CHAPTER 4

Overall Treatment Strategy

Chapter 4 - Overall Treatment Strategy

4.1 Introduction

The Overall Treatment Strategy for the Pima County Regional Optimization Master Plan entails planning efforts to satisfy two primary issues:

1. System Configuration - how much flow is to be treated at the Roger Road WRF and how much flow is to be treated at the Ina Road WRF.

2. Process Selection - selection of the best process to meet current regulatory requirements as well as probable future regulatory requirements.

To address these two primary issues, this chapter provides description and detailed evaluations on the following subjects:

- Future wastewater flows and characteristics
- Treatment strategy alternatives with three flow-split options
- Reclaimed water program
- Biological nutrient removal (BNR) treatment alternatives
- Alternative evaluation criteria
- Evaluation of alternatives
- Selection of recommended alternative
- Preliminary sizing facilities

4.2 Future Wastewater Flows and Characteristics

4.2.1 Future Wastewater Flows

The flow projection for the Roger Road WRF and the Ina Road WRF was made based on information described in the Pima County Wastewater Management Department's 2006 Metropolitan Facility Plan Update (2006 Facilities Plan). According to the report, the future flow projection was based on the projected population growth in the planning area and projected wastewater flows of 85 gallons per capita per day (gpcd). The wastewater flow projections for year 2030, along with the current (year 2005), in the planning areas are summarized as shown in **Table 4-1**.

Table 4-1
Current and Projected 2030 Wastewater Flows from 2006 Facilities Plan

Plan Area	2030 Projected Flow	
	Current (2005)	Future (2030) (1)
Roger Road Service Area, mgd	44.27	59.72
Ina Road Service Area, mgd	16.90	22.33
Total Flow, mgd	61.17	82.05

(1) Randolph Park WRF capacity of 3.0 mgd is not included. The existing Randolph Park WRF, located within the Roger Road WRF drainage area, will be continuously used to treat approximately 3 mgd flow and the effluent will be a part of the Tucson Water reclaimed water system.

Based on the projected flows for year 2030 shown in the above table, several flow split options between the two major treatment facilities, Roger Road WRF and Ina Road WRF, were developed. The following options were selected for detailed evaluation of plant configurations, operational and economical aspects.

- Option 1 – Referred to as the "Existing Plan" and is the recommended plan by the 2006 Facilities Plan study. It is based on a flow split of 32 mgd and 50 mgd between Roger Road WRF and Ina Road WRF, respectively.
- Option 2 – Referred to as the "Transfer Some" plan and is based on some flow transfer from the Roger Road WRF to the Ina Road WRF to make a flow split of 20 mgd and 62 mgd, respectively,.
- Option 3 – Referred to as the "Transfer All" plan and is based on transferring all flow from the Roger Road WRF to the Ina Road WRF and therefore treatment of all 82 mgd at the Ina Road WRF.

For the purpose of estimating the wastewater characteristics, each of the flow split options was divided into current (assumes that plant interconnect pipeline is constructed) and future flows as shown in **Table 4-2.**

Table 4-2
Wastewater Flow Split Options Used for Plant Evaluations

Flow Split Options*	Flow to Roger Road, mgd			Flow to Ina Road WRF, mgd		
	Current**	Future	Total	Current**	Future	Total
Existing Plan	22.6	9.4	32.0	36.5	13.5	50.0
Transfer Some	14.1	5.9	20.0	45.0	17.0	62.0
Transfer All	0.0	0.0	0.0	59.1	22.9	82.0

* Randolph Park WRF with capacity 3.0 mgd remains in service
** Assumes plant interconnect pipeline exists

4.2.2 Future Wastewater Characteristics

Wastewater characteristics for current flows were developed based on the data presented in the Modeling 2005 document (Additional Modeling of Ina Road WRF and Roger Road WRF – Final, Hydromantis, Inc., February 9, 2005). The modeling used the plant operating data for the following periods:

- Roger Road WRF – January to March 2001 (winter)
  August to September 2001 (summer)
- Ina Road WRF – March 2003

The calibrated model generated the influent characteristics for Roger Road WRF, but calibration was not made for Ina Road WRF because there were no operating data available for the BNRAS portion of the plant at the time of the modeling. A review of historical data showed that the strength of wastewater characteristics was highest during the winter and the data used for this period was considered to be the maximum month wastewater characteristics. The model-generated winter wastewater characteristics were selected for evaluation of the Roger Road WRF. The March 2003 data were used for evaluation of the Ina Road WRF. These values established current maximum month wastewater characteristics.

The future wastewater characteristics were developed applying a lower water consumption and therefore higher strength wastewater in the new development areas. This lower water consumption is a trend in a number of newly developed communities. A lower wastewater flow of 65 gpcd was used for future flow instead of 85 gpcd that was used in the 2006 Facilities Plan document. The flow projected in the 2006 Facilities Plan document was retained and applied to the predicted higher strength characteristics, resulting in a higher and more conservative estimate of total loads.

As a part of the current facility planning, the biosolids treatment evaluation has progressed and recommendations have been made on the biosolids treatment and handling alternatives as described in Chapter 6. Based on this information, more accurate recycle stream flows and characteristics were determined and complete mass balances were made for both plants with the recycle streams. Major assumptions applied to the mass balances associated with biosolids treatment and handling include:

- Recycle from gravity thickening of Roger Road WRF primary sludge and WAS is treated at the Roger Road WRF.
- Recycle from gravity thickening of Ina Road WRF primary sludge and WAS and centrifuge thickening/dewatering of digested sludge from both plants is treated at the Ina Road WRF.
- Estimated Non-Metro area sludge contributions to each plant are: Avra Valley WRF (4.13 tons per day (tpd)) to Roger Road WRF; and Marana WRF (6.16 tpd), Corona WRF (3.7 tpd), Fairgrounds WRF (0.004 tpd) and Mt. Lemon WRF 0.018 tpd) to Ina Road WRF. (Randolph Park WRF sludge is included with Roger Road WRF. Green Valley WRF and Southlands WRF were assumed to have separate sludge facilities.) The sludge was applied as a part of the influent stream for both plants.
- Primary sludge at 1% solids concentration.
- Secondary sludge yield of 0.7 pound (lb) TSS/lbs BOD applied and WAS concentration of 7,000 mg/L.
- Gravity thickener solids capture of 90% at 4.5% solids concentration.
- Volatile suspended solids (VSS) destruction of 50% in anaerobic digestion.

- Centrifuge solids recovery of 95% at 8% cake solids concentration.

Biosolids processing, except for sludge thickening, will not be performed at the Roger Road WRF and the wastewater characteristics were developed with only recycle from the thickening operations. Complete biosolids processing as described above will be performed at the Ina Road WRF and the wastewater characteristics were developed with the recycle stream from raw sludge thickening and digested sludge thickening/dewatering operations. To account for the recycle stream contribution, a percentage increase to each wastewater characteristics component, selected from previous plant design experience, was used.

The estimated wastewater characteristics were developed combining the current and future loadings, and recycle stream contribution. The estimated wastewater characteristics for three flow split options are shown in
Table 4-3 and
Table 4-4 for Roger Road WRF and Ina Road WRF, respectively.

Table 4-3
Development of the Roger Road WRF Year 2030 Wastewater Characteristics Based on Complete Mass Balance

Parameter	Units	Total Raw Influent	Recycles	Primary Influent	Primary Effluent
Existing Plan					
Flow	mgd	32.1	1.1	33.2	32.6
COD[(1)]	mg/L	648	1011	659	443
BOD_5[(2)]	mg/L	294	506	301	214
$sBOD_5$[(3)]	mg/L	121	116	121	123
TSS	mg/L	286	1011	310	126
VSS	mg/L	225	791	243	104
TKN	mg/L	47	51	47	46
TP	mg/L	10	19	10	10
Transfer Some					
Flow	mgd	20.1	0.7	20.8	20.4
COD	mg/L	665	1014	677	455
BOD_5	mg/L	303	507	310	220
$sBOD_5$	mg/L	123	117	123	126
TSS	mg/L	304	1014	329	134
VSS	mg/L	239	794	258	110
TKN	mg/L	48	51	48	47
TP[(1)]	mg/L	10	19	10	10
Transfer All					
Flow	mgd	0	0	0	0
COD	mg/L	0	0	0	0
BOD_5	mg/L	0	0	0	0
$sBOD_5$	mg/L	0	0	0	0

Parameter	Units	Total Raw Influent	Recycles	Primary Influent	Primary Effluent
TSS	mg/L	0	0	0	0
VSS	mg/L	0	0	0	0
TKN	mg/L	0	0	0	0
TP	mg/L	0	0	0	0

