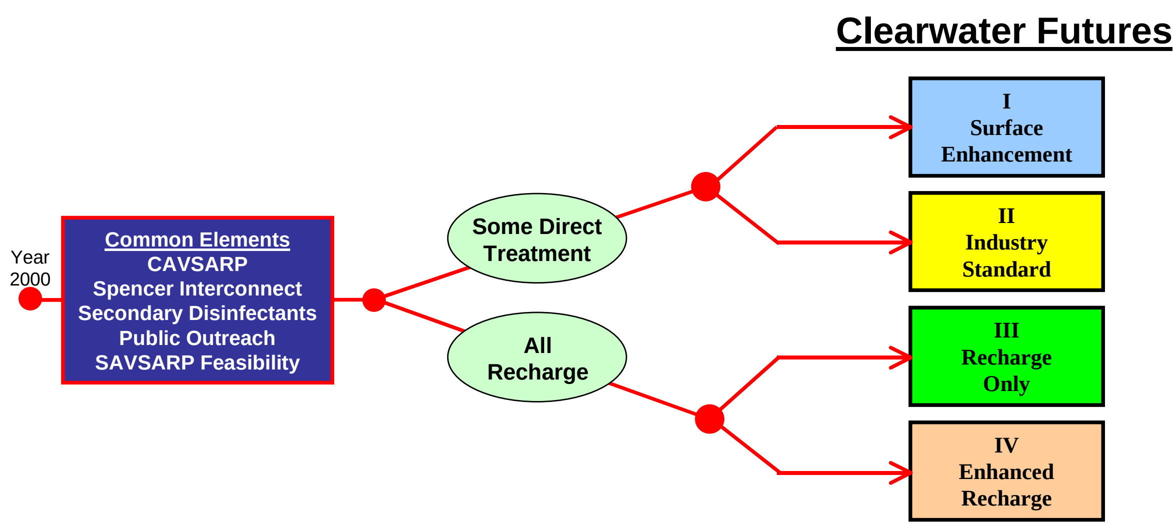

Figure D-8: Clearwater Program Common Elements and Pathways.

As each critical decision is approached at each juncture or as conditions and assumptions change, the Clearwater Program's scenario planning process will be revisited to determine whether a revised set of possible futures should be developed and reassessed.

Scenario Planning for Effluent Reuse

The other central water-resource planning issue was to identify how best to use the City of Tucson's effluent in a manner that would be acceptable to Tucson Water customers. Locally generated effluent is the only water supply that increases as the service area population grows. As shown on Figure D-9, sixteen driving forces were identified (Step 2).

Effluent Planning -
Driving Forces and Uncertainties

1. Quality of secondary effluent as a source water (future)
   - Who would be responsible for the treatment of the effluent to potable standards?
   - Who would pay for the needed treatment system?
2. Amount of available effluent (City of Tucson entitlement)
   - How much of the conservation effluent pool will be used?
   - What are some of the constraints of Tucson Water using effluent?
   - What are the effects of taking all City effluent out of the Santa Cruz River?
3. Treatment technologies (recharge and/or plant treatment)
4. How does the Utility produce the desired quality of effluent for the various reuse types
   - Is recharge (indirect reuse) assumed, or can a plant be used for potable treatment?
   - Are there synergistic health effects of emerging contaminants?
   - Can the Hayden-Udall Treatment Plant be used to treat effluent for potable supply?
   - Future potable and non-potable water quality standards
   - When should different levels of treatment be implemented?
5. Effluent priority to meet highest beneficial use(s)
   - What is the highest beneficial use? (potable, non-potable, restoration)
   - What percent of total potable demand will be met by non-potable reclaimed water?
   - If effluent is treated to a higher standard, should the non-potable system continue?
6. Public perceptions and/or acceptance of effluent for potable use (groundwater augmentation)
   - Reassurance about health effects (consumer safety) from potable reuse of effluent
   - Tap into the national initiatives on the topic
   - How do we present information to our customers to help them make choices?
   - How do we frame the crisis versus reacting to the crisis when it comes?
7. Timing of effluent use for potable supply
   - Driven by Assured Water Supply, aquifer impacts, cost, and/or public acceptance
8. Regulatory and permitting issues
   - What permits and/or changes in law will be needed to use effluent for potable?
   - Lead time to acquire the needed permits to begin accruing long-term storage credits
   - Potential changes to the Assured Water Supply rules (renewable groundwater)?
9. Salinity control – what alternatives are available (where do we put highly saline water)?
10. Availability of alternative potable water supplies
11. Regional cooperation on water issues, Regional Water Cooperative
12. Stakeholder involvement
13. The Community's vision of a sustainable future for Tucson Water
14. Locations of effluent sources/treatment plants in the future
15. Cost of treatment technology prior to use
16. Public cost threshold for using effluent

Figure D-9: Effluent Driving Forces.

The effluent reuse driving forces were plotted on the scenario planning graph of relative importance and uncertainty (Step 3 shown on Figure D-10.) As the planning work sessions proceeded, it was evident that driving force #4, "How does the Utility produce the desired quality of effluent for the various reuse types", was actually a combination of two distinct concepts. The planning group decided to break driving force #4 into its component parts as distinct driving forces as follows:

#4A – What type of treatment should be used for effluent?
#4B – What level of treatment should be provided for effluent?

