BLUFF, UTAH – DISTRIBUTED WASTEWATER MANAGEMENT CONCEPTS PROVE SUPERIOR

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Abstract: A wastewater system facility plan was prepared for Bluff, Utah, in which both distributed and centralized management concepts were considered. This small community along the San Juan River in southeastern Utah is a major put-in point for river recreation as well as being surrounded by a number of national monuments and BLM land. Energy exploration in the area is also a significant economic activity. These factors dictate that wastewater generation is dominated by commercial enterprises related to tourism and by transient workers who reside in large part in mobile home/RV parks. Those factors result in significant seasonal variations in the flow rate. The geography of Bluff, which is sandwiched between the river and BLM land and is bisected by one major wash and two minor ones, also offers challenges.

A presentation of options for wastewater management strategy in Bluff, Utah, was made at a public meeting convened by the Bluff Service Area (BSA) on December 12, 2006. Presentations were made by Souder, Miller & Associates, Inc., for "conventional" options and by David Venhuizen, P.E., for "decentralized concept" options—the conceptual approach that the Water Environment Federation has re-flagged as "distributed management"—which included four strategies:

- Two options employing a combination of continuing use of some on-lot systems along with "cluster" systems for some residences and for all the commercial properties.
- Employing several distributed small-scale treatment units.
- Employing two larger-scale treatment units, one on each side of the major wash.

Both direct discharge to the washes and dispersal of effluent in drip irrigation fields were considered as effluent management strategies for these options. The latter would most preferably be sited to deliver an irrigation benefit, as Bluff is in a high desert region, with an average annual rainfall of only 8 inches.

Subsequent to that presentation, the BSA assembled an "evaluation matrix" to solicit input from Bluff residents and business owners on which strategies were preferred. The matrix reflected a number of fiscal, societal and environmental quality evaluations. The ten options presented in that matrix represented the range of strategies reviewed at the public meeting, plus one "hybrid" option combining effluent sewerage with "conventional" treatment. Survey recipients were asked to rate each option on a scale of 1 to 10, with 1 denoting highest preference and 10 denoting lowest preference. The four decentralized concept strategies received by far the most positive response. The number of responses ranking these options "highly favorable" (1 or 2) or "favorable" (3 or 4) ranged from 28 to 38, while none of the other options received more than 15 such rankings.

Based upon this input and upon their review of the options with the State of Utah regulatory authorities during and subsequent to a meeting on July 2, 2007, the BSA determined that further consideration would be limited to the decentralized concept strategies. This paper reviews these

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decentralized concept options and the issues involved in using them to provide "organized" wastewater service in Bluff, Utah.

GENERAL ADVANTAGES OF A DECENTRALIZED CONCEPT STRATEGY

An important question is why the decentralized concept "should" be considered instead of just following the path of least institutional/regulatory resistance, installing the conventional "big pipe" sewer system and a passive lagoon treatment system, a rather "standard" strategy for small communities in Utah. A decentralized concept strategy offers a number of general advantages relative to a conventional "all or none" centralized wastewater management strategy, particularly for the circumstances in Bluff:

- A decentralized concept strategy offers a least cost approach in two ways. First, it offers the opportunity to concentrate resources on properties that actually need an "upgraded" wastewater system, while not incurring costs to address properties that are—and are expected to continue to be—adequately served by existing individual on-lot systems. Second, the options which collective the fewest number of properties, implying the least run of sewer line, would need to dedicate less resources to simply moving pollution from place to place. Also, the effluent sewer system inherent in the decentralized concept is significantly less costly to install and to maintain, so the cost of even the decentralized options which hook up all properties would be significantly less than options with a conventional "big pipe" sewer system. Decentralizing the treatment process also minimizes—perhaps eliminates—lift stations in the collection system, also lowering costs.
- A decentralized concept strategy can disperse risks due to any sort of problem that may beset components of the wastewater system. Under the conventional centralized strategy, larger flows are concentrated through one pipe or lift station, and all the flow goes through one treatment/dispersal system, so any problem implies "large" consequences. With the treatment/dispersal capacity distributed rather than centralized at one point, only a portion of the flow would be impacted by any such incident, thereby limiting the amount of damage that might accrue from any one episode. This consideration offers one basis for choosing the level of aggregation of flows to treatment/dispersal centers.
- Due to the type of infrastructure employed in a decentralized concept system, the risk of bypasses, leaks and overflows is lower to begin with. Lift stations would be minimized or eliminated, and those that remain would be relatively simple effluent pump stations. Carrying only liquid effluent to dispersed treatment centers, the collection system would consist of shorter runs of smaller pipes with "tight" joints and containing fewer openings (no manholes), providing less opportunity for infiltration, exfiltration and overflows. In Bluff, more decentralized options avoid crossing of the washes with lines carrying untreated wastewater, removing the risk of those lines being "washed out" by flash floods which commonly occur in Bluff. Also, treatment technologies used in decentralized concept strategies would be more "fail-safe" so that risk of poor treatment is minimized.
- The type of infrastructure inherent in a decentralized concept strategy causes less disruption during construction of the system, for the following reasons: (1) By decentralizing the system, less run of sewer is entailed in the installation; (2) The effluent sewer system entails smaller pipes that are shallowly buried, so trench width and depth is significantly smaller,