(1) COD = Chemical Oxygen Demand (2) BOD_5 = 5-day Biochemical Oxygen Demand
(3) $sBOD_5$ = soluble 5-day Biochemical Oxygen Demand

Table 4-4
Development of the Ina Road WRF Year 2030 Wastewater Characteristics Based on Complete Mass Balance

Parameter	Units	Total Raw Influent	Recycles	Primary Influent	Primary Effluent
Existing Plan					
Flow	mgd	50.2	2.3	52.6	51.4
COD	mg/L	663	1265	689	456
BOD_5	mg/L	318	456	324	229
$sBOD_5$	mg/L	123	125	123	126
TSS	mg/L	319	1201	358	146
VSS	mg/L	254	881	282	123
TKN	mg/L	55	219	63	61
TP	mg/L	11	102	15	14
Transfer Some					
Flow	mgd	62.2	2.7	64.9	63.6
COD	mg/L	654	1230	678	441
BOD_5	mg/L	31	462	317	223
$sBOD_5$	mg/L	122	124	122	125
TSS	mg/L	307	1172	343	140
VSS	mg/L	244	873	270	116
TKN	mg/L	54	196	59	57
TP(1)	mg/L	11	90	14	13
Transfer All					
Flow	mgd	82.3	3.4	85.7	84.0
COD	mg/L	654	1184	675	452
BOD_5	mg/L	307	472	314	222

Parameter	Units	Total Raw Influent	Recycles	Primary Influent	Primary Effluent
$sBOD_5$	mg/L	121	122	121	123
TSS	mg/L	304	1140	337	138
VSS	mg/L	241	852	265	115
TKN	mg/L	52	165	56	54
TP	mg/L	10	75	13	12

After detailed evaluations were made on the flow split options between the Roger Road WRF and Ina Road WRF as discussed in Chapter 4.7, Option (1): 32 mgd for Roger Road WRF and 50 mgd for Ina Road WRF, was selected. The final values of the wastewater characteristics for the selected flow-split option are shown in
Table 4-5.

Table 4-5
Selected Year 2030 Wastewater Characteristics
Based on Complete Mass Balance

Parameter	Units	Roger Road WRF		Ina Road WRF	
		Primary Influent	Primary Effluent	Primary Influent	Primary Effluent
Flow	Mgd	33.2	32.6	52.6	51.4
COD	mg/L	659	443	689	456
BOD_5	mg/L	301	214	324	229
$sBOD_5$	mg/L	121	123	123	126
TSS	mg/L	310	126	358	146
VSS	mg/L	243	104	282	123
TKN	mg/L	47	46	63	61
TP	mg/L	10	10	15	14

The future peaking factors for the flows and concentrations were based upon the historical peaking factors as described in Chapter 3 and are as follows:.

- Monthly Peak Flow (MPF) – 1.1 times average daily flow
- Daily Peak Flow (DPF) – 1.4 times average daily flow
- Hourly Peak Flow (HPF) – 2.0 times average daily flow

4.3 Treatment Strategy Alternatives ("Existing Plan", "Transfer All", "Transfer Some")

4.3.1 Existing Plan

The existing plan is for plants at both Roger Road WRF and Ina Road WRF to continue operating, following the present long-range CIP project schedule to address the capacity and regulatory needs of both Roger Road WRF and Ina Road WRF. As identified in the 2006 Metropolitan Area Facility Plan Update, the current plan is to complete the necessary rehabilitation and process optimization at both plants, incorporate enhanced odor control facilities, transfer all biosolids to Ina Road WRF, via a modified sludge line, develop a centralized biosolids processing facility with a potential for future modification to produce a Class A biosolids, and add an interconnect pipeline between the two plants that can provide a flow transfer from the Roger Road WRF service area to Ina Road WRF via gravity. This plan represents the flow split Option "Existing Plan" as shown in **Table 4-2.**

4.3.2 Transfer Some Wastewater Flows to Ina Road WRF

The transfer some plan is to maintain a facility at the Roger Road WRF to continue to provide effluent to the adjacent Tucson Reclaimed Water Treatment Plant, and direct the remainder of the flows to Ina Road WRF. Based on the economics of building and operating future facilities, it may be desirable to maintain a smaller treatment facility at Roger Road WRF, while directing the majority of the flows to Ina Road WRF. Under this option some of the existing facilities could be modified to treat all or a portion of the flow required for the Tucson Reclaimed Water Treatment Plant, CEP, SAWRSA, and other effluent water owners. All solids, including primary sludge and WAS, along with the remainder of the flow in the service area will be directed to Ina Road WRF. This would allow shutdown of a large portion of the facilities currently located at Roger Road WRF, and optimize operations and maintenance at this facility. This plan represents the flow split Option "Transfer Some" as shown in **Table 4-2**.

4.3.3 Transfer All Wastewater Flows to Ina Road WRF

This plan is to transfer all wastewater flow from the Roger Road WRF service area to Ina Road WRF and the Roger Road WRF would be shutdown. All flows would be directed by gravity flow from the Roger Road WRF to the Ina Road WRF. The two facilities are about 5 miles apart, and the Roger Road WRF is located approximately 75 feet higher in elevation than the Ina Road WRF. The transfer of all flows would be accomplished with a gravity sewer, and a plant expansion and/or process modifications at Ina Road WRF to accommodate the additional flows. The existing rehabilitation projects and potential future processing to Class A biosolids would be incorporated into the plan. Consolidation of treatment facilities would centralize treatment with the goal of optimizing operations and maintenance. Under this plan, the flow required for Tucson Water Reclaimed Water System, CEP, SAWRSA, Pima County and other reclaimed water owners are identified and addressed and would involve transfer of treated effluent from Ina Road WRF to the Roger Road site. This plan represents the flow split Option "Transfer All" as shown in **Table 4-2**.

4.4 Reclaimed Water Program

Effluent water will be made available to Tucson Water for their reclaimed water service system at the future Roger Road WRF, Ina Road WRF and Randolph Park WRF. The plan allows for approximately 30 mgd at Roger Road WRF and approximately 20 mgd at Ina Road WRF based on allocated effluent water shares in the year 2030. The 3-mgd effluent from Randolph Park WRF is also available for reclaimed water use. Up to 7 mgd could be made available for discharge into the Santa Cruz River at the Roger Road WRF site. This requires that up to at least 5 mgd (existing plan) and as much as 37 mgd (transfer all plan) of the Ina Road WRF effluent be transferred to the Roger Road WRF site via a pumping station/force main system. The balance of the Ina Road WRF effluent beyond reuse needs provided directly from the Ina Road WRF will be discharged into the Santa Cruz River. Reclaimed water system alternatives are presented in **Appendix F.**

Based on the ADEQ regulatory requirements for future wastewater treatment, effluent from the Roger Road WRF and Ina Road WRF will be classified as either Class B+, or Class A+. If the effluent is Class A+, Tucson Water would be able to decommission its pressure filter treatment system at Roger Road WRF and feed effluent directly into the reclaimed water distribution system after chlorination to meet residual requirements. Tucson Water will construct the necessary filtration system (as required for Class B+), pump station, reservoir, pipeline and chlorine feed facility at Ina Road WRF to provide its reclaimed water needs.

4.5 Effluent Disinfection

Arizona Administrative Code (AAC) Title 18, Ch. 9 includes disinfection requirements for all sewage treatment facilities, including expansions of existing sewage treatment facilities that treat wastewater containing sewage. Article 2. Aquifer Protection Permits – Individual Permits, Part B. BADCT for Sewage Treatment Facilities, defines the requirements for Pathogen Removal (sic: Disinfection) as follows:

> *i. No fecal coliform organisms or no E. coli bacteria are detected in four of the wastewater samples collected during the week, based on a sampling frequency of seven daily samples per week;*
> *ii. The single sample maximum concentration of fecal coliform organisms in a wastewater sample is not greater than 23 cfu/100 ml or the single sample maximum concentration of E coli is not greater than 15 cfu/100 ml.*

During the master plan investigations it was concluded that the cost effective disinfection process that would meet the BADCT requirements was inconclusive. Disinfection processes likely to meet the "demonstrated" disinfection requirements of the ACC include:

- Enhanced Chlorination
- Enhanced Chlorination preceded by effluent filtration
- UV Irradiation preceded by effluent filtration

Studies to determine if enhanced chlorination disinfection processes are capable of achieving the AAC disinfection requirements are included of this planning effort. The studies have provided favorable results but further review and regulatory approval is recommended before finalizing the conclusion of the study. Meeting Notes and the study results of the Enhanced Chlorination/De-Chlorination Evaluation are included in **Appendix G**. However, in an effort to make the planning process as complete as possible, particularly for the PCRWRD CIP, the most costly (capital and O&M) process, UV radiation preceded by effluent filtration is included for cost purposes.