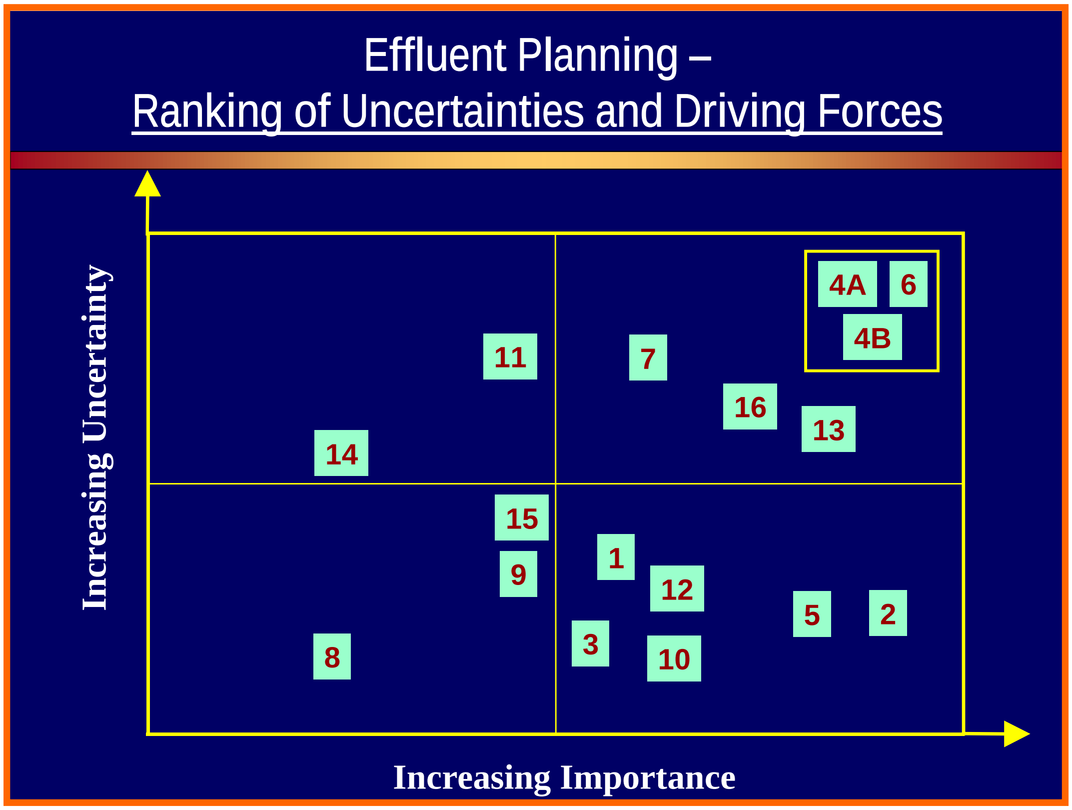

Figure D-10: Ranking of Importance and Uncertainty for Effluent Reuse.

Eight futures were developed based on three critical uncertainties (Step 4):

1. Will Tucson Water customers accept the use of effluent to augment the potable supply?

2. Should effluent be recharged prior to reuse?

3. Should all effluent be treated to potable standards or only treated to standards specific to the type of use?

The first critical uncertainty is portrayed on the *x*-axis (Step 5 shown on Figure D-11.) The *Potable Use* end of the axis establishes the possibility that the public would be willing to accept effluent to augment potable supply while the *No Potable Use* end represents futures where the public would reject the use of effluent for potable reuse.

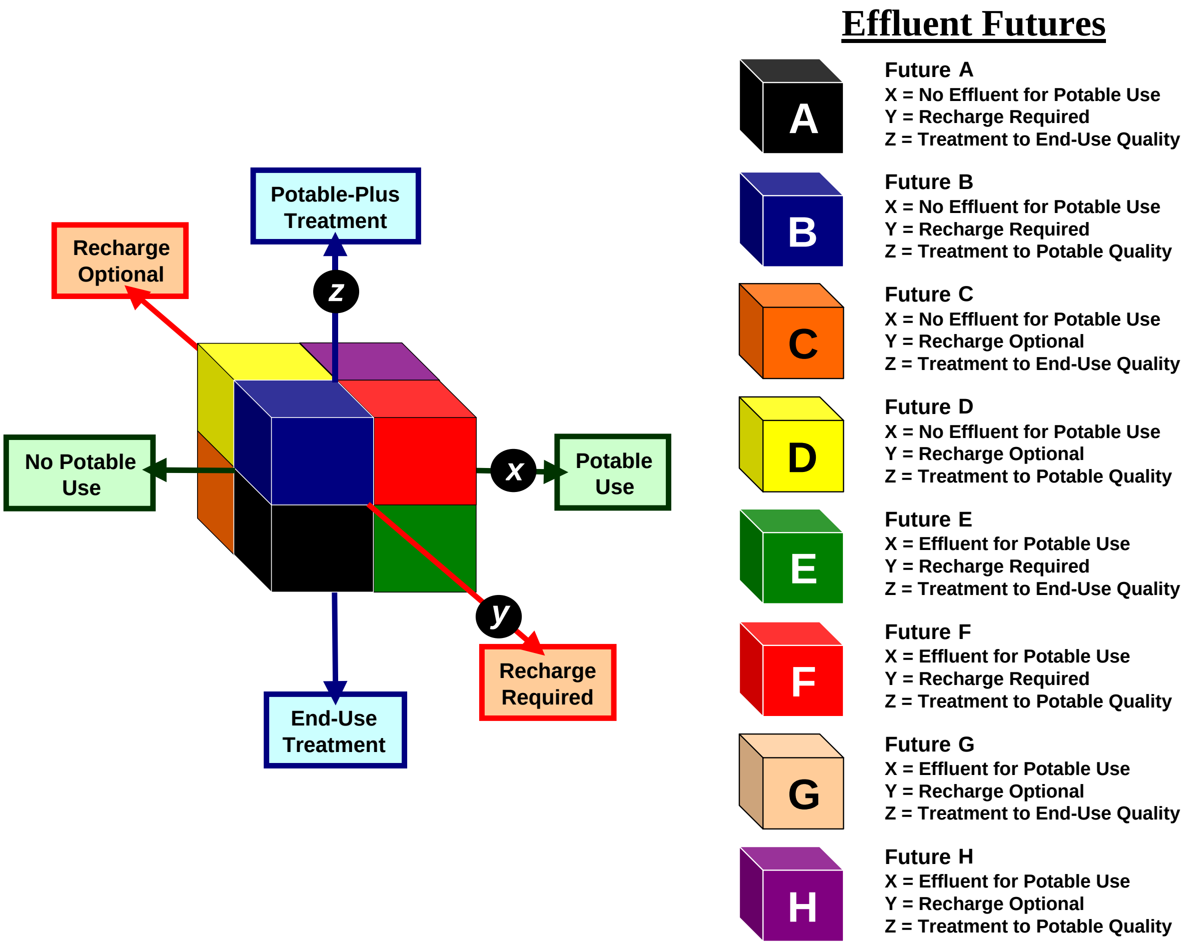

Figure D-11: The Eight Scenario Planning Futures Developed for Possible Effluent Reuse.

The second critical uncertainty is portrayed on the *y*-axis. The *Recharge Optional* end of the axis establishes that the public would be willing to accept some direct treatment of effluent while the opposite *Recharge Required* end represents futures where the public would require recharge prior to potable reuse. Like the Clearwater assessment, the latter means that all effluent would have to be recharged before it could be made available to customers for potable supply.

The third critical uncertainty is portrayed on the *z*-axis. The *Potable-Plus Treatment* end of the axis represents futures where all effluent will at minimum be treated to primary drinking water standards or better while *End-Use Treatment* establishes futures where effluent would only be treated to the level required for the specified use. For instance, effluent used for non-potable purposes would only be treated to reclaimed water-reuse standards. The resulting eight boxes shown on Figure D-11 represent eight equally possible effluent-reuse futures.