and the scale of disruption is considerably smaller; (3) The nature of the installation entails smaller scale equipment, which is visibly and audibly less obtrusive; (4) The speed at which this infrastructure can be installed shortens the length of time construction disruption lasts; (5) The lack of larger scale "interceptor" mains means that little or no infrastructure is installed in riparian corridors, eliminating or minimizing the disturbance of those areas.

- If upgrading is needed to increase the overall capacity of the system, that is done in a decentralized concept system by adding new treatment centers rather than by routing ever-increasing flows to existing treatment centers. This avoids any need to dig up and replace existing sewers to increase their capacity.
- A decentralized concept strategy employs multiple treatment centers, dispersed around the community typically much closer to the developed areas than a conventional centralized treatment center, so the cost of redistributing reclaimed water for beneficial reuse within the developed area is much less than for redistributing the reclaimed water from a centralized treatment center located away from the developed area.
- A decentralized concept system could accommodate any level of water conservation found to be economically attractive or ecologically necessary. Because only liquid effluent is transported, reduced wastewater flows resulting from water conservation measures would not cause clogging problems in the collection system, as has occurred in conventional, centralized systems.
- Each project would be small compared to installation or expansion of the centralized option. Management needs of each area or new development would be considered directly and could be implemented independently. This could allow the overall system to be installed in small increments, if funding conditions dictated this would be advantageous in Bluff. Much of the cost could be privatized or assigned directly to development generating the demands rather than being borne by the entire community through community-sponsored funding. Also, capacity expansion—and therefore capital requirements—would track demand much more closely, minimizing funds expended for facilities that are not fully utilized for years to come.
- In the effluent sewer system that is inherent in a decentralized concept strategy, the primary septic tanks—called interceptor tanks—at each wastewater generator are the main sludge management devices. Despite the multiplicity of sources and their being dispersed around the service area, addressing sludge removal from these tanks would be a more convenient and less costly process than sludge management at a centralized facility, as reviewed below.

SMALL-DIAMETER EFFLUENT COLLECTION SYSTEMS

As just noted, decentralized concept management strategies employ interceptor tanks (primary septic tanks) at each source of wastewater generation to intercept solids, allowing the use of small-diameter effluent sewers in the collection systems. Installing interceptor tanks at the sources of flow offers the following advantages:

- These interceptor tanks are the major sludge handling system. Sludge separation and storage is a passive process, requiring no operator intervention until the tank is pumped.
- Sludge digestion in septic tanks is an anaerobic process, which—relative to aerobic sludge digestion typically employed at conventional treatment plants—greatly reduces the volume of solids to be eventually handled.