4.6 BNR Process Alternatives

4.6.1 Universe of BNR Process Alternatives

The Pima County Wastewater Regional Optimization Plan Study addressed the need to upgrade existing wastewater treatment facilities at the Roger Road WRF, Ina Road WRF and Randolph Park WRF for increased capacity and more stringent effluent requirements in terms of suspended solids, nitrogen, phosphorus, and disinfection. A Master Plan for the design year 2030 must consider such effluent requirements, water reuse opportunities, and expanded facilities to treat the requirements. Although the existing permit does not require nitrogen or phosphorus removal, future discharge permits for the Roger Road WRF and Ina Road WRF require each facility to address ammonia toxicity. The current trend of regulatory requirements in the region indicates that more stringent phosphorus and total nitrogen removal requirements may be imposed in the future. The treatment process alternatives were developed to meet the goal of future effluent limits for nutrients with the following criteria:

- Ammonia nitrogen concentration of 2 mg/L or less
- Total nitrogen concentration of 8 mg/L or less
- Total phosphorus concentration of 1 mg/L or less

In addition to the treatment goals as stated above, a high quality effluent with low suspended solids is required for reuse of the effluent.

A number of biological treatment processes are currently available for nitrogen and phosphorus removal to meet the stated effluent goal. While chemical phosphorus (Chem-P) removal is a very effective method for removing phosphorus, particularly when the extremely low effluent phosphorus limit, such as 0.5 mg/L or less, is required, biological phosphorus (Bio-P) removal methods are considered preferable because they generate less sludge and do not require chemical storage and chemical feed system and do not incur additional chemical costs. In many cases biological phosphorus removal can be added to a nitrogen removal process with a minimum investment of additional tankage and provides the additional benefit of improving sludge settleability. Additionally, due to the size and location of the process units, it is considered prudent that the Bio-P removal process needs be addressed in the beginning of the project rather than as an add-on at some future date. Chem-P removal process (if required to meet more stringent effluent P limits than can be attained by Bio-P alone) could be easily added in the future.

From an overview of the universe of BNR processes (performed by the Consultant Team, the Peer Review Group and PCRWRD), the nitrogen removal processes that are considered best suited for further

consideration for the Pima County Regional Optimization Master Plan are listed below. An anaerobic process could be combined with these processes to achieve Bio-P removal as well.

- Suspended Growth System
  - Modified Ludzack-Ettinger (MLE)
  - Bardenpho
  - Step feed activated sludge system for nitrification-denitrification (NdeN)

- Attached Growth System
  - Biological Aerated Filters (BAF) and Denitrifying Sand Filters
  - Moving bed (MBBRs)
  - Trickling Filter (Biotowers)

- Integrated System
  - Integrated fixed film activated sludge (IFAS)
  - Membrane in activated sludge system, membrane bioreactor (MBR)

4.6.2 Initial Screening of BNR Process Alternatives

The available BNR processes were reviewed for their potential applicability and compatibility with the existing facilities, several BNR processes were initially screened for evaluation. The initially screened processes and descriptions are as follows:

- *Modified Ludzack-Ettinger (MLE)* – Suspended growth activated sludge with an anoxic zone followed by an aeration zone and secondary clarification. Mixed liquor from the aerobic zone is recycled upstream to the anoxic zone at a recycle flow rate of 3-4 times the influent flow rate. An anaerobic zone can be added to the front of the process if phosphorus removal is also required.

- *Bardenpho* – Similar to the MLE process but a second set of anoxic and aerobic zones is added after the first aerobic zone to provide additional nitrogen removal.

- *Step-Feed Nitrification and Denitrification (NdeN)* – This process has been used in many places in the U.S. to retrofit existing step feed activated sludge systems for biological nitrogen removal. The designs typically have 4 passes with the influent feed distributed at different ratios to an anoxic zone in each pass, followed by an aerobic nitrifying zone. Biological phosphorus removal is difficult to incorporate into each basin due to the complexity of the piping and tank arrangements.

- *Integrated Fixed-film Activated Sludge (IFAS)* – This process is a combination of fixed film and suspended growth biological treatment. The process can be envisioned as a standard activated sludge process that adds attached growth to the aeration tank to increase the amount of active biomass. The aeration tanks are partially filled with suspended inert media that serve as a surface for the attached growth. The aeration tank incorporates screens or sieves to retain the media in the aeration tanks. The aeration tank is followed by a secondary clarifier for suspended solids removal. A portion of the suspended solids are returned to the aeration tank.

- *Membranes (MBR)* – This is an activated sludge process in which microfiltration through a synthetic membrane is used in place of secondary clarification. The microfiltration occurs in a separate, final stage activated sludge tank. Essentially all suspended solids and bacteria are retained in the aeration tank due to the small pore size of the separation membrane. The membrane provides both solids removal and filtration. Sludge is directly wasted from the aeration tank to maintain the desired Solids Retention Time. With membrane separation a much higher mixed liquor suspended solids (MLSS) concentration (7-15,000 mg/L) can be used in the activated sludge process, reducing tank volume requirements. The MLSS concentration that can be achieved is limited by the oxygen transfer capacity of the aeration system and the fouling properties of the membranes.

- *Biological Aerated Filters (BAF)* – BAFs are upflow attached growth fixed film processes. Normal flow is upward through a packed bed of media. For BOD removal and nitrification, air is added concurrent with the wastewater flow to supply oxygen to the biomass. The media serves as both an attachment surface for the biomass and as a filter media. As a result these process doe not require clarifiers. Attached biomass is wasted from the filters when the filters are backwashed. The media size is in the range of 2 to 4 mm and oxygen for the biological process is supplied through an air header piping system below the media aerobic bio-treatment zones. The Biostyr and Biofor processes are the two most prominent BAF processes. The Biostyr process contains a light, buoyant polystyrene bead material and the Biofor process contains a dense expanded clay media. These processes have been used for BOD removal, nitrification and denitrification. For denitrification, an anoxic zone if provided by eliminating the air except for backwashing.

- *Activated Sludge/ Nitrifying Trickling Filter (AS/NTF) with denitrification filters at Roger Road WRF* – This process uses a mixture of attached growth and suspended growth process, and is intended to take advantage of some of the existing infrastructure at the Roger Road WRF. This is applicable only to the Roger Road WRF with the existing biotowers to be used as trickling filters. In the first step, a low sludge retention time (SRT) suspended growth activated sludge process is used for BOD removal and biological phosphorus removal. The process has an anaerobic zone followed an aerobic zone and secondary clarification. The effluent from this step is nitrified in trickling filters, with methanol added to the trickling filter effluent prior to denitrification and filtration on a deep bed denitrifying filter. Modification of this process includes adding metal salts, such as alum or ferric chloride to the primary treatment step for phosphorus precipitation and additional BOD and TSS removal.

- *Biotowers/Nitrifying Activated Sludge (BT/NAS) with denitrification filters at Roger Road WRF* – This is applicable only to the Roger Road WRF utilizing the existing biotowers. The existing biotowers are essentially deep packed bed gravity fed trickling filters. The wastewater is first treated in the biotowers, with the biotowers effluent treated next in an aerobic nitrifying activated sludge process before secondary clarification. Alum or ferric chloride is added before the secondary clarifier for phosphorus removal. Nitrogen and additional TSS removal from the secondary effluent is accomplished in deep bed denitrifying filters with methanol addition.

- *Moving Bed Bioreactor (MBBR)* – This process is an attached growth only process that uses media similar to that used in the IFAS process as the attachment media. The aeration tanks tend to be

deep to maximize oxygen transfers and are equipped with sieves or screens to retain the media. Wasting of biomass occurs by sloughing of the biomass from the media, similar to what occurs with a trickling filter. Clarifiers may or may not be needed based upon the effluent limits and the amount of sludge production.

Each of these processes needs to be combined with anaerobic process for Bio-P removal or chemical addition for Chem-P removal.

4.6.3 BNR Processes Selected for Detailed Evaluation

The initially screened processes were analyzed further using pass/fail criteria that were jointly selected by the Consultant Team, the Peer Review Group and PCRWRD. A matrix of process versus pass/fail criteria was used for this initial screening process. The pass/fail criteria applied to the screening are:

1. Ability to achieve the effluent goal
2. Adaptability to remove emerging contaminants of concern
3. Is high dose of methanol required?
4. Can use existing Bio-towers at Roger Road WRF?
5. Is it flexible for Bio-P removal?
6. Are capital costs in the range of Bardenpho? (Initial comparative cost analysis showed the lowest life cycle cost with Bardenpho)
7. Can use existing tankage?
8. Can achieve turbidity less than 2 NTU?
9. Can be applied with high purity oxygen (HPO)? (Ina Road WRF has a HPO system)
10. Are O&M costs in the range of Bardenpho? (Initial comparative cost analysis showed the lowest life cycle cost with Bardenpho)
11. Has the process been used in biological nitrogen removal in the plant size of larger than 20 mgd for more than three years?

