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City of Sedona

TECHNICAL MEMORANDUM NO. 3

EFFLUENT MANAGEMENT STRATEGY EVALUATION

DRAFT

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City of Sedona

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EFFLUENT MANAGEMENT STRATEGY EVALUATION

1.0 INTRODUCTION

The City of Sedona (City) is conducting a study to evaluate potential options to update its current effluent management practices at the Sedona Wastewater Reclamation Plant (WWRP). The 2 million gallon per day (mgd) design capacity WWRP is currently operating at a capacity of approximately 1.2 mgd. Effluent generated by the facility is disposed of through spray irrigation on adjacent City property. A variety of factors, including growth, land values/alternative utility, effluent disposal limitations, and other social, political, economic, and environmental factors have prompted the City to develop a comprehensive effluent management strategy.

A previous study completed for the City recommended further evaluation of effluent injection as a potential effluent management option. This option is further evaluated as part of Technical Memorandum No. 1 (TM 1) - Water Credit Analysis. In an effort to identify the best overall strategy to meet the City's goals, the Wastewater Effluent Disposal and Land Use Task Force (WEDLU) also investigated other effluent management and disposal alternatives, which include but are not limited to constructed wetlands, mechanical evaporators, and direct discharge to surface waters, including the Verde River. Ultimately, the selected effluent management strategy should incorporate the alternative, or combination of alternatives, which provide a robust and flexible solution to meet the City's technical, economic, social and sustainable objectives.

The purpose of this Technical Memorandum No. 3 (TM 3) is to document the results of the initial effluent management alternatives evaluation. While preliminary information is provided for each of the evaluated alternatives, additional, detailed information is provided for the constructed wetlands alternative. This more detailed evaluation was conducted primarily due to the additional information required to determine the validity of constructed wetlands as an effluent management option (compared to other, less complex alternatives). In addition, the team's significant interest in the constructed wetlands alternative further warranted the additional evaluation.

The information outlined in this TM is the result of a coordinated effort between City of Sedona staff, WEDLU, and Carollo Engineers. Each team member played a critical role in the evaluation and contributed to the results and opinions outlined in this TM.

2.0 EFFLUENT MANAGEMENT ALTERNATIVES

One of the primary components of the overall effluent management strategy evaluation was to conduct an analysis of various potential effluent management alternatives to determine their applicability as part of the City's comprehensive effluent management strategy. The alternatives evaluated as part of the study were determined based on input by the project team members. In addition to effluent injection, the team evaluated the following potential alternatives:

- Mechanical evaporation
- Algae farming
- Direct discharge to the Verde River
- Recharge Basins
- Constructed wetlands/riparian habitat

Each alternative is described in detail in the following sections.

2.1 Mechanical Evaporation

Mechanical evaporators have traditionally been used successfully in the oil, gas, and mining industries for disposal of liquid waste streams. Each mechanical evaporation unit is equipped with a pump designed to generate a high pressure. This high-pressure promotes the formation of small droplets of the liquid. These smaller droplets/mist have a higher surface area and facilitate significantly more rapid evaporation than traditional spray irrigation or evaporation ponds/basins.

The mist is discharged to the atmosphere above the unit where it is evaporated. The distance the mist travels from the discharge point, prior to evaporation, is dependent on the rate of evaporation, which is driven by various climactic conditions including wind speed, temperature, humidity, etc.

While there appears to be little definitive information on the subject, some experts, staff members, and regulators have voiced concern over the health and safety implications of the technology. Due to the small size of the particles generated by the unit, there is concern regarding the transport and inhalation of the effluent by plant staff members or future community members (depending on future land uses in the area). Consequently, at a minimum, the team would recommend that effluent disposed of using this technology be treated to Class A+ standards. In addition, further research is warranted to determine the potential for transport of the effluent during high wind or low temperature/high humidity periods. These analyses would serve to set the design criteria for any installation involving mechanical evaporation. (Note: Some of the installations researched automatically shut down the mechanical evaporation unit at sustained wind speeds over 15 miles per hour.)

Currently, there are no mechanical evaporation units in use for effluent disposal in the State of Arizona. WEDLU and Carollo both contacted the Arizona Department of Environmental Quality (ADEQ) to gauge their acceptance of this technology. While ADEQ indicated concern regarding potential adverse health impacts associated with the transport/inhalation of effluent, they are amenable to further reviewing the merits of the technology for an effluent disposal application.

Carollo and WEDLU contacted several mechanical evaporator manufacturers to obtain information on potential applications. In general, a single large mechanical evaporation unit, such as the unit depicted in Figure 3.1, could dispose of approximately 40,320 gallons per day (gpd) of effluent. Based on this assumption, 30 units would be required to manage the WWRP's current 1.2 mgd flow. The equipment cost for each unit is approximately $26,850 including a weather station for each evaporator. The equipment cost for 30 units is $805,000. Additional costs would be required for installation and any utility upgrades (power, etc.) required to accommodate the units.

Per information provided by the manufacturer, each unit requires approximately 582 kWh to operate. Assuming an energy cost of $0.09/kWh, the 30 units required to accommodate 1.2 mgd of effluent would result in an energy cost of approximately $575,000 per year. Appendix A includes a proposal from Resource West for the mechanical evaporation units described in this section.

The team identified several potential advantages and disadvantages of effluent disposal through mechanical evaporation as summarized below:

- Advantages:
  - Minimal footprint requirements.
  - Proven technology in oil, gas, and mining industries.
  - Can be easily and quickly implemented.
  - May provide a cost effective method to handle "peak" effluent flows or emergency conditions.
  - Simple operation.
- Disadvantages:
  - Does not provide a reuse option for the treated effluent.
  - Would require large number of units to accommodate entire facility flow.
  - Affected by wind speed and direction - previous installations shut down automatically at sustained winds of approximately 15 mph - a frequent condition in Sedona.
  - Not currently permitted by ADEQ.
  - ADEQ is concerned with adverse health implications - small water droplets not evaporated can be inhaled or ingested by the public including plant staff.
  - High energy and O&M (maintenance) requirements.
  - Due to the high energy requirements of the equipment, an evaluation of the existing electrical utilities at the plant should be performed prior to moving forward with this alternative. While sufficient primary power may be available at the site, additional electrical sections, conduit/cabling, etc. would likely be required to provide the required service to the units.

MECHANICAL EVAPORATION UNIT

FIGURE 3.1

CITY OF SEDONA
EFFLUENT MANAGEMENT STRATEGY

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Overall Recommendation:

Due to the large number of units required, high O&M costs, lack of reuse potential, and concerns regarding adverse health impacts, mechanical evaporation is not recommended as a stand-alone effluent disposal option for the City of Sedona. However, the technology could provide a reasonably cost effective method of accommodating effluent peaks or could serve as a supplementary or emergency/back-up effluent management option, if potential health impacts and permitting challenges could be adequately addressed.

2.2 Algae Farm

The team also explored algae farms as a potential method to reuse/dispose of treated effluent produced by the City's WWRP. Effluent could be utilized to facilitate the growth of algae in a series of large ponds adjacent to the site. Fifty percent of algae weight is comprised of oil, which can be used to produce biofuel. In the right conditions, algae can grow rapidly and is a reasonably efficient method of producing oil for biofuel, as almost the entire plant engages in photosynthesis to produce oil. Once algae is harvested, it is dried and mechanically pressed to extract the oil from the plant. The leftover algae is disposed of, while the collected oil is transported to a processing facility where it is converted to biofuel through a transesterification reaction with the addition of methanol, a catalyst and heat.

The team identified several potential advantages and disadvantages of effluent disposal through algae farming as summarized below:

- Advantages:
  - Technology is at the forefront of alternative energy development.
  - Is consistent with the City's goal to be a "green" community.
  - Could serve as a source of revenue for the City (depending on the agreement negotiated between the City and processor).
- Disadvantages:
  - Growing algae does not require a significant amount of water. Therefore, it would not be an efficient disposal method for effluent. An additional disposal/reuse alternative would still be required to accommodate a majority of the effluent produced by the WWRP.
  - The process is very land insensitive. A significant land area would be required to grow sufficient algae to justify the financial investment for the processor.
  - Energy is required to grow, harvest, and press/process the algae, dispose of leftover algae, and transport and process the resultant oil. These cradle-to-grave carbon footprint requirements could counteract the inherent "green" nature of the process. Further analysis would be required to determine if Sedona's location would impact the financial feasibility or sustainability of the process.

- There are hundreds of thousands of different species of algae. An extensive feasibility study would be required to determine the specific species of algae that would be most conducive to Sedona's climate and if that species could be grown and processed cost effectively.