As with the Clearwater Program scenario planning assessment, the objective of Step 6 was to characterize each of the eight effluent reuse futures. The descriptions included defining characteristics and significant issues associated with each future.

Pathways were specified to realize each of the effluent-reuse futures (Step 7) as shown on Figure D-12. Review of the project and program elements associated with each pathway (Step 8) indicated that fourteen elements (Common Element Set #1) were common to all pathways prior to the first decision point. At this point, a critical choice will have to be made on whether to expand the reuse of effluent or continue current effluent disposal practices. If expanded use of effluent is pursued, additional common elements have been identified (Common Element Set #2).

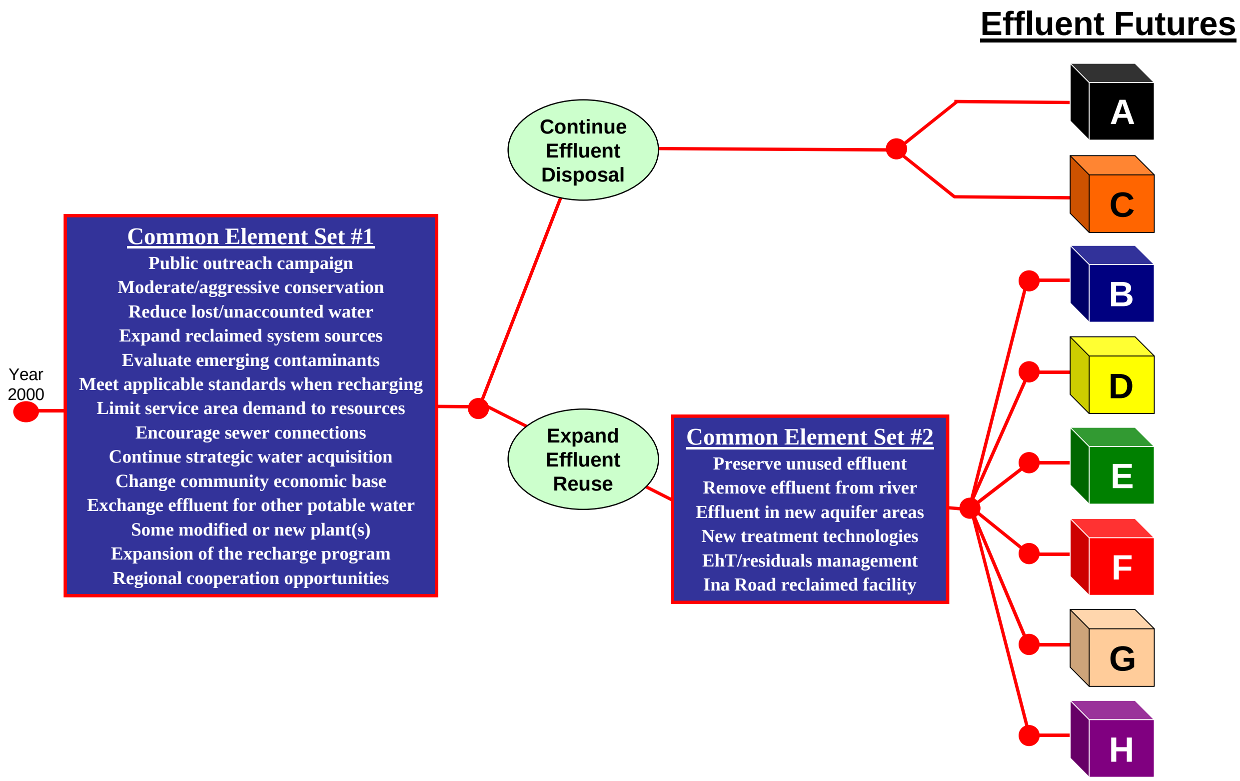

Figure D-12: The Sets of Common Elements for Effluent Reuse.

INTEGRATING THE OUTCOMES

To merge the futures identified for implementing the Clearwater Program and the possibilities associated with effluent reuse, Tucson Water identified the effects that near-term Clearwater Program decisions will have on mid- to long-term options for effluent reuse. Each of the four Clearwater Program futures chronologically precedes all eight of the effluent reuse futures. Futures from within these two sets were uniquely mixed and matched to form a total of 32 "combined futures." These combined futures collectively constitute a wide range of planning possibilities which utilize both Colorado River water and municipal effluent. Four combined futures were eliminated since they would have allowed for the direct treatment and reuse of effluent, but recharge would be required for Colorado River water supplies. Such a combination of treatment types was determined to be highly unlikely to occur; therefore, these futures were excluded from the remaining analysis.

The remaining 28 combined futures are defined by 14 sets of paired planning pathways. The mineral content of the Clearwater blend was used as the "toggle switch" that defined each paired pathway. This toggle switch can be turned to TDS concentrations of either 500-650 mg/L or 450 mg/L along each of the 14 pathways. Therefore, the 14 pathways cover the full range of possibilities represented by the 28 combined futures.

As with the individual assessments, the scenario planning process was employed to identify the common elements that apply to the combined futures each of which constitutes a unique combination of critical uncertainties. In addition, critical decision points were identified through time that will determine future directions.

Families of Futures

The combined futures and the 14 paired pathways were grouped by their shared characteristics into four Families of Futures. These characteristics include the range of effluent reuse options deemed acceptable, the potential role of recharge, the technologies which may be used to treat Colorado River water and effluent to acceptable levels of quality, and the level of operational flexibility provided under each Family. Based on shared characteristics, four Families of Futures were identified:

- *No Effluent for Potable Use*
- *Total Recharge*
- *Combined Technology*
- *Treatment Flexibility*

These Families represent unique combinations of the four futures associated with Clearwater Program and the eight futures associated with effluent reuse. The four resulting Families are described below and summarized in Figure D-13.

No Effluent for Potable Use

In this Family, no effluent would be used for potable supply. As a result, drought resistance is minimal since effluent is not fully utilized to help offset shortfall years on the Colorado River system. An eventual shortfall in potable supply would likely occur before 2020 due to the finite availability of both Colorado River water and ground water unless additional renewable water supplies were acquired or ground-water pumping was increased above hydrologically sustainable levels. This Family includes all four futures developed for the Clearwater Program (I, II, III, and IV) but only four of the eight effluent futures (A, B, C, and D). This accounts for 16 of the 28 combined futures.