Criteria 2, 4, 8 and 9 were determined to be secondary in consideration for purposes of BNR process selection and the remaining criteria were determined to be primary considerations.

Cost estimates for the alternatives were made on a comparative cost basis and common costs to all processes such as site preparation, yard piping, and various architectural structures, etc., were not included. Present worth analysis was based on 20 years with 8 percent interest.

A matrix analysis was made based on the pass/fail criteria and comparative cost estimates with the input from Consultant Team, the Peer Review Group and PCRWRD. The results with majority answers from the review groups are summarized in **Table 4-6** and **Table 4-7** for Roger Road WRF and Ina Road WRF, respectively.

Table 4-6
Roger Road WRF Process Selection Matrix Analysis – Majority Answers

Criteria	MLE	Bardenpho	AS/NTF	BT/NAS	Step NdeN	Biostyr/ Biofor	IFAS	MBR	BT/NdeN	MBBR
Primary Considerations										
1	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	N	N	Y	Y	N	Y	N	N	Y	Y
5	Y	Y	Y	N	Y/N	N	Y	Y	N	Y/N
6	N	Y	Y	Y	Y	N	Y	N	DK	DK
7	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
10	N	Y	N	N	Y	N	Y	N	N	N
11	Y	Y	DK	DK	Y	Y	N	N	DK	DK
Secondary Considerations										
2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	N	N	Y	Y	N	N	N	N	Y	Y/N
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: Y = Yes; N = No; DK = Do not know; NA = Not applicable

As shown in **Table 4-7**, AS/NTF, BT/NAS and BT/NdeN are not applicable to the Ina Road WRF because treatment with existing trickling filters is available only at the Roger Road WRF.

Table 4-7
Ina Road WRF Process Selection Matrix Analysis – Majority Answers

Criteria	MLE	Bardenpho	AS/NTF	BT/NAS	Step NdeN	Biostyr/ Biofor	IFAS	MBR	BT/NdeN	MBBR
Primary Considerations										
1	N	Y	NA	NA	Y	Y	Y	Y	NA	Y
3	N	N	NA	NA	N	Y	N	N	NA	Y
5	Y	Y	NA	NA	Y	N	Y	Y	NA	Y/N
6	N	Y	NA	NA	Y	N	Y	N	NA	DK
7	Y	Y	NA	NA	Y	N	Y	Y	NA	Y
10	N	Y	NA	NA	Y	N	Y	N	NA	N

Criteria	MLE	Bardenpho	AS/NTF	BT/NAS	Step NdeN	Biostyr/ Biofor	IFAS	MBR	BT/NdeN	MBBR
11	Y	Y	NA	NA	Y	Y	N	N	NA	DK
Secondary Considerations										
2	Y	Y	NA	NA	Y	Y	Y	Y	NA	Y
4	NA	NA	NA	NA	NA	NA	N	NA	NA	NA
8	Y	Y	NA	NA	Y	Y	Y	Y	NA	Y
9	N	N	NA	NA	N	N	NA	NN	NA	N

Notes: Y = Yes; N = No; DK = Do not know; NA = Not applicable; NN = Not usable

Based on the comparative cost estimates and matrix evaluations using the pass/fail criteria stated above, the failed processes that are not to be considered for further evaluation and the reasons are as follows:

- Step Feed NdeN
  - Difficulty in incorporating the Bio-P removal
  - May require high dose of methanol
- Biostyr/Biofor
  - Difficulty in incorporating the Bio-P removal
  - High capital and operation and maintenance costs
  - Can not use existing tankage

- AS/NTF
  - Difficulty in incorporation of Bio-P removal
  - High capital operation and maintenance costs
  - No track record of long period, large plant operation (>3 years and >20 mgd)
  - Only applicable to Roger Road WRF

- MBR
  - Very high capital operation and maintenance costs
  - No track record of long period, large plant operation (>3 years and >20 mgd)
  - May require high dose of methanol
  - Unknown life expectancy of membranes

- MBBR
  - High capital operation and maintenance costs
  - No track record of long period, large plant operation (>3 years and >20 mgd)
  - No high temperature (20-33°C) wastewater experiences

Among the remaining processes, the Bardenpho process received the highest ranking followed by IFAS and MLE. The BT/NAS process has essentially similar advantages and disadvantages to those of AS/NTF. However, it was determined that there was a merit to include an alternative utilizing the existing biotowers for Roger Road WRF. Therefore the following four alternatives were selected for detailed evaluation.

- Bardenpho
- MLE
- IFAS
- BT/NAS for Roger Road WRF and Bardenpho for Ina Road WRF

4.7 Alternative Evaluation Criteria

4.7.1 Technical Criteria

The purpose of alternative evaluation is two fold: to select the most viable process applicable to both treatment plants; and then to select the most favorable flow split options between the plants. Technical criteria used in the analysis to determine the most viable alternative were:

- Operability
- Proven process
- Life cycle cost
- Site compatibility
- Resource consumption
- Ease of operation and maintenance during construction

4.7.2 Financial Criteria

Financial criteria used in the evaluation of alternatives included:

- Capital costs
- Operation and maintenance (O&M) costs
- Present worth of capital and O&M costs

4.7.3 Non-Economic Factor Criteria

Non-economic Factor Criteria were also used in the final evaluation to determine optimal flow split between the Roger Road WRF and the Ina Road WRF. These criteria and the evaluation are described in detail in Chapter 4.8.3.

4.8 Evaluation of Alternatives

4.8.1 Technical Evaluation

Technical aspects pertinent to each alternative are described below. Each of the processes described below is a nitrogen removal process and is typically preceded by an anaerobic process for Bio-P removal.

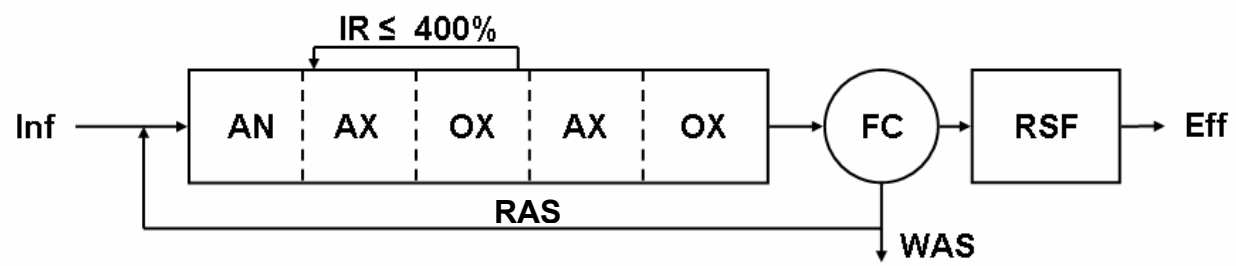
- *Bardenpho* – This process configuration consists of a series of four anoxic and aerobic zones with internal recycle of the mixed liquor from the last compartment of the first aerobic zone to the first anoxic zone at a rate of up to 400 percent of the average influent flow rate. This process is intended

to remove more nitrogen than the two-stage process such as MLE. Anaerobic zones for Bio-P process step are normally located ahead of the nitrogen removal process. Denitrification filters with methanol addition would not be required to achieve effluent limits for ammonia and nitrogen.

This process has at least 30 years of history in application and proven technology with a track record of small to plants > 100 mgd and wide range of influent characteristics while meeting effluent criteria more stringent than required for PCRWRD.

A typical process diagram for the Bardenpho process is shown on **Figure 4-1**.