Overall Recommendation:

Although algae farming to produce biofuel could provide the City with a cutting edge, "green" and potentially lucrative effluent management alternative, it is likely not a good fit for Sedona based on the City's current goals and objectives. The process is land and energy intensive and would utilize only a portion of the City's effluent. Consequently, additional management alternatives would need to be employed to accommodate the remainder of the effluent produced by the WWRP. Should the City determine that adequate land was available and feasibility studies indicated a potential financial benefit for the Community, the technology could be further explored as a social or economic program, beyond effluent management.

2.3 Direct Discharge to the Verde River

Another potential effluent management alternative is direct discharge to the Verde River. This alternative would involve conveying the treated effluent, via a pipeline, from the Sedona WWRP to the Verde River for discharge.

The team identified several potential advantages and disadvantages of effluent disposal via direct discharge to the Verde River as summarized below:

- Advantages:
  - Eliminate possibility of effluent flowing directly or indirectly to Oak Creek.
  - Effluent can potentially be conveyed by gravity, thereby minimizing operational and maintenance costs.
- Disadvantages:
  - Requires approximately nine miles of pipeline to convey the effluent from the WWRP to the Verde River. The cost to design and construct the pipeline could be very substantial.
  - Will require a right-of-way permit along Highway 89A through the Arizona Department of Transportation (ADOT).
  - ADEQ and SRP will likely require upgrades to the City's WWRP to produce Class A+ effluent.
  - Effluent water credits may be lost. See TM No. 1 for additional details.

Overall Recommendation:

While construction of a pipeline to the Verde River would be costly and would require significant permitting efforts, direct discharge to the Verde River could provide the City with a definitive and low maintenance effluent disposal option. Depending on the results of discussions/negotiations with SRP and ADWR, it may or may not be possible to obtain water credits for discharge to the Verde River. Based on the City's desire to pursue other effluent management options, additional information may need to be obtained and evaluated to determine the ultimate feasibility of direct discharge of effluent to the Verde River.

2.4 Recharge Basins

Recharge Basins were also considered as a potential effluent management alternative for Sedona WWRP effluent. Recharge basins are commonly used at other wastewater treatment plants, and promote the disposal of effluent to the underlying aquifer via percolation through large, open-air basins.

As part of this study, a literature review was conducted to gather information pertaining to the hydrogeology at the WWRP as well as the surrounding area. This research indicated that surface alluvium, a clay-rich material up to 68 feet deep, overlies a basalt layer at the WWRP site. The hydraulic conductivity of the alluvium at the surface has been measured at approximately 5.92 feet per day. The underlying basalt has a significantly lower hydraulic conductivity of only approximately 0.6514 feet per day. Therefore, although water could easily percolate through the surface alluvial layer relatively quickly, the recharge potential at the WWRP would be severely limited by the underlying basalt layer.

In addition, the Sedona WWRP was previously equipped with rapid infiltration basins to dispose of effluent. However, the basins experienced significant groundwater mounding, and were subsequently converted to wetlands under the last major Aquifer Protection Permit amendment.

The team identified several potential advantages and disadvantages associated with effluent disposal via recharge basins as summarized below:

- Advantages:
  - Cost effective alternative.
  - Low operations and maintenance required.
- Disadvantages:
  - Due to the low percolation rate, a significant amount of land would be required.
  - A similar technology was previously utilized at the WWRP with limited success. Groundwater mounding occurred, and the basins were ultimately converted to wetlands.

Overall Recommendation:

Due to the limited percolation rates in the area around the WWRP, a significant amount of land would be required to provide adequate recharge basin area to accommodate the entire volume of effluent produced by the facility. See the Wetlands discussion (Section 3.0) for additional information regarding required area for effluent disposal via recharge. As recharge basins would generally require the same land area as wetlands, but would not provide the same ancillary/Community benefits and likely would not achieve the same support from USFS and other outside agencies, they are generally not considered a favorable effluent management alternative.

3.0 CONSTRUCTED WETLANDS

The following section includes a conceptual level evaluation of the constructed wetlands effluent management alternative. This more detailed evaluation was conducted primarily due to the additional information required to determine the validity of constructed wetlands as an effluent management option (compared to other, less complex alternatives). In addition, the team's significant interest in the constructed wetlands alternative further warranted the additional evaluation.

3.1 Goals and Objectives

The team studied and evaluated the feasibility of incorporating a constructed wetlands component for all, or a portion of the City's effluent management strategy, as a component of a multi-faceted plan using other management alternatives in combination with wetlands. It is intended that the constructed wetlands be a multi-purpose facility including:

- Effluent disposal
- Wildlife habitat
- Recreational features such as hiking trails, and a fishing lake
- Public outreach and educational programs

The buildout plan for Sedona indicates that the ultimate wastewater flow will be approximately 2 mgd. Existing wastewater flows amount to approximately 1.2 mgd. To explore the range of possible wetland configurations and implications associated with each, the City requested that the study team develop wetland basin layouts for three disposal capacity alternatives - specifically 1.0, 1.5, and 2.0 mgd effluent disposal capacities. Based on the results of a preliminary workshop with the City/WEDLU Task Force, the team generated a fourth alternative which represented developing constructed wetlands on City–owned property only (with the goal of determining the resulting capacity).

Through discussions with the City/WEDLU Task Force, the team identified several potential advantages and disadvantages of effluent disposal through constructed wetlands as summarized below:

- Advantages:
  - Flexible strategy that can accommodate all or a portion of the effluent depending on land availability and partnering opportunities with the United States Forest Services (USFS).
  - Can provide a community benefit for recreation and education, as well as wildlife habitat.
  - Can be easily combined with other technologies for effluent management/ disposal.
  - Multiple wetland basins provide for a robust and reliable operational strategy.
- Disadvantages:
  - As a total solution, the wetland basins are potentially land intensive and will likely necessitate a partnership with the USFS. Partnering with USFS will require significant negotiations regarding effluent quality, facility design criteria, monitoring requirements, land use, access, etc, and various permit approvals.
  - Disposal of all of the effluent through constructed wetlands may not provide for a marketing component (or may make the “accounting” associated with water credits more difficult to prove/monitor).
  - Wetland design criteria and operational performance are challenging to assess at the conceptual level due to the lack of site-specific climatological and hydrogeological data.

3.2 Conceptual Planning Criteria

The development of the conceptual wetland basin layout required the consideration of several planning criteria. The following criteria served as the framework for the wetlands evaluation completed as part of the study:

1. Develop the wetland basins using a modular concept that takes into consideration adapting to variable terrain, shallow versus deep pool areas for habitat, minimizing wave erosion action on embankments, etc.

2. Locate/layout basins to account for existing topography and to minimize required cut and fill for new basins.

3. Utilize the existing WWRP site, then adjacent City property to the maximum extent possible.

4. Incorporate gravity flow distribution to the basins to the extent feasible to minimize the pumping and re-pumping of the effluent.

5. Assume each basin will be multi-functional, providing for permanent wetland habitat areas as well as seasonal effluent overflow areas for evaporative disposal.

6. Design basins to provide capacity for total effluent management on a month-by-month basis through evaporation and minor seepage losses. Due to the lack of on-site seepage data, rough, conservatively low estimates were made for this conceptual study.

7. Provide for controlled public access, and an urban fishing lake and other amenities. It is intended that the public access features will include educational facilities/ components.