Total Recharge

Under *Total Recharge*, Tucson Water would be able to make full use of its available Colorado River water and effluent resources through recharge and recovery. Under this future, all Colorado River water and effluent would be recharged as part of the treatment process prior to being used to satisfy potable demands. The impacts of future drought would be minimal since the total volume of available water supply is larger. This would require an aggressive expansion of Tucson Water's recharge and recovery capabilities. This Family accommodates two Clearwater Program futures (III and IV) and two effluent futures (E and F). This accounts for four of the combined futures.

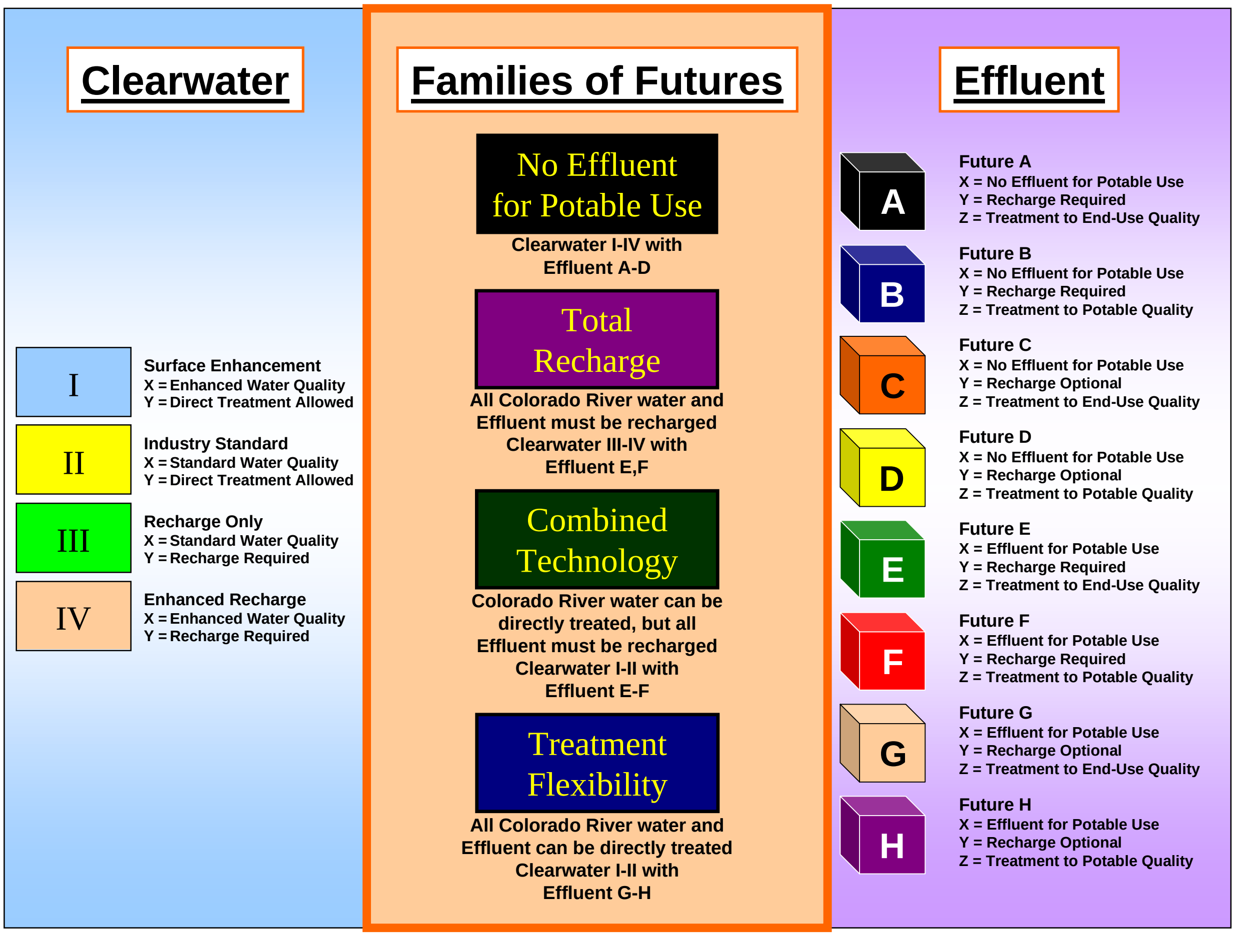

Figure D-13: The Four Families of Futures.

Combined Technology

In the *Combined Technology* Family, Tucson Water would again be able to make full use of the available Colorado River water and effluent resources for potable and non-potable supply. The Utility would have the ability to use direct treatment and/or recharge and recovery for Colorado River water supplies. However, all effluent would be recharged prior to being used to satisfy potable demands. The impacts of future drought would be minimal since the total volume of available water supply is larger. The type of Colorado River water treatment would not be restricted. All effluent would be recharged resulting in continued expansion of Tucson Water's recharge and recovery capabilities. This Family accommodates two Clearwater Program futures (I and II) and two effluent reuse futures (E and F). This accounts for four of the combined futures.

Treatment Flexibility

In *Treatment Flexibility*, Tucson Water would not only be able to make full use of the available Colorado River water and effluent source waters, but the manner in which these supplies are treated is completely flexible. Tucson Water could use direct treatment technologies and/or recharge and recovery for all Colorado River water and effluent supplies. Similar to *Total Recharge* and *Combined Technology*, the impacts of future drought would be minimal. This Family accommodates two Clearwater Program futures (I and II) and two effluent futures (G and H). This accounts for four of the combined futures.

Pathways to 2050

Over the next 50 years, Tucson Water must implement a number of projects and programs to increase the use of renewable water supplies to meet growing water demand. Depending on what the future holds, some projects and programs will continue to be viable while others may not. Scenario planning provides a framework to identify common elements that are applicable under the broadest range of possible futures. The 14 pathways that lead to the 28 combined futures are presented on Figure D-14.