Figure 4-1
Typical 5-Stage Bardenpho Process Diagram

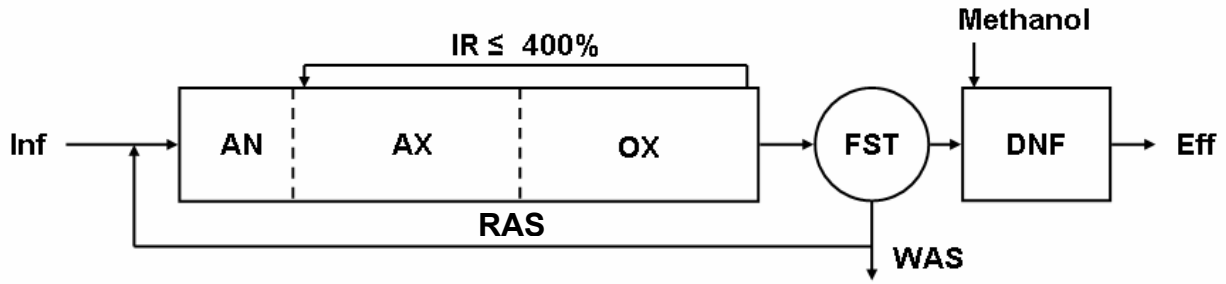


Inf – Influent
AX – Anoxic Chamber
RSF – Rapid Sand Filter
Eff – Effluent
AN – Anaerobic Chamber
IR – Internal Recycle
RAS – Return Activated Sludge
WAS – Waste Activated Sludge
OX – Oxic Chamber
FC – Final Clarifier

- *MLE* – This process consists of anoxic and aerobic zones with internal recycle of the mixed liquor from the aerobic zone to the anoxic zone at a rate up to 400% of the influent flow. The maximum percentage removal of nitrogen is less than the Bardenpho process. Denitrification filters with methanol addition would be required to achieve effluent limits for ammonia and nitrogen. Anaerobic zones for Bio-P process step are located ahead of the nitrogen removal step.

  A typical process diagram for the MLE process is shown on **Table 4-2.**

Figure 4-2
Typical MLE Process Diagram



Inf – Influent
AX – Anoxic Chamber
FST – Final Settling Tank
Eff – Effluent
AN – Anaerobic Chamber
IR – Internal Recycle
DNF – De-Nit Filter
WAS – Waste Activated Sludge
OX – Oxic Chamber
FC – Final Clarifier
RAS – Return Activated Sludge

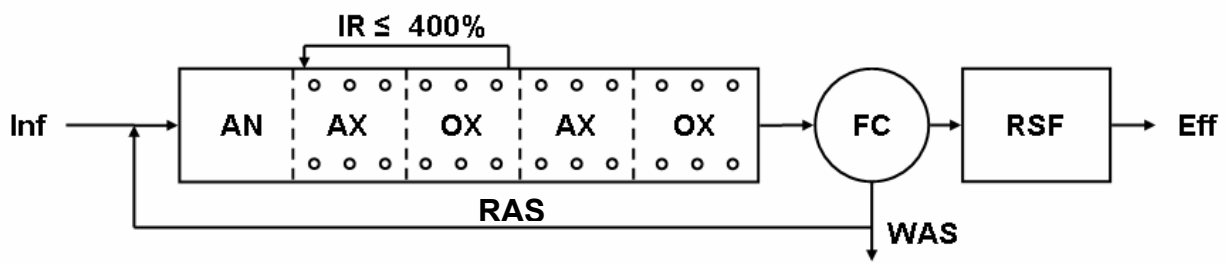
- *IFAS* – This process is a combination of fixed film and suspended growth biological treatment. The aeration tank configuration employs the same concept of MLE process with anoxic and anaerobic zones. Aeration tanks containing porous plastic media provide high surface area for attached biological growth. The media is separated from the aeration tank effluent with screens installed and retained in the aeration tanks. The attached growth enables the system to maintain an equivalent MLSS concentration of 4000-6000 mg/L without a high solids load to the clarifiers. Anaerobic zones for Bio-P process step are located ahead of the nitrogen removal process.

  This process is a relatively new, emerging technology and a few small scale applications with limited operational experience are available.

  Advantages of this process include a smaller foot print requirement to implement the process, increasing the capacity of the existing facilities by adding the media, good biomass control and high solids inventory in the aeration tanks. The attached growth nitrifiers are also less sensitive to potential washout then suspended growth. Disadvantages of this process include the cost of media, higher energy requirement for the aeration tanks with media, and no operational experience at high wastewater temperatures.

A typical process diagram for the IFAS process is shown on **Figure 4-3.**

Figure 4-3
Typical IFAS Process Diagram



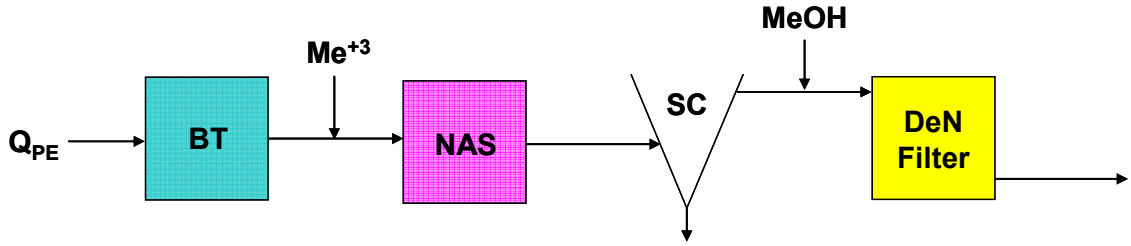
Inf – Influent
AX – Anoxic Chamber
RSF – Rapid Sand Filter
Eff – Effluent
o – Fixed Film
AN – Anaerobic Chamber
IR – Internal Recycle
RAS – Return Activated Sludge
WAS – Waste Activated Sludge
OX – Oxic Chamber
FC – Final Clarifier

- *BT/NAS for Roger Road WRF and Bardenpho for Ina Road WRF* – This process is intended to utilize the existing treatment facility and retrofit the required facilities treatment facilities at Roger Road WRF.

  The advantage of this process would be maximum utilization of existing facilities. The disadvantages would be difficulties of retrofitting the new process with the existing facilities, chemical requirement for phosphorus removal, requirement of denitrification filters with methanol addition and potentially high costs. In addition there would be no commonality of the processes at the two treatment plants which could require more operational training and a higher inventory of spare part.

  A typical process diagram for the BT/NAS process is shown on **Figure 4-4**.

Figure 4-4
Typical BT/NAS Process Diagram



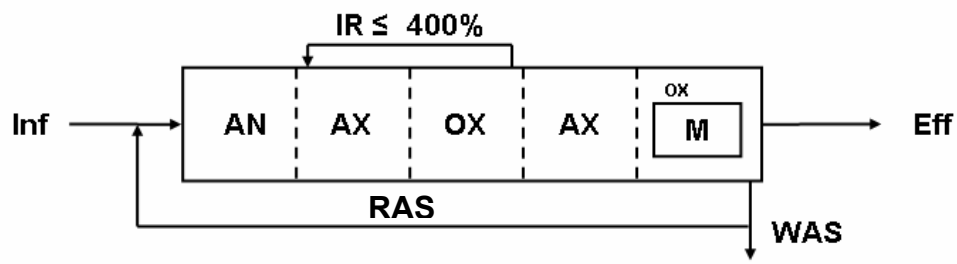
BT – Biotower
MeOH – Methanol
NAS – Nitrifying Activated Sludge
Me^{+3} – Metallic ion, Al or Fe
SC = Secondary Clarification

- *MBR* – This process combines an ultrafiltration membrane system for solids separation with an activated sludge reactor eliminating the need for separate clarification. Wastewater is screened before entering the biological treatment tank where aeration within this aerobic zone provides the oxygen required for biological respiration and maintains solids in suspension. MLSS in the bioreactor are maintained at high levels (1% - 3%) allowing high levels of organic loading to the reactor. All solids are retained within the reactor, thus requiring no return activated sludge system. The process runs at a high solids retention time and nitrifiers are easily maintained within the system. The process is capable of achieving low levels of effluent BOD, suspended solids, nitrogen, and phosphorus.

  A major advantage of this process is a smaller footprint and increased capacity for existing aeration tanks. The disadvantages would be high energy demand, high capital cost, and high costs associated with membrane maintenance. In addition there would be no commonality of the processes at the two treatment plants which could require more operational training and a higher inventory of spare parts.

  A typical process diagram for the MBR process is shown on **Figure 4-5**.

Figure 4-5
Typical MBR Process Diagram



Inf – Influent
AX – Anoxic Chamber
M – Membrane Bio-Reactor
WAS – Waste Activated Sludge
AN – Anaerobic Chamber
IR – Internal Recycle
RAS – Return Activated Sludge
OX – Oxic Chamber
Eff – Effluent

A matrix analysis was made with inputs from Consultant Team, the Peer Review Group and PCRWRD based on the technical evaluation parameters as stated above and the comparative cost estimates summarized in **Table 4-9**. The system evaluation matrix with evaluation criteria and completed scores for various flow split options are shown in **Table 4-8.**

Table 4-8
Summary of Technical and Financial Evaluation of Alternatives for Roger Road WRF

Criteria	Bardenpho RR/IR	MLE RR/IR	IFAS RR/IR	BT/NAS RR/IR	MBR RR/IR
Operability	0 / 0	0 / 0	0 / 0	0 / NA	
Proven process	+ / +	+ / +	0 / 0	0 / NA	
Life cycle costs	+ / +	- / -	- / -	- / NA	
Site compatibility	+ / +	- / -	+ / +	+ / NA	
Resource consumption	+ / +	- / -	- / -	- / NA	
Ease of maintaining treatment capacity during construction	+ / +	+ / +	+ / +	+ / NA	
Recommended process	Yes	No	No	No	

Notes: 0 means neutral; + means positive; – means negative;
NA means not applicable; RR = Roger Road WRF; IR = Ina Road WRF

Based on the results the Bardenpho process was determined to be the most viable technology for both plants for the given raw wastewater characteristics and effluent requirements.