8. Size basins to avoid the Arizona Department of Water Resources' (ADWR) jurisdictional dam regulations.

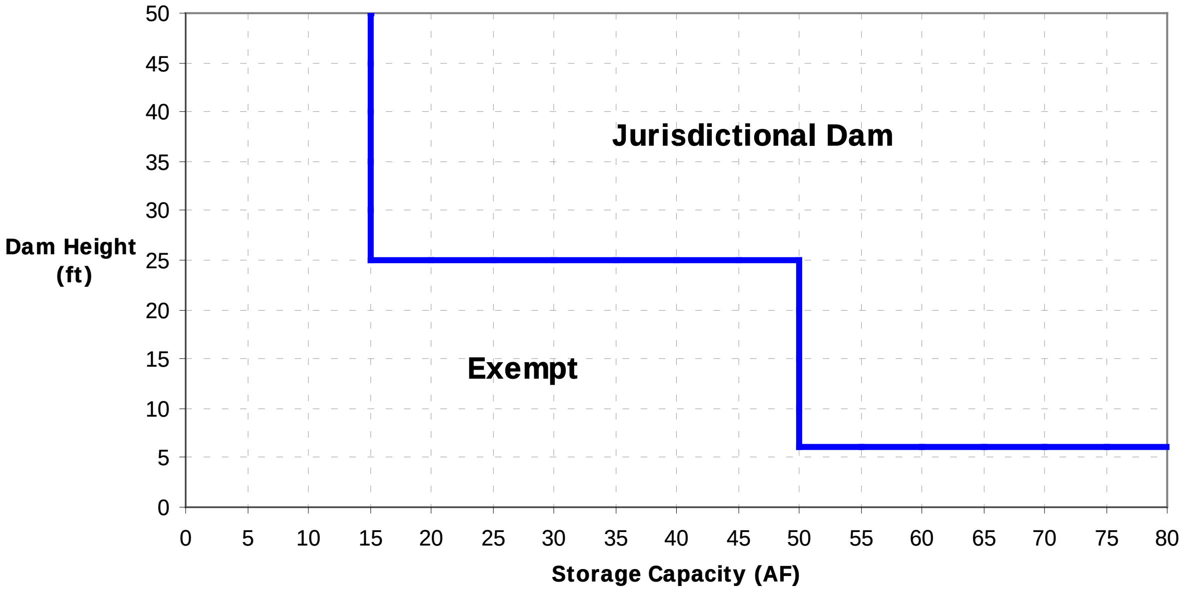
A "jurisdictional dam" is defined by statutes and rules as an artificial barrier for impounding water that is either 25 feet or more in height or has a storage capacity of more than 50 acre-feet. All appurtenant work associated with the impoundment are included in the jurisdiction. The Arizona Revised Statutes (A.R.S.) assigns the responsibility for supervision of the safety of dams to the Director of ADWR. The statutory authority for the Dams Safety Program is found in A.R.S. §45-105 et seq and §45-1201 et seq. The rules were developed to provide guidelines for the safe design, construction, operation, maintenance, and removal of dams under jurisdiction. It should be noted that the City currently operates its storage Reservoir No. 3 with a storage capacity of 70 million gallons (215 acre-feet), and is therefore subject to the jurisdictional dam regulations for that facility.

Figure 3.2 includes a chart summarizing the jurisdictional limits for a dam and identifies criteria for exemption from regulation. For the purposes of this study, the wetland basins layouts were developed to avoid regulation under the Dam Safety Program.

3.3 Water Balance

In order to determine the size of the wetland basins required for each flow alternative, it was necessary to develop the seasonal water balance. The seasonal water balance for the basins considered influent sources including effluent and rainfall, and outflows including surface evaporation, plant evapotranspiration, and seepage losses. Figure 3.3 shows a conceptual diagram of the water balance for wetland basin sizing.

Rainfall and evaporation data were obtained from existing sources including the National Oceanic and Atmospheric Administration (NOAA), and ADWR. The NOAA database provided precipitation data based on an average of 50 years' of historic rainfall in Sedona. The range of data was not available. The evaporation data obtained from ADWR was developed through research by Keith Cooley (commonly referred to by ADWR as the "Cooley" method to determine evaporation throughout Arizona). The Cooley method derived minimum, maximum and normal values of evaporation throughout Arizona, incorporating various sources of data from the years 1966-1968, 1917-1967, and 1946-1955.



BASINS SIZED TO AVOID JURISDICTIONAL DAM REGULATIONS

FIGURE 3.2

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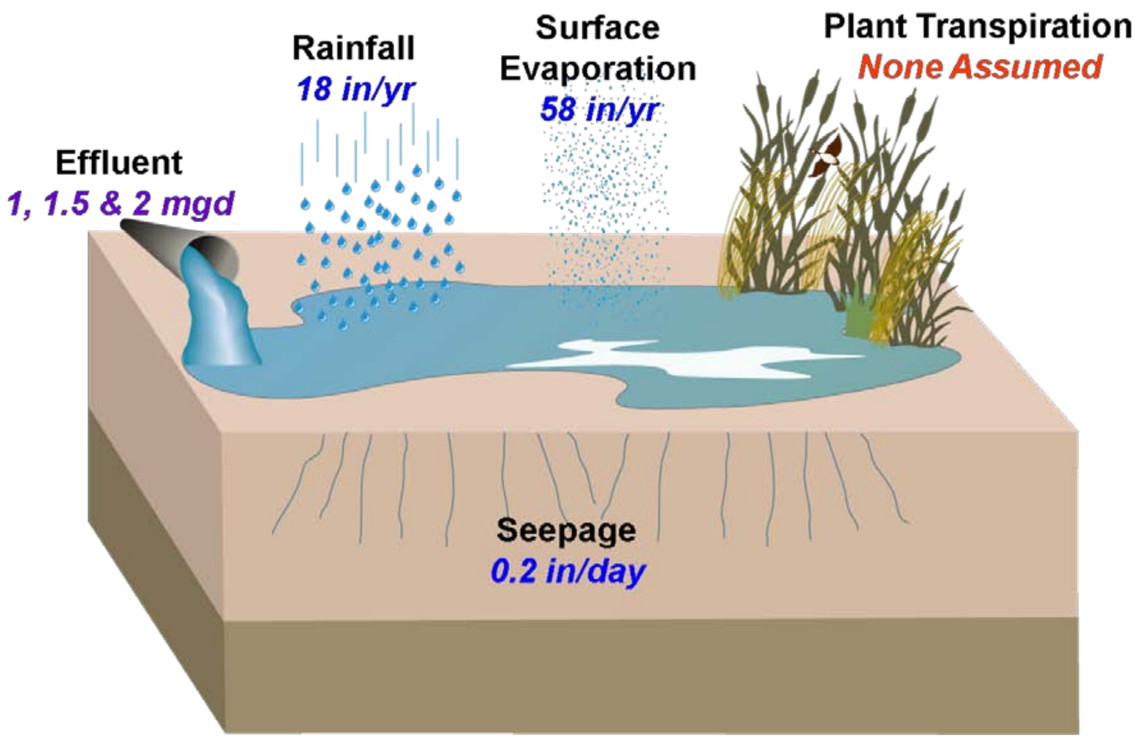

WATER BALANCE FOR WETLAND BASIN SIZING

FIGURE 3.3

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Table 3.1 presents a summary of the climatological data used for sizing the wetland basins. Evaporation data are reported as maximum, normal, and minimum monthly values. For the purposes of this study, the normal evaporation was used for basin sizing.

Table 3.1 Climatological Data for Sedona, Arizona
Effluent Management Strategy Evaluation
City of Sedona

Month	Rainfall (in/month)(1)	Evaporation (in/month)(2)		
		Maximum	Normal	Minimum
January	2.00	2.88	1.76	1.28
February	1.84	3.60	2.48	1.84
March	2.00	5.20	4.00	2.48
April	1.14	6.72	5.28	3.60
May	0.57	8.72	7.20	4.96
June	0.38	9.12	7.92	6.00
July	1.78	9.44	7.92	6.48
August	2.17	8.40	7.20	4.80
September	1.60	6.96	5.52	3.28
October	1.44	5.60	4.24	2.24
November	1.34	3.84	2.64	1.44
December	1.64	2.48	1.76	1.28
TOTAL	**17.90**	**72.96**	**57.92**	**39.68**

Source:
(1) National Oceanic and Atmospheric Administration (NOAA)
(2) ADWR "Cooley" method

While accurate climatological data was available for the proposed site, several additional design criteria were less defined. As previously stated, data associated with site-specific seepage losses were not available. Therefore, it was necessary to develop a conservative seepage estimate from available geological information. The seepage rate selected for the purposes of this study was 0.0167 ft/day.

In addition, the extent and type of wetlands habitat vegetation suitable/beneficial for the proposed wetlands application in Sedona is still undefined at this conceptual level. Consequently, to provide additional conservatism in the wetlands evaluation approach, plant evapotranspiration was not included in the analysis. Together these assumptions (use of a conservative seepage rate and exclusion of plant evapotranspiration) are expected to result in a conservative basin surface area requirement, prudent for this planning level evaluation. Collection of on-site evaporation and seepage data will be required to further refine the water balance and basin sizing.

Using these assumptions, together with the projected inflows and outflows, a spreadsheet water balance model was developed to determine the seasonal surface area and basin volume requirements for each alternative. For purposes of determining basin storage volumes, it was assumed that each basin would have an average depth of 3 feet, which accounts for deep pool areas for habitat and shallow (1 to 2 feet) depth areas for the seasonal overflow to meet evaporation needs.