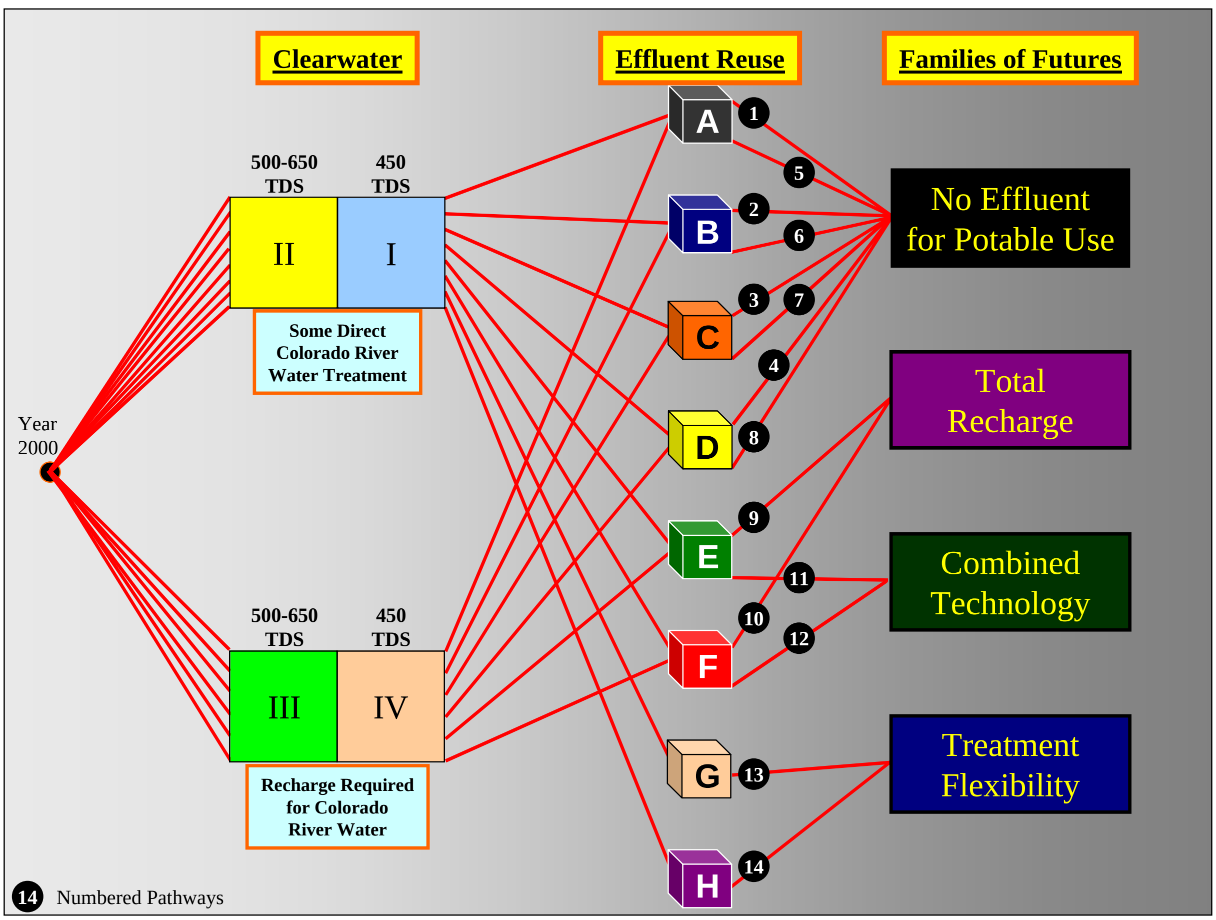

Figure D-14: Pathways to the Four Families of Futures.

The pathways are impacted by critical decisions made regarding the treatment technology used for Colorado River water (direct treatment versus recharge) and the TDS concentration of the Clearwater blend (450 mg/L versus 500-650 mg/L). Looking beyond this first critical decision point regarding Colorado River water, subsequent decisions addressing the reuse of effluent will need to be made. To capture the range of possible effluent reuse decisions, pathways were extended from each of the four possible Clearwater futures to each of the eight effluent reuse futures. The Families of Futures are defined by pathways that lead to combined futures which share a similar characteristic. For instance, all the combined futures under the *No Effluent for Potable Use* Family share this characteristic. However, each of the combined futures within this family has one or more other characteristics which makes it unique.

Pathway Elements

A set of projects and water supply sources served as a pool of discrete elements from which each of the pathways was assembled. These projects fall into three general categories: potable system, reclaimed system, and major pipelines. The supply sources include currently available ground water, Colorado River water, and effluent. Should additional water supplies be acquired or if future demand management programming significantly reduces per capita water use, a reassessment of pathway elements may be necessary.

<u>Potable System Projects</u>

Potential improvements to the potable system could include expansions of existing recharge projects and/or the construction of new recharge facilities. The existing CAVSARP facility can be expanded to increase Colorado River water recharge and/or recovery capacity. In addition, the CAVSARP facility could be made available to recharge effluent for long-term banking or indirect potable use. The SAVSARP facility could be constructed to expand Colorado River water recharge. This facility would consist of two phases where the first would have the capacity to recharge 45,000 acre-feet per year of Colorado River water while the second would expand the facility up to 100,000 acre-feet. Tucson Water could also deliver treated effluent to the Pima Mine Road Recharge Project for long-term banking.

Potable system improvements could also include the construction of direct and/or enhanced treatment plants. Direct treatment plant options include the potential rehabilitation of the Hayden-Udall Treatment Plant for the direct treatment of Colorado River water and the potential construction of the Sweetwater Enhanced Treatment Plant near Roger Road. Each of these facilities could be upgraded to perform enhanced treatment (mineral content removal) if elected by the public. In addition, the Sweetwater Enhanced Treatment Plant could potentially be equipped to treat effluent to potable standards as a contribution to the blended water supply.

<u>Reclaimed System Projects</u>

There are two main ways to provide treated effluent for use in the reclaimed water system: plant treatment and soil-aquifer treatment via recharge. As demand for reclaimed water grows into the future, Tucson Water's sources of reclaimed water must be expanded. The pathways to 2050 include either expansion(s) of the Tucson Reclaimed Water Treatment Plant or expansion(s) of its effluent recharge and recovery program. Constructed recharge can be expanded at the existing Sweetwater Recharge Facilities up to 10,000 acre-feet per year. This would require the construction of additional recharge basins. In addition, new constructed effluent recharge facilities can be built to recharge and recover additional effluent as needed to satisfy reclaimed water demand through 2050.

Pipeline Projects

Tucson Water must construct pipelines to convey Colorado River water and effluent to treatment and/or recharge facilities. Additional pipelines could be constructed to convey potable water into the distribution system. The Spencer Interconnect would provide the ability to bring additional ground water into the Hayden-Udall Treatment Plant for blending as well as provide another route to deliver finished water from the Hayden-Udall Treatment Plant to Tucson Water customers. The Avra Valley Transmission Main Augmentation would increase the volume of water that can be delivered into Tucson via the Martin Reservoir. This would provide a back-up route for the blended water supply to enter urban Tucson.