4.8.2 Financial Evaluation

More detailed comparative cost estimates were made for the entire treatment facilities for Roger Road WRF and Ina Road WRF including interconnect pipelines, primary clarifiers, aeration tanks, final clarifiers, disinfection facility and odor control system. The costs were estimated in two sets: first, cost estimates were made for the four selected alternatives for the purpose of selection of the most viable alternative; second, the cost estimates were made for the Bardenpho process with the three flow split options for the purpose of selecting the most cost effective flow split between Roger Road WRF and Ina Road WRF. For each case capital and O&M costs were estimated and present worth (PW) costs were calculated based on a project period of 20 years at an interest rate of 8 percent. The major items of the capital costs included:

- Plant interconnect wastewater transmission pipelines
- Demolition and removal of existing obsolete facilities
- Construction of new facilities
- Reclaimed water return transmission lines
- Tucson Water booster pump station
- Tucson Water reservoir

The operation and maintenance (O&M) costs included:

- Labor
- Methanol
- Polymer for sludge thickening and dewatering
- Alum for phosphorus removal
- Power for wastewater treatment
- Power for reuse water pumping
- Interconnect line, pumps and mechanical maintenance

Comparative costs did not include items such as site work, paving, architecture, fencing, irrigation, administration, laboratory, and other elements common to all alternatives.

Capital and O& M costs were estimated using a computerized data base of costs for similar components at many other wastewater treatment plants (Water Cost model), recent experience of the consultant team with construction bids for similar facilities, and published (Means) data based on limited quantity take-offs and vendor quotes. Capital costs for major structures and facilities used in the comparative cost estimates were:

- New screening facility - $60,000/mgd
- New grit facility - $50,000/mgd
- Aeration Tank - $14/cubic feet (cf) of aeration tank volume
- Primary and secondary clarifiers - $350/square feet (sf) of surface area
- Denitrification filters - $3,000/sf surface area
- Rapid sand filters - $2,300/sf surface area
- In plant pump station - $60, 000/mgd
- UV disinfection facilities - $60,000/mgd
- Plant interconnect - $11/inch-foot
- IFAS media - $20/cf of media volume

Comparative costs for major O&M costs were:

- Power cost – 8.7 cents/kilowatthour (kWh)
- Methanol - $1.0/gallon
- Alum - $1.0/gallon
- Polymer - $2/pound
- Labor - $35/hour

Comparative capital costs and present worth (PW) costs are summarized in **Table 4-9**.

Table 4-9
Capital and Present Worth (PW) Costs of Alternatives (1) (2)

Process	Flow Split RR/IR = 32/50		Flow Split RR/IR = 20/62	
	PW	Capital	PW	Capital
Bardenpho at RR and IR	$431	$287	$464	$319
IFAS at RR and IR	$439	$295	-	-
MLE at RR and IR	$446	$300	-	-
BT/NAS at RR and Bardenpho at IR	-	-	$479	$327

(1) Physical limitations of existing trickling filters at Roger Road WRF limit the BT/NAS process application to the 20/62 mgd flow split.
(2) The costs are shown in million dollars.

The Bardenpho process offers the lowest cost treatment approach and is the most widely used process, Therefore, the costs for only the Bardenpho process were prepared to compare the relative costs of the three flow split alternatives.

The Roger Road WRF is aging and is difficult to retrofit with new facilities that are capable of meeting the effluent goals, while meeting all environmental requirements and odor control. The Roger Road WRF site has not sufficient available space to accommodate all new treatment facilities on the existing plant site. Therefore a new treatment plant on the available space referred to as the new Roger Road WRF option was considered as an alternative to the modification/expansion of the existing plant for Roger Road WRF. Major benefits of a new plant include:

- Eliminates risks associated with costs and schedule for rehabilitation
- Can be more flexible, reliable and operable
- Better integrates with reclaimed water system
- Provides least risk for regulatory non-compliance
- Maintains existing eco-system in Santa Cruz River
- Frees up the existing plant property for economic development

The results of the cost estimates for all options, including the new water reclamation campus (WRC) option adjacent to the existing operating facility are summarized in **Table 4-10.**

Table 4-10
Present Worth (PW) Costs for Bardenpho Process with Three Flow Split Options(1)

Flow Split	Capital Cost	PW Cost
RR WRF=32 mgd IR=50 mgd	$287	$431
RR WRF=20 mgd IR=62 mgd	$319	$464
RR WRF=0 mgd IR=82 mgd	$375	$514
New WRC=32 mgd IR=50 mgd	$320	$457
New WRC=20 mgd IR=62 mgd	$340	$480

(1) The costs are shown in million dollars.

The treatment of 32 mgd at Roger Road WRF and 50 mgd at Ina Road WRF is the lowest cost flow split alternative.

The comparative costs in **Table 4-10** for the rehabilitation of Roger Road WRF and the new Roger Road WRF options were based on costs without consideration of the potential costs of the risks inherent in rehabilitating the older Roger Road WRF. Exclusive of these risk-related costs, it would appear that there is a cost savings with the rehab option. However, there are extraordinary risks associated with the Roger Road WRF rehabilitation option that would not be found in the new Roger Road WRF option. The potential cost impacts of these risks are discussed in the following paragraphs.

Schedule – It will take longer to construct the rehabilitation project than to construct a new Roger Road WRF due to the added time needed to phase pieces of the construction to keep the existing plant in operation. There is also the risk of additional time associated with encountering unexpected conditions within the existing plant (piping in unexpected locations, unanticipated utility conflicts, poor underground structural conditions that take time to remedy, etc). There is the additional risk that it may take longer to gain public acceptance of the rehabilitation option than for the new Roger Road WRF option because of the history of odor problems and generally poor public perception of the existing Roger Road WRF. There would be added costs resulting from inflation and added field overhead if these risks materialize. In addition to the inflation, there has been extreme volatility and large cost increases for steel, concrete and copper experienced in the last year. Concrete costs are reported to have increased 15-18 percent from July 2005 to July 2006. Steel bar used to reinforce concrete is reported to have increased at least 50 percent. The net effect on construction costs has been reported to be an increase of 30 percent from July 2005 to July 2006. It is speculative whether or not these increases will continue but if they do, substantial additional costs would be incurred from schedule delays.

If the regulatory deadlines are missed because of delays, a fine for permit violations would likely result. Under Federal law, fines up to $35,000 per day can be imposed in Pima County for each such violation. There is also the potential that a building moratorium would be imposed until the permit violations cease creating added schedule-related costs. The costs and community impacts of such a moratorium would be enormous.

Constructability – Construction within the Roger Road WRF will be very difficult. Claims for changed conditions could be substantial. Existing "as-built" plans in older facilities are never complete or totally accurate. It is not possible to be knowledgeable about the condition of underground structures or the location of underground piping and utilities. These changed conditions could increase the cost of the rehab option.

System Operability – Once the plant is complete, owing to the fact that substantial portions of the plant retain older mechanical equipment and components, the resulting plant will be a patchwork of old and new facilities will cause the rehabilitation plant to be more cumbersome to operate than a new Roger Road WRF. This will require added operating/maintenance staff.

System Reliability – The rehab option which results in a plant that will be a mixture of old and new mechanical equipment that will be inherently less reliable than a new Roger Road WRF. There is a greater risk that a failure of older equipment could cause a violation of the discharge permit. There is a potential liability of $35,000 per day for each such violation.

Environmental Impacts – The rehab option will result in heavy construction occurring in the midst of an operating treatment plant. This increases the chances that a construction activity may disrupt the treatment process causing a violation of the discharge permit. There is a potential liability of $35,000 per day for each such violation. In the event that the disruption causes a severe failure of the treatment process, there could be substantial damage to the downstream environment and health risks with an associated liability.

The risk-related costs for the rehab option at the Roger Road WRF are estimated to be $50,000,000-$80,000,000 exclusive of the cost of a potential building moratorium. When the risk-related costs are considered, the cost difference between the rehabilitation and a new Roger Road WRF options for the Roger Road WRF shown in the above table disappear.