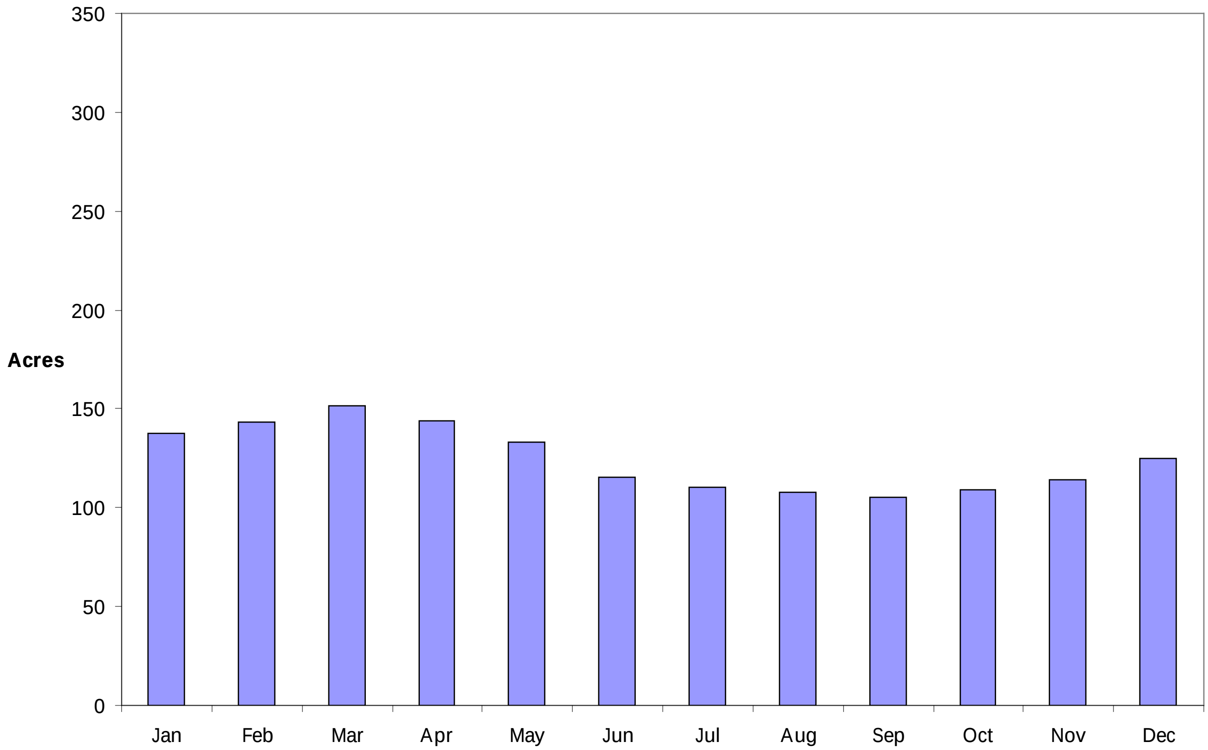
Figures 3.4, 3.5, and 3.6 present a summary of the water balance model results showing the monthly basin surface area variation based on the climatological and hydrogeological assumptions. Figure 3.4 shows a range of required surface area ranging from approximately 110 acres during the summer, to approximately 150 acres during the winter, for a 1.0 mgd equivalent effluent disposal capacity. The goal of the design would be to accommodate the full 1.0 mgd volume of effluent throughout the entire year. Consequently, the high end of the range of surface area requirements would be necessary. Figure 3.5 shows a range of required surface area ranging from approximately 150 acres to 230 acres for a 1.5 mgd equivalent effluent disposal, and for a 2.0 mgd system at buildout, the required surface area ranges from approximately 220 acres to 300 acres as depicted in Figure 3.6.

Assumed seepage losses significantly affect the total basin area required to dispose of the associated effluent. If the assumed seepage rate was ultimately doubled, the assumed conservative value (based on actual site specific data), the required evaporative area would be reduced to approximately 130 acres to 175 acres for a 2.0 mgd equivalent effluent disposal capacity. Consequently, doubling the assumed seepage rate would require half the acreage for an equivalent effluent disposal capacity.

3.4 Recommendation for Phase I Wetlands Construction

Constructed wetlands is a viable alternative for effluent management. However, as outlined above, several of the critical planning criteria have been assumed due to a lack of site-specific data. Determination of the actual disposal capability of wetlands is dependent on this information. As these data can have a significant impact on the actual facility capacity required, it is recommended that wetlands be constructed in phases. Climatological, hydrogeologic, and operational data collected from the first phase of the wetlands would be used to determine appropriate expansion of the wetlands.

The recommended location for the Phase I wetlands would be on City/WWRP property through modification of the existing Rapid Infiltration Basins/marshes. The WWRP areas proposed for modification are shown on Figures 3.7 through 3.10 as Phase I wetlands areas. Multiple cells within the existing basins can be formed for trial applications of habitat material, variable basin operating depths, etc. A weather station will be needed to collect site-specific rainfall, temperature, wind, solar radiation, and pan evaporation data to be used in calculating site-specific seasonal evaporation rate.



BASIN SURFACE AREA -
1.0 mgd AADF

FIGURE 3.4

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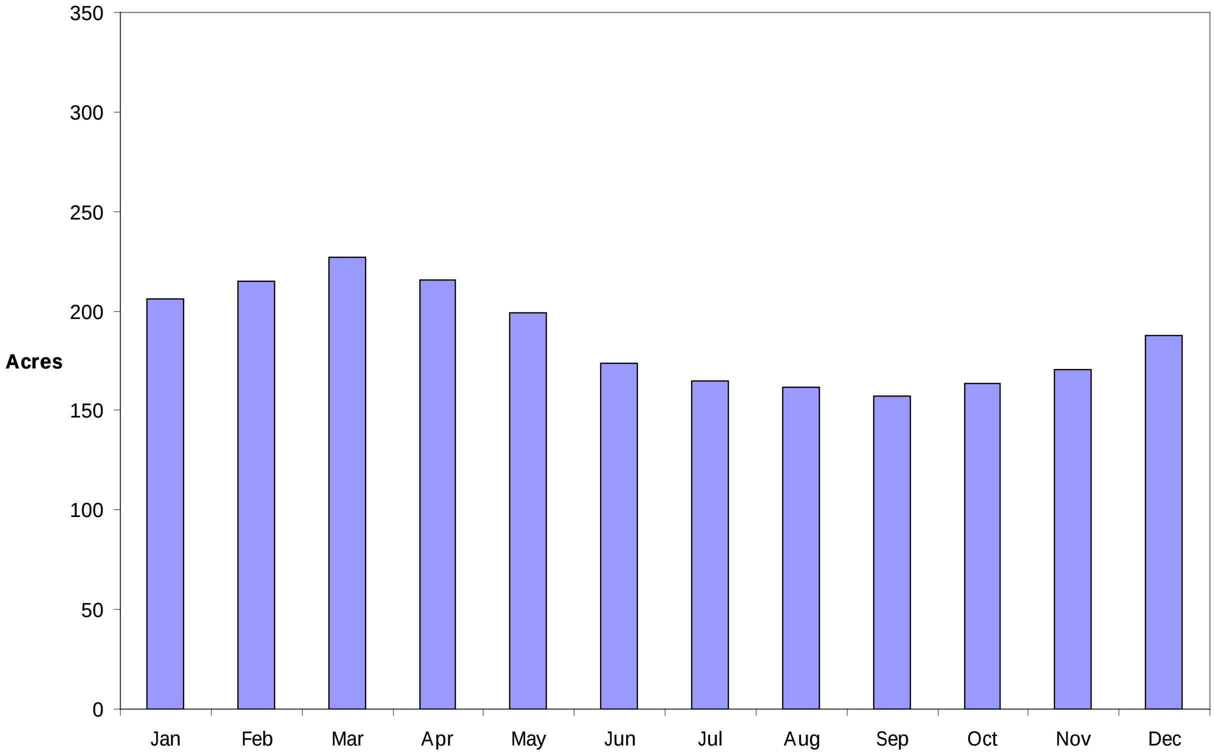