- Sludge from each tank only needs to be handled at very long intervals. So even though there would be many dispersed sources, sludge management logistics would not be untenable.
- Sludge handling is executed without taking any part of the system out of service. Each tank can be pumped in a very short amount of time, and the users can even load the system while it is being pumped.
- Sludge handling is executed in small increments—one or a few tanks at a time, depending on the capacity of the pumper truck. This allows maximum flexibility, and thus perhaps maximum cost efficiency, in planning for sludge handling.
- Timing of sludge removal is not critical because sludge builds up very slowly. Several months could pass between the time that sludge monitoring indicates pumping should be executed and the time that pumping occurs without degrading the system.
- Because timing of sludge removal is not critical, tank pumping could be scheduled when the biosolids could be readily used, perhaps eliminating need for storage and handling facilities.
- Sludge from each generator is segregated, so it can be classified by source. Sludge from domestic sources rarely contains contaminants rendering the sludge unusable as a soil amendment. Being readily reusable, this sludge stream is a potential revenue source.
- Institutional arrangements for sludge handling are already in place. Existing septic tank pumpers could be contracted to pump the interceptor tanks.
- If found to be necessary or cost efficient, a local sludge handling process could be readily set up, requiring only a pumper truck and an area on which to landspread the sludge, or a composting area to "treat" the septage. However, these costs can be deferred for several years, until it is time for the first tank pumping.

Effluent sewers convey interceptor tank effluent from the tank to further treatment or to a remote dispersal field. Advantages of effluent sewers include:

- Because they carry only liquid effluent, effluent sewers can employ small-diameter pipes and can be very flexibly routed. Varying, non-uniform grades can be used—even locally negative gradients are allowed—so construction is somewhat less exacting.
- Small-diameter pipes can be flexed, further enhancing routing flexibility.
- No minimum flow velocity needs to be maintained to prevent solids deposition, so gravity effluent sewer lines can be laid on significantly smaller grades than conventional mains.
- Because routing is so flexible and very small grades can typically be used, burial depth is generally shallow.
- The small pipes and shallow burial allow installation in a very narrow construction corridor. This allows effluent sewers to be more easily fit into the built environment.
- Shallow, narrow trenches obviate expensive trench safety requirements—as workers do not enter the trench—and minimize the need to dewater trenches.
- The small pipes are joined with "tight" joints, and cleanouts instead of manholes are used to access the system if cleaning is needed. Therefore, infiltration/inflow is typically not a problem in an effluent sewer system.
- The smaller pipes, shallower burial, narrower construction corridor, more flexible routing, and lack of manholes allow effluent sewers to be installed at significantly lower cost than conventional mains.

- Because effluent sewers can run at very small grades, gravity flow can be maintained for a longer distance relative to conventional mains without requiring deep trenches. This can allow some or all lift stations to be eliminated in some circumstances.
- Where grades are unfavorable, septic tank effluent pump (STEP) systems can be used, with a pump station at each interceptor tank, or a collective pump station for a group of tanks. Pumps need be used only where grades require it, utilizing gravity flow in the rest of the system.

Based on a preliminary review of its topography, it is expected that STEG (septic tank effluent gravity) sewers can be employed exclusively in Bluff. A STEP line might be needed in specific cases to lift effluent from an interceptor tank, but it is expected that gravity flow can be used throughout.

RECIRCULATING PACKED BED MEDIA FILTER TREATMENT SYSTEM

A variant of recirculating packed bed media filter technology is the treatment concept proposed for use in the decentralized concept strategies in Bluff. This technology, termed the high performance biofiltration concept, is reviewed in detail in another paper in these proceedings. The general justifications for favoring this technology in Bluff include:

- This process typically uses a primary septic tank as the first stage of the treatment process, so it mates well with the effluent sewer system, which delivers primary treated septic tank effluent to the treatment center.
- The treatment process is inherently stable and robust, and consistently and reliably produces a high quality effluent while incurring low O&M liability.
- Maintenance processes, for both the filter bed and the "peripheral" equipment, are fairly simple and straightforward, and are generally not highly time-critical.
- Low O&M liability makes this treatment concept very amenable to dispersed deployment, since observations and routine maintenance would be required relatively infrequently.
- Even for a fully centralized system with only one treatment center, this low O&M liability is a critical factor in Bluff, due to its isolation, making it expensive to rely on specialized expertise that would be required to operate more complex "mechanical" plants.
- The technology is scalable—it can be implemented for a single home or for an entire community without compromising the technology.
- The system can be implemented in "modules" so system expansion can be accommodated without interrupting the treatment process.
- These modules can be fairly small, so the system can be expanded in small increments of capacity. This allows the system to better track growth. It can be expanded on a very short time scale, so capacity does not have to be installed in large increments, years in advance of the need for it.
- This modular nature also allows maintenance to be conducted on one module while the rest of the system continues in operation. Properly executed, this modular design also minimizes the vulnerability of the system to mechanical failures.
- Being modular and scalable, this process can be cost efficiently installed at varying scales.