4.8.3 Non-Economic Factor Criteria

A set of non-economic factor criteria and weighting factors were used for a system analysis to determine the most viable and cost effective flow split configuration between the two plants. The evaluation criteria and weighting factors were selected with the input from the Consultant Team, the Peer Review Group and PCRWRD. The cost estimates as shown in the above table were used for the cost criterion. The selected non-economic factor criteria are included in the list shown below:

1. Cost (exclusive of risk-related costs involved in the rehab Roger Road WRF option)
2. Schedule
3. Constructability
4. Flexibility

5. System Reliability
6. System Operability
7. Environmental Impacts
8. Water/Waster System Optimization
9. Public Acceptance
10. Potential for Cost Sharing
11. Effect on Financing

The system evaluation matrix with evaluation parameters, weighting factors and total scores agreed upon by the Consultant Team, the Peer Review Group and PCRWRD in a workshop, are shown in **Table 4-11.**

Table 4-11
Non-Economic Factor Criteria Evaluation Matrix with Complete Scores
(Rating scale of 1-5 with a rating of 5 being most favorable)

Criteria	Weighting	Un-Weighted Score					Weighted Score				
		RR=32 IR=50	RR=20 IR=62	RR=0 IR=82	RRGF=32 IR=50	RRGF=20 IR=62	RR=32 IR=50	RR=20 IR=62	RR=0 IR=82	RRGF=32 IR=50	RRGF=20 IR=62
1	5	5	4	2	4	3	50	40	20	40	30
2	5	3	3	5	5	5	15	15	25	25	25
3	3	2	2	4	5	4	6	6	12	15	12
4	4	3	3	5	5	5	12	12	20	20	20
5	4	4	4	5	5	5	16	16	20	20	20
6	4	3	3	4	4	4	12	12	16	16	16
7	4	3	3	4	4	4	12	12	16	16	16
8	5	5	4	3	5	4	25	20	15	25	20
9	5	1	2	2	3	2	5	10	10	15	10
10	3	5	4	3	5	4	15	12	9	15	12
11	3	5	4	2	4	3	15	12	6	12	9
Total		39	36	39	49	43	183	167	169	219	190

This evaluation demonstrated that the flow split option of 32 mgd with a new Roger Roads WRF design for Roger Road WRF and 50 mgd with rehabilitation of existing facilities for Ina Road WRF employing the Bardenpho process provides the best option for the Regional Optimization Master Plan. The new Roger Road WRF option has a higher rating than the rehabilitation of Roger Road WRF options even without consideration of the risk-related costs involved in the rehab option. The new Roger Road WRF design option for Roger Road WRF was further reviewed to determine if there would be savings or other benefits of eliminating primary treatment in the new Roger Road WRF. Since all sludge produced at both plant sites would be processed at the Ina Road WRF, it would simplify operations if the primary treatment is eliminated at Roger Road WRF. Potential benefits of a new Roger Road WRF design without primary treatment include:

- Eliminates construction and operating costs of primary clarifiers at Roger Road WRF
- Eliminates primary sludge pumping to Ina Road WRF and processing it at Ina Road WRF
- Provides a carbon source necessary for Bio-P and nitrogen removal

A disadvantage is increased aeration tank size and aeration power at Ina Road WRF. However, comparative cost estimates concluded that the additional capital cost of larger aeration tanks is offset by the elimination of capital cost for primary clarifiers at Roger Road WRF. Considering the bulk of BOD removal is achieved through anaerobic and anoxic processes for Bio-P and nitrogen removal, the additional aeration power may be somewhat higher than with primary treatment. During start-up of the Ina Road WRF's BNRAS system, primary clarifiers have been bypassed and the new BNRAS plant has been operated with the raw wastewater resulting in an effluent total nitrogen concentration of 3.5 mg/L. This has been accomplished without appreciable additional aeration costs for air from the blower system. The other disadvantage is that without primary treatment, fine influent screening and good grit removal systems are essential to protect operating pumps and equipment. With these considerations, the new facility design without primary treatment is recommended.

4.8.4 Recommendation

As a result of the evaluations of the BNR process alternatives and flow-split options between Roger Road WRF and Ina Road WRF, the following recommendations are made:

- Use Bardenpho process at both plant locations
- Use a flow split of 32 mgd for Roger Road WRF and 50 mgd for Ina Road WRF
- Use the new facility design for Roger Road WRF plant and rehabilitation for the Ina Road WRF facilities
- Implement the new facility design at Roger Road WRF without primary treatment

4.8.5 Preliminary Sizing of Facilities

The facility for Roger Road WRF and Ina Road WRF was sized to adequately treat the future wastewater loads and to consistently meet the future effluent requirements meeting the treatment goals. The facilities were initially sized based on conventional design approach and confirmed by the GPS-X modeling.

The sizing of the aeration tank was based on the raw wastewater without primary treatment for the Roger Road WRF plant and with primary treatment for the Ina Road WRF. The flows and loading conditions used for the initial sizing are shown in
Table 4-5. The aeration tanks were configured with three-anaerobic bio-selector zones, five-anoxic zones, four-aerobic zones, one-anoxic zone and one-aerobic zone in series for a total of 14 zones. A typical internal recycle of 400 percent was used with the recycle flow from zone 12 to zone 4. This configuration utilizes zones 1-3 for anaerobic process for Bio-P removal and the rest of the zones for BOD removal, nitrification and denitrification.

The Roger Road WRF requires a new aeration capacity of 21 million gallons (MG) for the new facility design option without primary clarifiers. The Ina Road plant requires a total aeration tank capacity of 33

MG. The existing BNRAS aeration tanks provide 7.5 MG of capacity. The balance of 25.5 MG for new aeration tanks needs to be constructed.
Due to carbon limitation to achieve both biological phosphorus removal and denitrification, some chemical addition of ferric chloride (or alum) or methanol is required to remove additional N and/or P beyond the denitrification and Bio-P can achieve in order to meet the effluent requirements. Because of advantage of chemically binding of phosphorus in the biosolids treatment processes and reduced phosphorus in the recycle, additional chemical phosphorus removal, after optimal removal of phosphorus by Bio-P, is recommended. The ferric chloride can be added to the stream of aeration tank effluent ahead of the final clarifiers to clean-up the residual phosphorus to meet the future effluent limit for phosphorus.

The new WRC should be designed for a peak hourly flow of two times of the average daily flow. The peak hourly flows are 64 mgd for the new WRC adjacent to the existing Roger Road WRF and 100 mgd for Ina Road WRF.

Table 4-12
Peak Hourly Flows for Year 2030 at NEW WRC and Ina Road WRF

Item	Roger Road WRF New Facility Design without Primary	Ina Road WRF Existing Plus New Addition
Peak Hourly Flow, mgd		
Influent Pump Station	64	100
Grit Removal Facility	64	100
Primary Treatment	64	100
Aeration Tanks	64	100
Final Clarifiers	64	100
Rapid Sand Filters	64	100
UV Disinfection Facility	64	100
Preliminary Aeration Tank (AT) Size, MG		
Existing AT	0	7.5
New AT	21.0	25.5
Total AT	21.0	33.0

Preliminary site plans are shown on **Figure 4-6 and Figure 4-7** for the new WRC and Ina Road WRF, respectively.