BASIN SURFACE AREA -
1.5 mgd AADF

FIGURE 3.5

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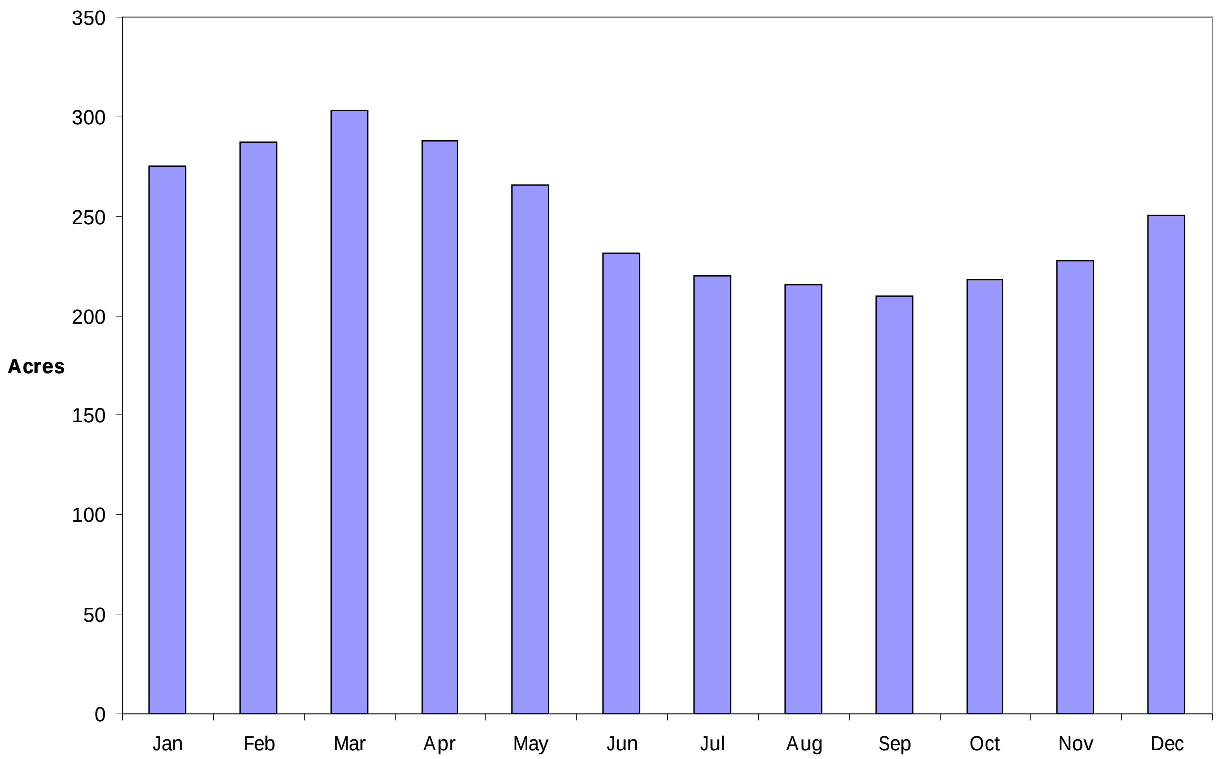

BASIN SURFACE AREA -
2.0 mgd AADF

FIGURE 3.6

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To allow the collection of these data, the City will need to make an application for an Aquifer Protection Permit (APP) to the Arizona Department of Environmental Quality (ADEQ) to utilize the Phase I constructed wetlands as a pilot/demonstration project. The pilot/demonstration program could run for up to eighteen months in order to collect a full seasonal distribution of variable conditions. However, data collected after six months may provide sufficient data to proceed with the next phase of construction. In addition to climatological and other performance data, the pilot program could also help identify appropriate plant species for the wetlands habitat, and quantify actual seepage losses.

The following protocols, criteria, and data/information collection efforts should be considered/implemented as part of the pilot project:

1. Test pilot/demonstration basin soils to establish a baseline of characteristics to be used to evaluate the design criteria/performance of future phases.
2. Standardize the basin size so that data collected will not be affected by variable size conditions.
3. Develop a system to accurately monitor the flow to each basin.
4. Establish one or more basins as a control basin representing existing conditions without vegetation.
5. Accurately monitor the depth of water in each basin.
6. Accurately monitor the surface water pan evaporation rate onsite to provide data for water use comparison among plant species as well as estimate seepage losses.
7. Establish wetland plants in basins that include several mixes of shallow and deep-water species to determine which species grow best under local conditions, and provide increased water uptake/disposal through evapotranspiration. A basin could be established in a monoculture of species such as bulrush or cattail, and monitored for the same data as the mixed species. Depending on basin depth, operating water depth, and side slope configuration, one or more basins may need to be modified to provide shallower areas for some wetland species.
8. One or more basins could be developed with woody species such as cottonwood and willow to determine the suitability of these species in the wetland development. These species can be high water users, potentially increasing the water loss through evapotranspiration. Woody species would also be an important component in developing a future park/recreation area for the public since they would provide shade, and attract additional wildlife species.
9. Monitor water quality in each basin to assess how the basins are either enhancing or negatively impacting water quality. The pilot/demonstration project should be implemented after WWRP improvements have been made to achieve a Class A+ effluent.

10. Monitor the variety of wildlife attracted to the wetland areas to design around future education/outreach programs and amenities.

The results of the recommended pilot/demonstration project within the Phase I wetlands will be critical in defining the required capacities of the future phases of the wetland facilities. In addition, the pilot project will play a critical role in establishing APP permit conditions as ADEQ will require information associated with seepage losses and the disposition and quality of this water relative to the aquifer.

3.5 Alternative Basin Layout

Based on the previously outlined assumptions and criteria, several combinations of basin layout strategies were developed at the request of the City.

Figures 3.7, 3.8, 3.9, and 3.10 present the basin layouts that meet the established planning criteria for each of the following scenarios:

- 1.0 mgd capacity
- 1.5 mgd capacity
- 2.0 mgd capacity (ultimate build out), and
- City owned property only (approximately 1.0 mgd)

The alternative basin layouts incorporate development of wetlands on City-owned property, including using Phase I constructed wetlands modified from existing WWRP basins as a pilot program (green areas), as well as USFS land where necessary to achieve the ultimate capacity required for disposal. A 5-acre urban fishing lake is included in each scenario. The Department of Game and Fish requires a minimum of one acre for the associated pond. Additional acreage was included to more closely resemble similar Game and Fish projects throughout the state. Initial input from Game and Fish/USFS indicated that the lake would need to be filled with groundwater, rather than directly with effluent from the WWRP. However, recent dialogue with the agencies has indicated this may not be considered a strict requirement. Additional discussion is necessary to determine the potential source water for the lake. If groundwater is required, it could be provided by pumping local groundwater or recovered reclaimed water that has been recharged and stored in the aquifer.

The wetland basin layouts are color-coded to show a potential phased progression of implementation for the basins to accommodate increasing capacity. The strategies were developed to initially locate the wetlands basins on the west side of Highway 89A. This strategy would allow utilization of existing disposal spray fields and WWRP basins while the project was being developed. In addition, it would continue to promote WEDLU’s on-going efforts to develop other potential future land uses east of the Highway. Basin locations were largely driven by topography, existing land uses, and drainage ways. To a large extent, basin volume controlled the size for many of the basins, in an effort to stay within the 50 acre-foot storage capacity required by the ADWR Jurisdictional Dam criteria. The color-coded basins show the maximum seasonal basin surface area with the cross hatched area indicating the minimum seasonal basin surface area.

Table 3.2 shows the surface area, volume, and disposal capacity of each basin based on the same color-coding format utilized in the associated figures/layouts. The “green” basins represent areas on the existing plant site, and are designated for the pilot/demonstration project within the Phase I constructed wetlands described in Section 3.4. Following completion of the pilot project, these basins will remain as part of the permanent wetlands program. The additional color-coded basins can be successively added to achieve the desired wetlands disposal capability.

Table 3.3 presents the surface area, volume, and disposal capacity of each basin associated with Alternative 4 – Wetland Basins located on City-owned property only.