- Sludge management for this system is not a time-critical operation. Most of the sludge is retained in the interceptor tanks. As detailed previously, these can be pumped essentially whenever it is convenient. The remainder of the sludge is removed by pumping the treatment system tanks and during the filter bed cleaning process.
- The system can be designed to be completely contained in covered containments that prevent odors from being emanated, so treatment centers can be installed in close proximity to inhabited areas (this process is used for home "septic systems" installed in the home yard without any odor problems). Along with unobtrusive operation—there is no noise, as the only moving parts are pumps which are under water within the sealed tanks—this allows the treatment centers to be very flexibly sited.

The process is capable of consistently and reliably delivering advanced secondary quality effluent—effluent quality is <15 mg/L of BOD_5 and TSS, and <10 mg/L is not at all atypical. This consistently high clarity allows reliable UV disinfection of the effluent, if required prior to dispersal, with a minimum of O&M attention to the UV unit. With appropriate design, this process can also remove a majority of the nitrogen from the wastewater. Removal rates of 60% or greater are typically observed, attaining <20 mg/L of total nitrogen in system effluent. This capability is detailed in another paper by the author in these proceedings.

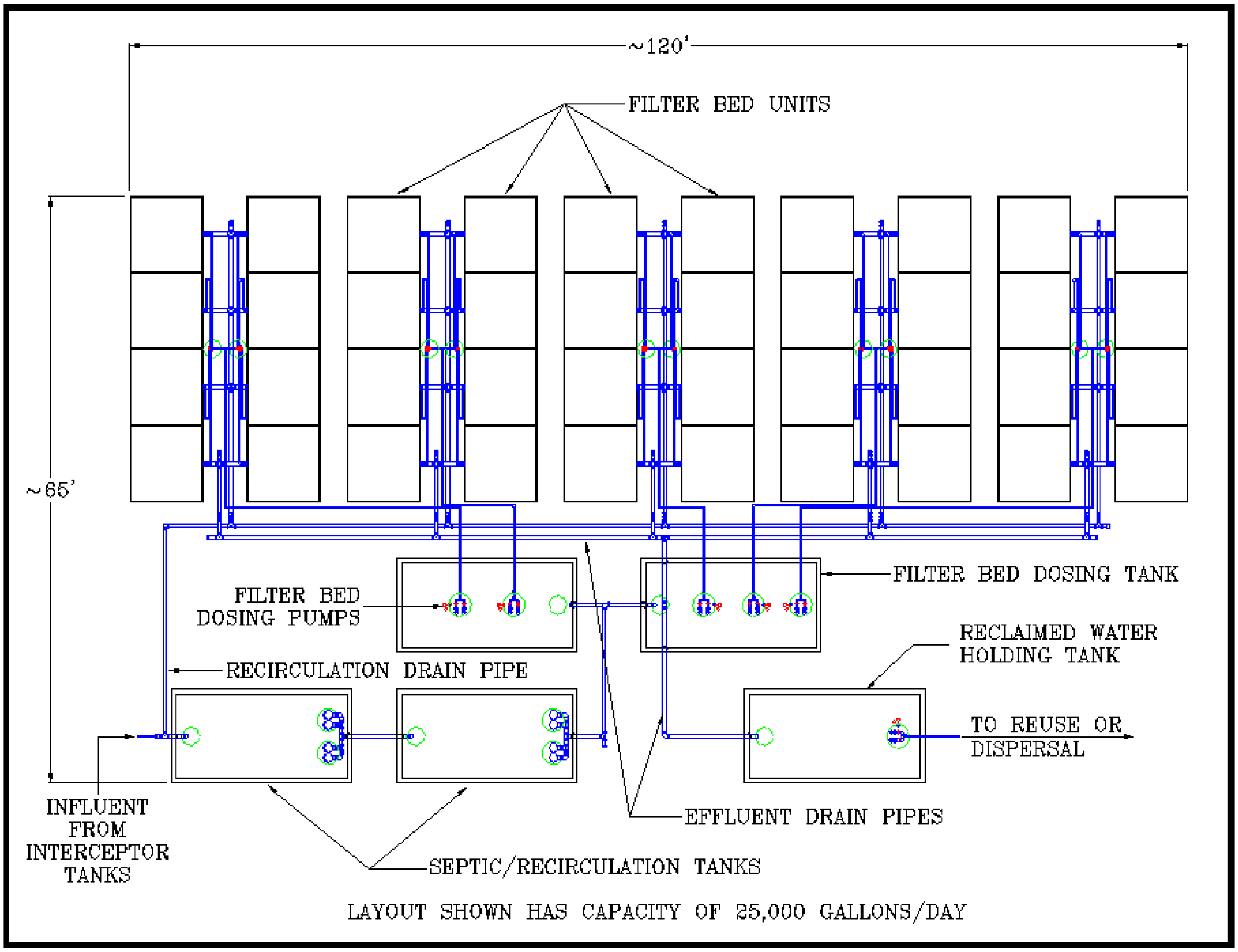
Since the only power requirement is for pumps that intermittently spray water over the filter beds, energy demand of this treatment system is fairly low. For example, a 10,000 gallon per day treatment center would demand only about 23.95 Kwh per day. This is an "energy intensity" of only 782 Kwh/AF/day of capacity, fairly low for a high quality treatment process. At 8 cents per Kwh, this would result in a monthly energy cost of about $58, or 0.58 cents per gallon per day of treatment capacity.