A pipeline from the potential Sweetwater Enhanced Treatment Plant to the CAVSARP facility would provide the opportunity to recharge effluent in Avra Valley under certain pathways. The Ina Road Interconnect would provide Tucson Water access to effluent from the Ina Road Water Pollution Control Facility for reuse. Finally, a pipeline from the potential Sweetwater Enhanced Treatment Plant to Pima Mine Road (Tucson basin pipeline) would provide the ability to convey effluent to the Pima Mine Road Recharge Project or other locations east of the Tucson Mountains for long-term storage.

Currently Available Supply Sources

As described in previous chapters, there are three current water supplies available for use by Tucson Water: ground water, Colorado River water, and effluent. For the planning pathways, the minimal ground water usage was assumed to be equal to the pumping rate that can be hydrologically sustainable within Tucson Water's projected service area. For planning purposes, it is conservatively assumed that an annual ground water withdrawal of 50,000 acre-feet can be produced from within the projected Tucson Water service area without causing significant water level declines. Under ten paired pathways, ground water production is limited to this volume. However, under four paired pathways, effluent that is not available for potable use will be banked in long-term storage facilities. In these latter pathways, the recharge credits granted for the banking activities can be used to offset additional ground water pumping, although, this could cause a shift back toward localized over-drafting of the aquifer and declining groundwater levels.

Tucson Water's full Central Arizona Project allocation is assumed to be fully utilized under all pathways. The current allocation of 135,966 acre-feet per year is assumed to be available under all years. Tucson Water's effluent supply is used to varying degrees under the 14 pathways. The one base assumption is that effluent will continue to be used via the reclaimed water system to offset 8 percent of total demand. This usage rate assumes that 20,200 acre-feet of reclaimed water would be used in 2050 and the annual volume of effluent not used through the reclaimed system could total 46,000 acre-feet.

Under four pathways (Pathways 1, 3, 5, and 7), effluent would only be used in the reclaimed system to meet non-potable demands. In four other pathways (Pathways 2, 4, 6, and 8), effluent not used in the reclaimed system would be banked in long-term storage facilities. The recharge credits accrued through these long-term storage activities could be used to offset additional ground-water pumping in excess of the annual sustainable rate; however, this could cause a shift back toward localized over-drafting of the aquifer and declining ground-water levels. In the remaining six pathways (Pathways 9 through 14), the effluent not used through the reclaimed system is used to augment potable water supplies. The projects that were used to develop each of the 14 pathways are presented in Table D-1.

DISTINGUISHING THE PATHWAYS

Nine assessment criteria were developed to rate the overall benefits and drawbacks of each of the 14 possible pathways. These criteria were developed from a wide range of factors that could serve as assessment performance measures. Many of these factors could not be used as distinguishing criteria because they were common to all 14 pathways and hence were considered non-discriminating or “neutral.” These neutral factors applied equally to all pathways while the nine assessment criteria served to distinguish the pathways. Each of the nine criteria is assigned to one of three assessment categories: Source Water, Operations, and Environment. The criteria were developed in order to evaluate the overall capability of each pathway to meet the following Tucson Water planning goals:

- Meet Projected Total Demand.
- Utilize Renewable Resources.
- Meet Water-Quality Targets.
- Achieve Sustainable Pumpage.
- Manage Costs and Rate Impacts.
- Comply with Assured Water Supply Program.

Each criterion is assigned a rating from one to ten points where the highest score fully expresses the value embodied in any given criterion. The point sum of the ratings is the measure of how well each pathway meets the overall planning goals.

Neutral Ground – Similarities Among the Pathways

There are a number of characteristics that are included on all of the pathways. These include factors over which Tucson Water has no control, which apply under all future scenarios, and which are not affected by the projects selected under each path. The commonality of these factors does not lessen their importance; in fact, many will likely be critical driving forces in the future. However, since they apply to all pathways, they cannot be used as distinguishing criteria to rate the relative effectiveness of the pathways to achieve the overall planning goals. Several of these neutral but important factors are discussed in this section.

Pathway	Spencer Interconnect	Avra Valley Main Augmentation	Effluent Pipeline to Avra Valley	Effluent Pipeline to Tucson Basin	Ina Road Interconnect	Expand CAVSARP Recharge to 80k	SAVSARP Phase I	Rehabilitate Hayden-Udall	SAVSARP Phase II	Enhanced Treatment at Hayden-Udall	Effluent Recharge at CAVSARP	Effluent Recharge at Pima Mine Road	Expand CAVSARP Operations to 100k	Sweetwater Enhanced Treatment Plant	Expand CAVSARP Recovery	Effluent Recharge at CAVSARP	Expand Sweetwater Recharge Facilities	Expand Reclaim Plant	Reclaimed System Recharge Project	Clearwater Future(s)	Effluent Reuse Future	Family of Futures
	Major Pipelines					**Potable System**											**Reclaimed System**					
1	2006	2009				2005		2009		2011*							2007		2012	I/II	A	No Effluent for Potable Use
2	2006	2009	2017		2017	2005		2009		2011*	2017			2017			2007		2012	I/II	B	
3	2006	2009				2005		2009		2011*								2007		I/II	C	
4	2006	2009	2017		2017	2005		2009		2011*	2017			2017				2007		I/II	D	
5	2006	2009				2005	2007		2009	2011*							2007		2012	III/IV	A	
6	2006	2009		2017		2005	2007		2009	2011*		2017					2007		2012	III/IV	B	
7	2006	2009				2005	2007		2009	2011*								2007		III/IV	C	
8	2006	2009		2017		2005	2007		2009	2011*		2017						2007		III/IV	D	
9	2006	2009	2017		2017	2005	2007		2009	2011*	2017		2017	2017	2025		2007		2012	III/IV	E	Total Recharge
10	2006	2009	2017		2017	2005	2007		2009	2011*	2017		2017	2017	2025		2007		2012	III/IV	F	
11	2006	2009	2017		2017	2005		2009		2011*	2017			2017	2025		2007		2012	I/II	E	Combined Technology
12	2006	2009	2017		2017	2005		2009		2011*	2017			2017	2025		2007		2012	I/II	F	
13	2006	2009		2017	2025	2005		2009		2011*		2017		2025		2025		2007		I/II	G	Treatment Flexibility
14	2006	2009		2017	2025	2005		2009		2011*		2017		2025		2025		2007		I/II	H	

* This element can be "on" or "off" in all fourteen pathways and serves as the "toggle switch" for the mineral content of the Clearwater Blend.

Table D-1: Pathways to 2050 – Schedules of Projects.