3.6 Permitting Issues

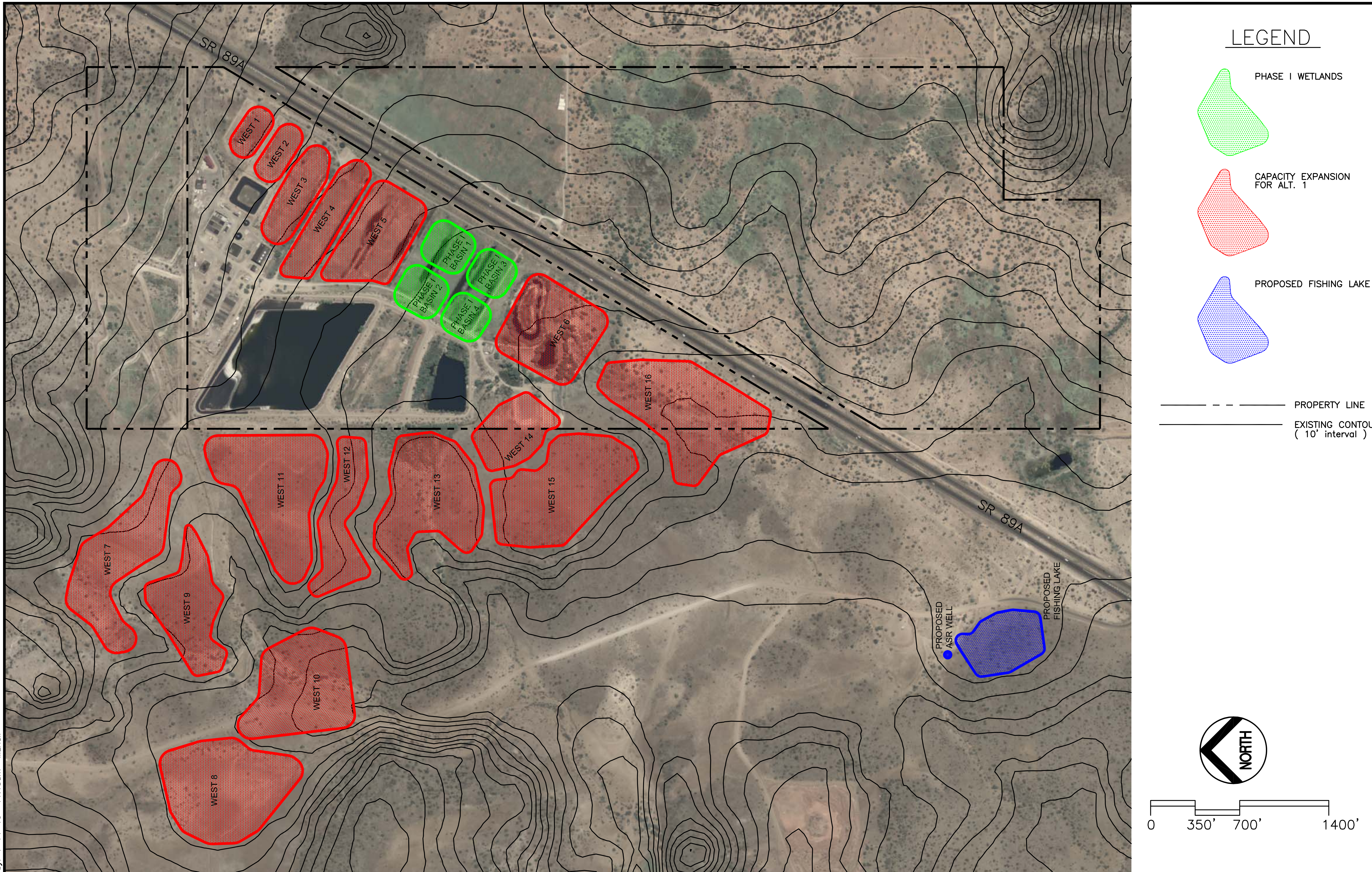
Depending on the final configuration of the wetlands and required use of USFS property, various partnering agreements, access permits, rights of way/easements, and long-term occupancy permits may be required by the USFS.

In addition, Sedona’s existing APP will have to be modified to accommodate the new wetlands disposal practice. The results of the recommended pilot/demonstration project will define the criteria for establishing permit conditions. In addition to the WWRP discharge quality, ADEQ will require information associated with seepage losses and the disposition and quality of this water relative to aquifer. One or more new monitoring wells may be required as a permit condition.

Unless some portion of the WWRP discharge is used for aquifer storage and future marketing, permitting through ADWR will not be required.

3.7 Conceptual Planning Level Cost

The costs to design, permit and construct a wetlands facility can vary widely based on a variety of factors. Very basic facilities, focused primarily on recharge, require substantially less capital investment than wetland facilities that include riparian components and other ancillary facilities like walking trails, riparian areas, fishing lakes and other Community Buildings. As the components to be included in a wetlands project for the City of Sedona are undefined at this point, it is difficult to determine a reasonable cost for the facility.



City of Sedona, Effluent Management Strategy
Conceptual Basin Layout

ALTERNATIVE 1
1.0 mgd BASIN CAPACITY

Figure 3.7

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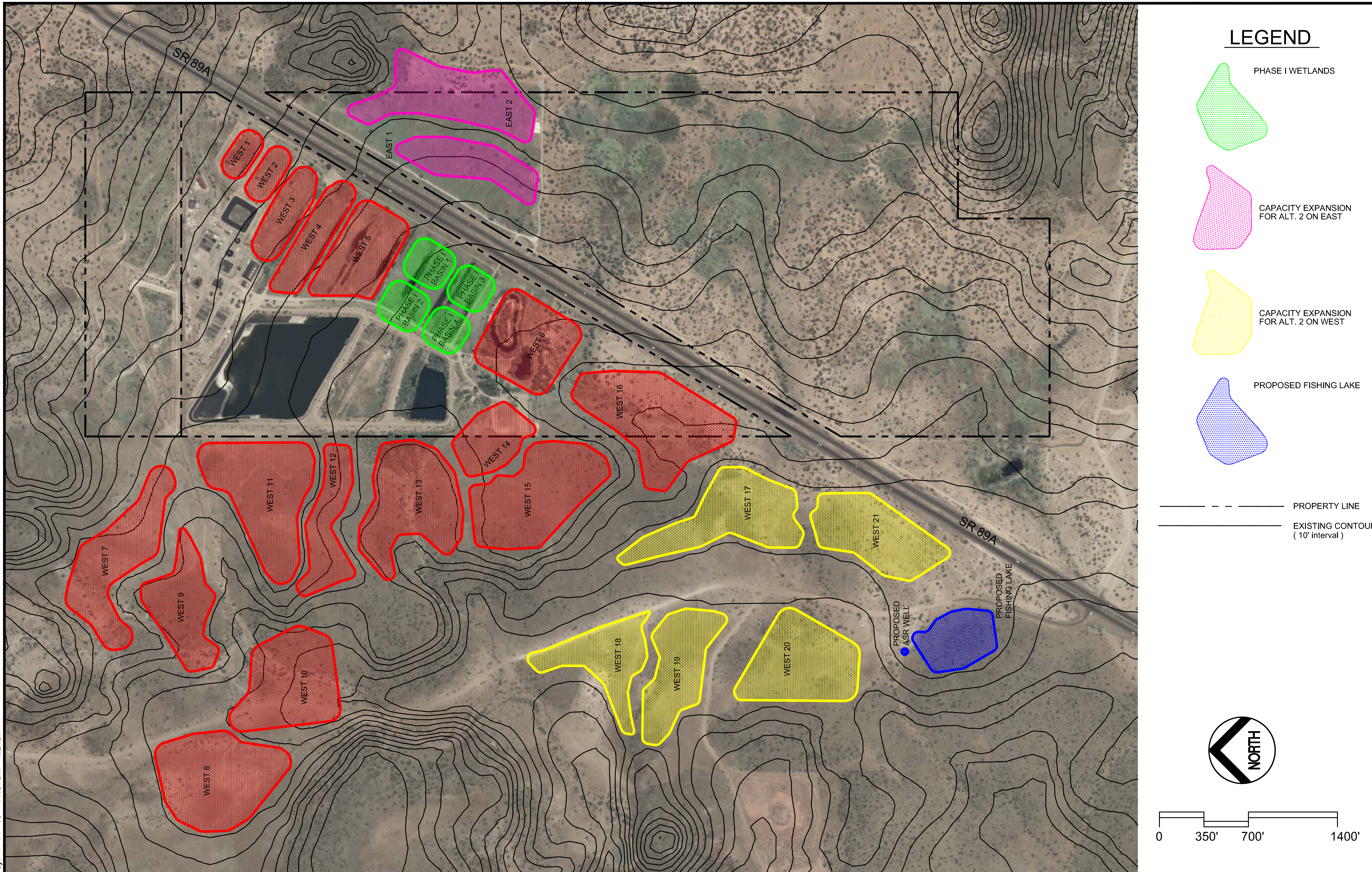

City of Sedona, Effluent Management Strategy
Conceptual Basin Layout

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ALTERNATIVE 2
1.5 mgd BASIN CAPACITY