Figure 4-6
32-mgd Water Reclamation Campus Preliminary Site Plan

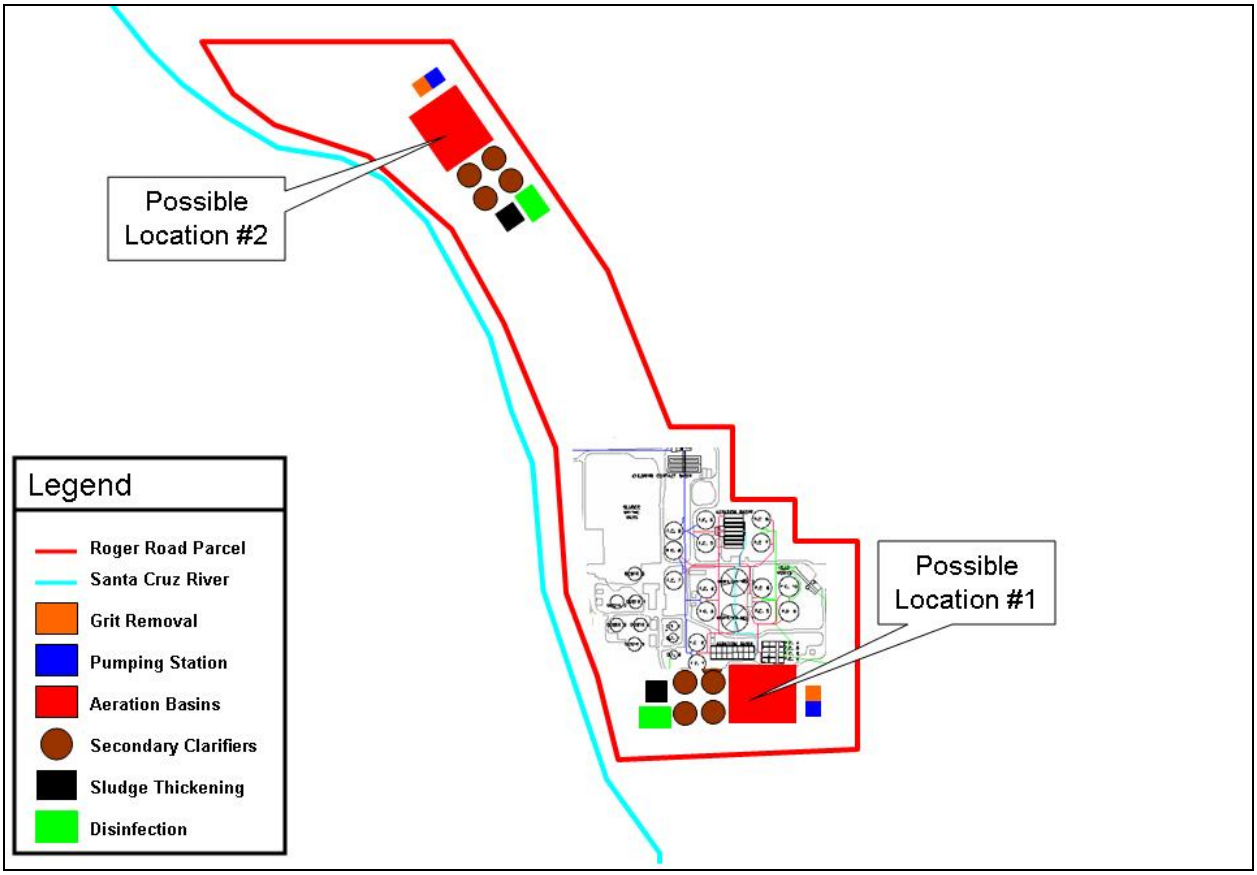
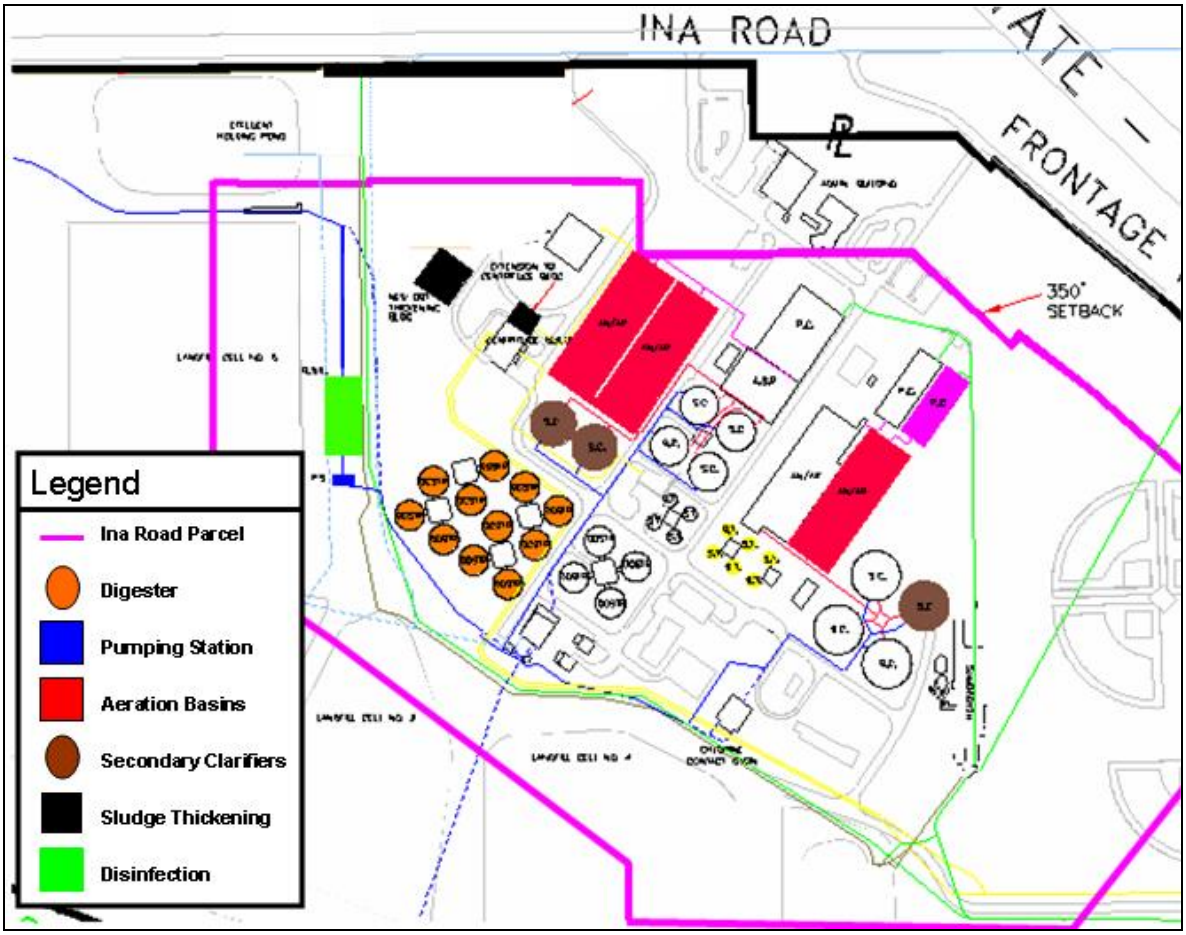


Figure 4-7
New 50-mgd Ina Road WRF Preliminary Site Plan



4.9 Summary

A detailed analysis on the wastewater treatment strategy was made and the results are summarized as follows:

- The year 2030 wastewater flows in the Roger Road WRF and Ina Road WRF service areas were estimated based on the population projections and flow estimates contained in the 2006 Facilities Plan document. The year 2030 total flow within the two service areas is approximately 82 mgd

- Wastewater characteristics were determined based on the information contained in the 2004-2005 GPS-X modeling, future loadings predicated on water conservation, and mass balance with recycle flows from expected future biosolids operation. Because of higher recycle contribution, the nutrient concentrations in the Ina Road WRF influent were substantially higher than the Roger Road WRF influent. Peaking factors were estimated based on operating data.

- Among a number of flow-split options reviewed, three flow-split options were selected for flow split between the treatment plants for further analysis and these include:
  - 32 mgd to Roger Road WRF and 50 mgd to Ina Road WRF
  - 20 mgd to Roger Road WRF and 62 mgd to Ina Road WRF
  - All 82 mgd to Ina Road WRF
- Due to expected stringent effluent requirements and effluent reuse requirements, a high degree of treatment would be required and the effluent goals were set at:
  - Ammonia nitrogen concentration of 2 mg/L or lower
  - Total nitrogen concentration of 8 mg/L or lower
  - Total phosphorus concentration of 1 mg/L or lower
  - Low turbidity

- To meet the effluent goals, a combination of biological nitrogen removal processes and biological phosphorus (Bio-P) removal was found to be the most cost effective.

- A review of BNR processes for nitrogen and phosphorus removal resulted in consideration of nine processes which were screened based on economic and non-economic criteria. As a result, four alternatives were selected for further evaluation:
  - Bardenpho
  - MLE
  - IFAS
  - BT/NAS (for treatment of 20 mgd at Roger Road WRF)

- Four BNR alternatives were further evaluated based on technical and economic criteria. The Bardenpho process was determined as the most reliable and cost effective process for both treatment plants.

- Using on the Bardenpho process, the flow split options were analyzed based of technical and economic criteria. The flow-split option of 32 mgd to Roger Road WRF and 50 mgd to Ina Road WRF was determined as the most reliable and cost effective option.

- The new facility option of replacing the existing Roger Road WRF with a new treatment plant at the Roger Road location was evaluated. Considering the cost uncertainties involved in rehabilitating and modifying the Roger Road WRF and considering non-economic factors, the new WRC option was determined to be the favorable option for the future Roger Road WRF.

Preliminary sizing was made for both treatment plants based on conventional design approach and was confirmed with GPS-X modeling. No chemical use is required for the new WRC, but some amount of alum (or ferric chloride) will be required at the Ina Road WRF when phosphorus removal becomes a requirement at some time in the future. This is due to relatively high nutrient concentration in the Ina Road WRF influent and insufficient carbon source to support for both denitrification and Bio-P. The chemical will remove additional amount of P, after Bio-P removal, to meet the effluent P requirement in the future.