Demand Management

Reducing per capita water demand applies to all futures. Conservation programming is one way to manage demand. Because many conservation programs rely on voluntary actions or behavioral changes on the part of customers, demonstrating a quantifiable improvement can be problematic. Emphasizing mandatory technologically based conservation programs that result in measurable water savings and continuing broad-based public education efforts would be necessary to further reduce per capita water demand. An extended period of monitoring and evaluation of these programs would be needed to demonstrate quantifiable water savings. In addition to conservation programs, Tucson Water will continue to improve the efficiency of its distribution system to further reduce water demand.

Full Utilization of Colorado River Water

Fully utilizing the City of Tucson's annual Central Arizona Project allocation is critical toward maximizing the use of renewable supplies in Tucson Water's service area. The community currently accepts the indirect use of Colorado River water where it is recharged and recovered through the Clearwater Program prior to delivery for potable use. Over the next 10 years, this program will be expanded to achieve full utilization. While the pathways differ as to what projects would be constructed to accomplish this goal, the full use of Tucson Water's Central Arizona Project allocation is a priority common to all pathways and futures.

Reclaimed System

Also common to all pathways is that effluent will continue to be used in the reclaimed system to offset at least eight percent of total demand. This usage rate assumes that 20,200 acre-feet of reclaimed water would be used to satisfy non-potable water demands by 2050.

Blended Water Quality

All of the pathways can provide enhanced water quality for the blended water supply. Tucson Water's customers would have to pay the incremental costs to make discretionary improvements in water quality. The most common measure of the blended water quality is TDS which refers to the concentration of dissolved minerals present virtually in all water supply sources. The renewable Colorado River water supply being imported into the Tucson area differs in mineral content from the native ground water to which Tucson Water's customers have grown accustomed. Customers may be willing to pay for the enhanced treatment of the blended water supplies to maintain a mineral content below that of untreated Colorado River water. The *At the Tap Program* established a targeted TDS concentration of approximately 450 mg/L. If this mineral content were to be sustained over the long-term, then enhanced treatment would eventually be required. Enhanced treatment could be performed on directly treated or on recharged and recovered Colorado River water. This would require a significant capital and annual operations and maintenance investment that would then be incrementally added to all 14 pathways.

Water Treatment Flexibility

The ability to effectively treat all available potable water sources is an important factor in water-resource planning. This will become more critical in the future as drinking water standards become increasingly stringent. However, since each of the pathways places a premium on establishing central points of control where renewable water supplies would be treated before entering the distribution system, this factor is considered well-managed under each pathway and cannot serve to distinguish one pathway from another. Central points of control allow for a greater degree of treatment flexibility since additional treatment train components can be efficiently added at centralized treatment locations as needed.

Hydrologically Sustainable Ground-Water Pumping

Sustainable ground-water pumping was identified as a long-term source of supply in *Tucson Water Resource Plan 1990-2100* and is a resource-management strategy that will continue to be pursued. However, the current AWS rules do not grant credits for annually renewable ground water. Regulations will need to be modified in order to recognize this important renewable resource. Under current regulations, almost all ground-water usage is currently classified as “mined” ground water with no allowance given to natural recharge. Instead current regulations assigned a portfolio of ground-water credits and a 4 percent incidental recharge allowance to municipal providers which limits the amount of ground water that can be legally pumped. The key to sustainable ground-water use is to balance ground-water withdrawals with this natural level of replenishment. Hydrologically sustainable ground-water pumping would be an indefinite source of renewable supply. Pursuing changes to the AWS Program to allow for sustainable pumping is common to all of the combined futures.

Supply Augmentation

In any future, the more water supplies Tucson Water owns or controls, the better positioned it will be to meet future demands. The City of Tucson will seek to acquire additional Colorado River water and effluent supplies under any future or pathway that satisfies all of the long-range resource-planning goals. If local water providers work cooperatively, the chances of successfully acquiring additional supplies would be greater. These additional supply sources might include additional Central Arizona Project allocations, leased or purchased Colorado River water, and possibly ground water from basins in western Arizona.

Regulatory Compliance

Compliance with all applicable regulatory standards is required for any pathway to the future. In all cases, regulatory compliance will become more challenging in the future as requirements become increasingly stringent. Hence, this factor cannot be used as a distinguishing characteristic when analyzing the various pathways and futures.

Assessment Criteria

<u>Source Water Criteria</u>

Criterion 1: Colorado River Water Source Acceptance

Tucson Water's customers currently accept basin recharge as the primary type of treatment of Colorado River water. However, other communities have had success with direct treatment processes, and these might eventually become accepted in Tucson as well. This criterion was evaluated based on how far each pathway departs from what is presently being done because current practice is the baseline against which customer preference is measured.

- Colorado River water is rejected in the future for potable supply. <u>1 Pt.</u>
- Direct treatment technologies are used to treat Colorado River water. <u>5 Pts.</u>
- All Colorado River water is recharged before being used for potable supply. <u>10 Pts.</u>

Criterion 2: Effluent Water Source Acceptance

The community currently accepts using effluent for non-potable needs. As water resources become increasingly limited in the future, effluent use will likely be expanded to meet increasing water demand. However, the level of customer acceptance of expanded effluent use is not yet known. This criterion was developed based on how far each pathway departs from what is presently being done since current practice is the baseline against which customer preference is measured.

- Effluent is directly treated for potable supply. <u>1 Pt.</u>
- Effluent is used to augment groundwater for potable supply. <u>5 Pts.</u>
- Effluent is only used to meet non-potable demands. <u>10 Pts.</u>

Criterion 3: Renewable Supply Utilization

Maximizing use of all currently available water supplies and being able to acquire additional sources of supply will ensure that the community is sustainable over the long-term. All of the paths assume that full utilization of Tucson Water's Central Arizona Project allocation is a critical component in achieving that sustainability. However, the paths differ on how and to what degree the effluent resource is used. The use of effluent to augment potable and non-potable supplies provides the highest level of renewable supply utilization. In lieu of using effluent to help meet potable demands, banking it at long-term storage (recharge) facilities would at least preserve this resource for the future and would allow for the accrual of recharge (paper-water) credits to offset ground-water pumping.

- Neither potable use nor long-term banking of effluent. <u>1 Pt.</u>
- No potable use, but construction of long-term banking projects for effluent. <u>5 Pts.</u>
- Maximize use of effluent for non-potable and indirect potable uses. <u>10 Pts.</u>

Operations Criteria

Criterion 4: Meeting Projected Water Demand

Each pathway makes use of a certain volume of available water supply which can support the growing community until some point in the future. The longer in time each pathway can meet projected wet-water demand, the more highly it is rated.