Figure 3.8

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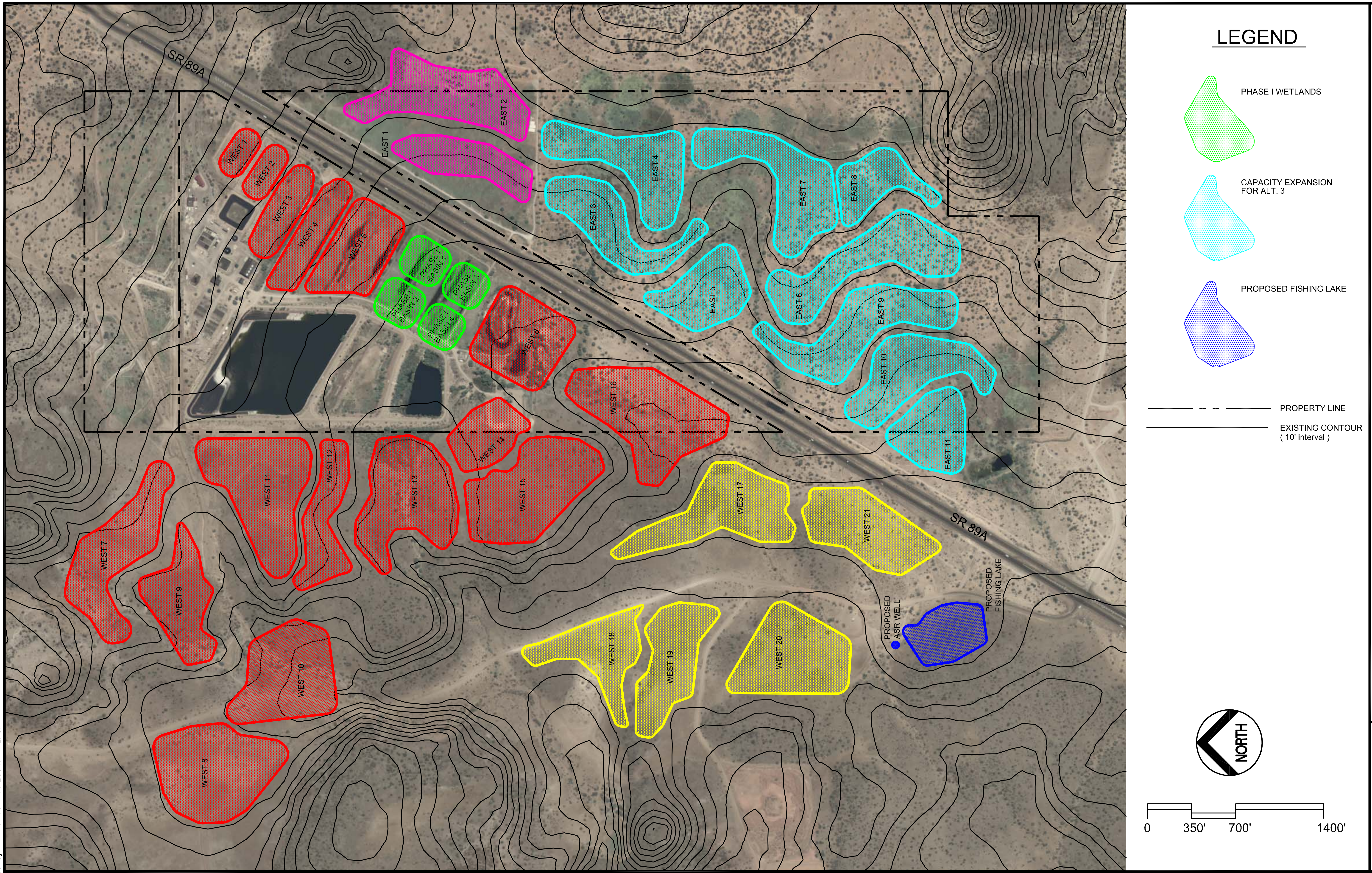

City of Sedona, Effluent Management Strategy
Conceptual Basin Layout

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ALTERNATIVE 3
2.0 mgd BASIN CAPACITY

Figure 3.9

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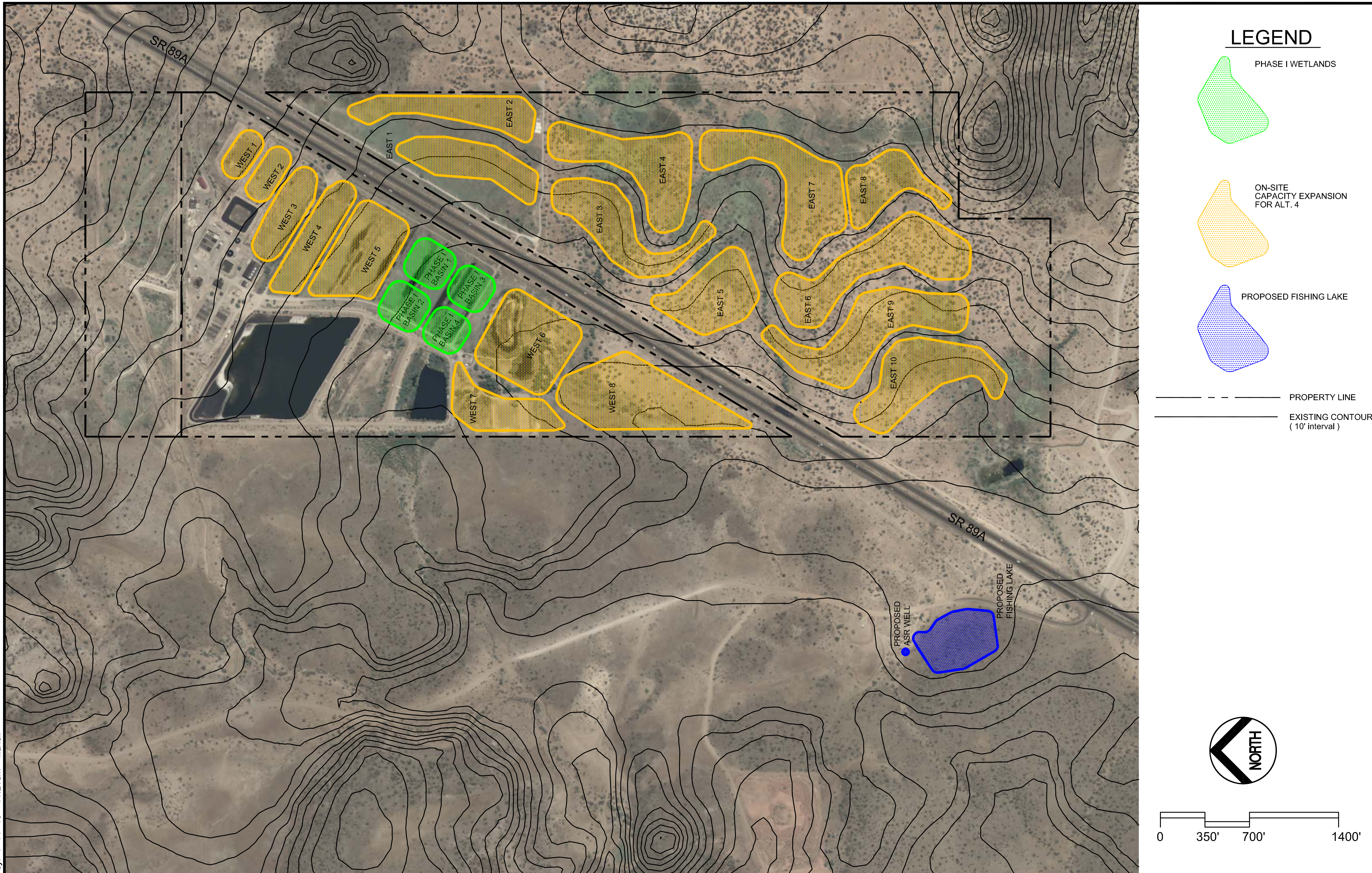

City of Sedona, Effluent Management Strategy
Conceptual Basin Layout

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ALTERNATIVE 4
BASIN LAYOUT CITY PROPERTY ONLY

Figure 3.10

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Table 3.2	Proposed Wetlands Basin Area and Equivalent Disposal Capacity Effluent Management Strategy Evaluation City of Sedona			
Alternative	**Basin ID**	**Surface Area (acre)**	**Equivalent Basin Volume (ac-ft)**	**Equivalent Effluent Disposal Capacity (mgd)**
1 - 1.0 mgd	Phase I Basin 1	2.61	7.83	0.017
	Phase I Basin 2	2.61	7.83	0.017
	Phase I Basin 3	2.39	7.17	0.016
	Phase I Basin 4	2.39	7.17	0.016
	West 1	1.79	5.37	0.012
	West 2	2.05	6.15	0.013
	West 3	4.36	13.08	0.029
	West 4	5.19	15.57	0.034
	West 5	8.2	24.6	0.054
	West 6	9.82	29.46	0.065
	West 7	11.4	34.20	0.075
	West 8	13.8	41.4	0.091
	West 9	8.13	24.39	0.053
	West 10	11.84	35.52	0.078
	West 11	13.87	41.61	0.091
	West 12	6.68	20.04	0.044
	West 13	13.15	39.45	0.087
	West 14	5.36	16.08	0.035
	West 15	13.77	41.31	0.091
	West 16	15.19	45.57	0.100
2 - 1.5 mgd	West 17	11.77	35.51	0.077
	West 18	7.85	23.55	0.052
	West 19	9.04	27.12	0.059
	West 20	11.48	34.44	0.076
	West 21	10.4	31.2	0.068
	East 1	6.63	19.89	0.044
	East 2	11.88	35.64	0.078
3 - 2.0 mgd	East 3	8.89	26.67	0.058
	East 4	10.36	31.08	0.068
	East 5	7.49	22.47	0.049
	East 6	11.51	34.53	0.076
	East 7	12.21	36.63	0.080
	East 8	5.62	16.86	0.037
	East 9	11.92	35.76	0.078
	East 10	9.98	29.94	0.066
	East 11	6.96	20.88	0.046