- Shortfall in wet-water supply is projected to occur before 2020. 1 Pt.
- Shortfall in wet-water supply is projected to occur between 2020 and 2030. 4 Pts.
- Shortfall in wet-water supply is projected to occur between 2030 and 2050. 7 Pts.
- Wet-water supply is sustainable through 2050. 10 Pts.

Criterion 5: Source Reliability

This criterion evaluates the ability to deliver water under adverse conditions such as during extended drought, unplanned canal outages, and Colorado River shortages. Greater use of recharge and recovery projects to utilize Colorado River water and effluent resources increases the reliability of these supplies since the recovery component of recharge facilities can still provide wet-water supply despite changing weather patterns or system outages. In contrast, total dependence on direct treatment plants has less reliability since there would not be a water-resource buffer in place to make up a reduction in wet-water supply.

- No potable use of effluent with direct treatment and delivery of Colorado River water. 1 Pt.
- No potable use of effluent with recharge of Colorado River water prior to delivery. 3 Pts.
- Direct treatment and delivery of both effluent and Colorado River water. 5 Pts.
- Direct treatment of Colorado River water with recharge of effluent for indirect potable use. 7 Pts.
- Recharge of both effluent and Colorado River water prior to delivery. 10 Pts.

Environmental Criteria

Criterion 6: Impacts to Recharge Neighbors

Constructing recharge projects can have local impacts on immediately surrounding areas. These include construction nuisances and/or changes in local ground-water quality resulting from recharge activities. Under this criterion, minimal construction of additional recharge projects will result in minimal impacts to neighbors living in close proximity.

- Recharge of all renewable supplies; maximum recharge impacts. 1 Pt.
- Combination of recharge and direct treatment plants for renewable supplies. 5 Pts.
- Minimal construction of new recharge projects; minimal recharge impacts. 10 Pts.

Criterion 7: Riparian Issues

As water availability becomes increasingly limited in the future, effluent supplies will most likely be more widely utilized. The degree to which effluent is put to use will have an adverse impact on riparian habitats that could otherwise be supported by the in-channel disposal of unused effluent.

- Effluent not used for non-potable purposes used to augment potable supply. 1 Pt.
- Effluent not used for non-potable purposes placed in banking facilities. 5 Pts.
- Effluent not used for non-potable purposes discharged to channel. 10 Pts.

Criterion 8: Salinity Control

The control of salinity is a growing concern in the arid west. Salts will be imported to Tucson and other central Arizona communities via the Central Arizona Project. In addition, the imported salts incrementally increase the salt concentration in municipal effluent. All of the alternative pathways are considered equivalent to one another for their potential to manage salinity in imported Colorado River water supplies. Hence, the level of salinity treatment/control that is applied to Colorado River water is considered an option that applies equally to all pathways. However, the way in which the community uses and/or disposes of its effluent and its associated build up of salts are evaluated in this criterion.

- Effluent is recharged but not recovered (salts distributed). 1 Pt.
- Effluent continues to flow down the Santa Cruz River (salts concentrated). 4 Pts.
- Effluent is put in recharge and recovery project (salts managed). 7 Pts.
- Effluent is treated through enhanced treatment technologies (salts removed). 10 Pts.

Criterion 9: Subsidence Prevention

The degree to which Tucson Water reduces its reliance on mined ground water will determine how well the Utility can manage the local aquifer to address declining water levels and the associated potential for additional land subsidence.

- Minimal use of renewable supplies; maximum mined ground-water use. 1 Pt.
- Preservation of effluent for future use; moderate mined ground-water use. 5 Pts.
- Use of effluent for indirect potable supply; minimal mined ground-water use. 10 Pts.

Assessment Results

Review of Table D-2 indicates that Pathways 9 through 14 are rated higher than Pathways 1 through 8. The more highly rated pathways lead to three Families of Futures: *Total Recharge*, *Combined Technology*, and *Treatment Flexibility*. The main element that sets Pathways 9 through 14 above Pathways 1 through 8 was their ability to maximize use of renewable resources with emphasis on effluent utilization. Increasing use of effluent and fully utilizing Colorado River water are critical factors which contributed to these pathways realizing four of the planning goals: Meet Projected Total Demand, Utilize Renewable Resources, Achieve Sustainable Pumpage, and Comply with Assured Water Supply Program.

Pathway	Colorado River Water Source Acceptance	Effluent Water Source Acceptance	Renewable Supply Utilization	Meeting Projected Water Demand	Source Reliability	Impacts To Recharge Neighbors	Riparian Issues	Salinity Control	Subsidence Prevention	TOTAL	Clearwater Future(s)	Effluent Reuse Future	Family of Futures	Planning Goal Achievement
	<<<<<Source Water>>>>>			<<Operations>>		<<<<<<<<Environment>>>>>>>				Overall				
1	5	10	1	1	1	10	5	4	1	38	I/II	A	No Effluent for Potable Use	FAIL
2	5	10	5	4	1	5	10	1	5	46	I/II	B		FAIL
3	5	10	1	1	1	10	5	4	1	38	I/II	C		FAIL
4	5	10	5	4	1	5	10	1	5	46	I/II	D		FAIL
5	10	10	1	1	3	5	5	4	1	40	III/IV	A		FAIL
6	10	10	5	4	3	1	10	1	5	49	III/IV	B		FAIL
7	10	10	1	1	3	5	5	4	1	40	III/IV	C		FAIL
8	10	10	5	4	3	1	10	1	5	49	III/IV	D		FAIL
9	10	5	10	10	10	1	1	7	10	64	III/IV	E	Total Recharge	PASS
10	10	5	10	10	10	1	1	7	10	64	III/IV	F		PASS
11	5	5	10	10	7	5	1	7	10	60	I/II	E	Combined Technology	PASS
12	5	5	10	10	7	5	1	7	10	60	I/II	F		PASS
13	5	1	10	10	5	10	1	10	10	62	I/II	G	Treatment Flexibility	PASS
14	5	1	10	10	5	10	1	10	10	62	I/II	H		PASS

Table D-2: Rating of Pathways to 2050.

The use of effluent has the added benefit of providing greater operational reliability because it is locally generated and hence always immediately available. In addition, Pathways 9 through 14 provide the community the best options to prevent continued subsidence by controlling ground-water withdrawals and stabilizing water levels in the aquifer.

In the planning approach used in this assessment, the most highly rated pathways and their associated futures serve as indicators of the programs and projects that could best achieve the stated planning goals. As the community evolves, these planning goals may change. Because change is the one certainty, all potential pathways are retained in developing the recommended plan. The common elements represented in the 14 pathway pairs provide the direction and the flexibility needed to manage uncertainty and the inevitable challenges which lie ahead.