Table 3.3	Wetlands Basin Area/Equivalent Disposal Capacity on City Property Effluent Management Strategy Evaluation City of Sedona			
Alternative	**Basin ID**	**Surface Area (acre)**	**Equivalent Basin Volume (ac-ft)**	**Equivalent Effluent Disposal Capacity (mgd)**
4	Phase I Basin 1	2.61	7.83	0.017
	Phase I Basin 2	2.61	7.83	0.017
	Phase I Basin 3	2.39	7.17	0.016
	Phase I Basin 4	2.39	7.17	0.016
	West 1	1.79	5.37	0.012
	West 2	2.05	6.15	0.013
	West 3	4.36	13.08	0.029
	West 4	5.19	15.57	0.034
	West 5	8.2	24.6	0.054
	West 6	9.82	29.46	0.065
	West 7	5.48	16.44	0.036
	West 8	12.96	38.88	0.085
	East 1	6.63	19.89	0.044
	East 2	6.64	19.92	0.044
	East 3	8.89	26.67	0.058
	East 4	10.36	31.08	0.068
	East 5	7.49	22.47	0.049
	East 6	11.51	34.53	0.076
	East 7	12.21	36.63	0.080
	East 8	5.62	16.86	0.037
	East 9	11.92	35.76	0.078
	East 10	9.98	29.94	0.066

Consequently, the team evaluated several other facilities, including the Town of Gilbert Riparian Habitat and Chandler Heights Recharge Project, to determine a relative cost range for a similar facility. Based on these analyses, a wetlands facility similar in size to the City of Sedona's could be expected to cost between $50,000 and $100,000 per acre to design and construct. Table 3.4 presents a summary of the wetlands alternatives discussed in this TM and the associated conceptual planning level cost estimate for each based on the range of costs discussed in this section.

Table 3.4 Conceptual Planning Level Cost Estimates for Constructed Wetlands
Effluent Management Strategy Evaluation
City of Sedona

Alternative	Disposal Capacity (mgd)	Maximum Surface Area Required (acres)(1)	Conceptual Planning Level Cost Estimate(2)
1	1.0	150	$7.5 - 15.0M
2	1.5	230	$11.5 - 23.0M
3	2.0	300	$15.0 - 30.0M

Notes:
(1) Maximum surface area required to achieve the equivalent effluent disposal capacity during winter months.
(2) Conceptual planning level cost estimates developed based on range of $50,000 to $100,000 per acre typical of other wetland facilities similar in size and scope to the City of Sedona's.

The conceptual level cost estimates for each wetlands alternative were developed assuming the maximum estimated surface area required to achieve the equivalent disposal capacity during winter months. As described in the previous sections, the maximum surface areas for each alternative were developed using conservative assumptions for seepage rate and exclude any disposal associated with plant evapotranspiration. The actual surface area required to dispose of the effluent may ultimately be significantly less than estimated as part of this study due to higher seepage rates and/or the addition of evapotranspiration associated with wetlands flora. At this conceptual level, the team could not predict an accurate seepage rate value or determine the vegetation conducive to a wetlands application in Sedona. Consequently, conservative values were assumed, which ultimately impact the cost estimates presented.

A pilot/demonstration project could help resolve some of these unknown factors to provide a more accurate representation of the area required to achieve the necessary effluent disposal. The team recommends that the City complete the Pilot/Demonstration Project within the Phase I constructed wetlands as recommended above, followed by a Constructed Wetlands Master Plan to determine the desired wetland system components and size. In addition to facilitating funding, permitting, and other coordination issues, this information would promote the development of a more detailed and accurate cost estimate for the proposed facility.

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Appendix A

MECHANICAL EVAPORATOR PROPOSAL

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Specialized services & systems customized to fit YOUR nee

Apex

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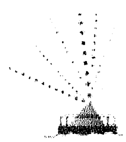
The advantage of the Apex floating wastewater evaporator is the increased run time allowed by the in-pond location. While land based evaporators are more prone to shut down due to the wind gusts, the Apex evaporator can continue to evaporate in the same conditions because the spray plume is closer to the pond surface and is more likely to drop back into the pond instead of on surrounding vegetation. The easy mobility of the Apex enables the operator to adjust the location of the equipment to compensate for wind direction leading to greater net evaporation rates. Evaporation rates depend greatly on weather conditions such as ambient temperatures, relative humidity, wind speed, etc.



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Date: February 10, 2009

PARTIES AND CONTACT INFORMATION:

SUPPLIER NAME:	**Resource West, Inc.**
SUPPLIER ADDRESS:	**2314 Logos Drive Grand Junction, Colorado USA 81505**
CONTACT NAME:	**Randall Jochim**
FAX NUMBER:	**(970) 241-9942**
E-MAIL:	**randall@resourcewest.net**
CUSTOMER NAME:	**City of Sedona Arizona**
CONTACT NAME:	**Larry Cepek**
CONTACT TITLE:	**Consultant**
TELEPHONE:	**928-282-6110 (office) 928-300-4641**
FAX NUMBER:	
E-MAIL:	**consult@esedona.net**

Acknowledgement of Receipt:

CUSTOMER shall acknowledge receipt and acceptance of the terms of this order by signing the last page and returning it by fax to RESOURCE WEST, INC.

Supply of Equipment:

CUSTOMER confirms the purchase of the following goods (hereinafter "Goods") subject to the General Terms and Conditions of Purchase which form part of this agreement and are attached hereto. Optional equipment such as mounting device, extended power cable, extra nozzles, spray fan, weather station, diffuser, and pump package upgrade should be included here as well.

N	DESCRIPTION	QTY	UNIT PRICE IN USD	TOTAL PRICE IN USD
1.	Apex Floating Evaporator	15	$23,900.00	$358,500.00
2.	Weather Stations (optional)	15	$2,950.00	$44,250.00
3.				
4.				
5.	Applicable taxes may apply			
	TOTAL AMOUNT			$402,750.00

Power cable from the control box to the CUSTOMER'S power supply is not included.

Site Conditions:

Customer must provide information regarding site conditions such as length, depth and width of pond, vegetation surrounding the pit or pond, wind patterns, power available on site, pond location related to ownership (ie. private property, BLM, National Forest), water depth in pond, distance from the top of the pond structure to the water level, water data analysis (if possible), and how much water needs to be evaporated per day.

Freight Forwarder: (check one)

Truck ________ **Pick up from Supplier:** ________

Air Freight ________ **Supplier Delivery:** ________

Delivery:

RESOURCE WEST, INC. shall ensure that the Goods are ready to deliver to CUSTOMER'S nominated forwarder as agreed to by both parties.

Terms and Agreement of delivery are as follows:

Expected Ship Date:________________________________

Expected Delivery Date:________________________________

Freight being arranged by : Supplier: ________ **Customer:** ____________

Freight being paid by: Supplier: __________ **Customer:** ____________

Shipping costs are subject to change based on timeframe between proposal approval and ship date. Actual costs will be invoiced.

Shipping and Packing List:

RESOURCE WEST, INC. shall provide to CUSTOMER's nominated freight forwarder a faxed provisional packing list and commercial invoice for shipping purposes at least five (5) working days in advance of the proposed shipment date advising the Purchase Order number, line item numbers, quantities and values. Upon completion of packing, RESOURCE WEST, INC. shall advise the actual cargo weights and dimensions.

In no event is RESOURCE WEST, INC. responsible for costs incurred for customs clearance or other related matters. These costs are the responsibility of the CUSTOMER. If CUSTOMER requires special instructions regarding shipment, those instructions are required to be provided to RESOURCE WEST, INC. at time of acceptance of order.

Goods will be suitably packed and protected to ensure safe delivery to the freight forwarder or to the site. Labor to crate and pack equipment will be added to the invoice.