In order to model this treatment process for application in Bluff, "nominal" configurations of the treatment centers were presumed, utilizing a commercially available filter bed unit with a nominal capacity of 625 gpd. A treatment center layout plan for a 25,000 gpd plant utilizing this filter bed is shown in the figure below. The outer dimensions of the layout illustrate that the land area requirement for a treatment center is rather negligible. Along with the unobtrusive nature of this technology, this allows the treatment centers to be very flexibly sited.

DRIP IRRIGATION DISPERSAL SYSTEM

For options which propose soil dispersal as the fate of the effluent, it is proposed to use subsurface drip irrigation fields. A review of soil treatment mechanisms reveals that, for all pollutants of concern, effectiveness is enhanced by three main factors: (1) shallow dispersal, in the root zone, (2) low areal loading rate, and (3) uniform distribution with a dose/rest loading cycle. An appropriately designed drip irrigation system practically maximizes all these factors. Further, using subsurface drip dispersal practically maximizes the irrigation benefit that can be obtained from the reclaimed water.

In Bluff, a significant evapotranspiration (ET) potential exists throughout much of the year, and local sentiment is that the effluent "should" be dispersed in a manner that provides an irrigation benefit. The design philosophy is therefore to maximize the irrigation benefit while minimizing the amount of water that would percolate to groundwater during periods of low ET.



Typical Treatment Center Layout Plan

From pan evaporation data at Mexican Hat, Utah, about 20 miles down the San Juan River from Bluff, it is determined that the average evaporation rate through the May-September peak irrigation period is 12.63 inches/month. Applying a pan coefficient of 0.7, the average reference ET over this period is 8.83 inches/month, or 0.295 inches/day. This is equivalent to 0.18 gal/ft^2/day. Based upon this, a design loading rate of 0.15 gal/ft^2/day is used to calculate drip field areas for modeling the system options that employ soil dispersal in Bluff.

Loading at this rate would satisfy a large portion of the irrigation demand during the peak period, meeting the desire to maximize irrigation benefit. Since there is no long-term storage built into the wastewater systems, rather each day's flow would be dispersed very soon after it runs through the treatment system, the drip dispersal field must act like a "drainfield"—some of the applied water percolates downward—when ET is below the application rate for extended periods of time. While it might be presumed that loading at the rate derived above would result in a significant amount of effluent leaching to groundwater during the winter months, it is noted that this rate is applied to design flow rates of the wastewater systems, based on peak period flows from the commercial generators in Bluff, which dominate the flow there. Flows from these generators are significantly below the design flow rates during the months with lower ET, so actual field loading rate would be significantly lower through those months, and the leaching potential would be correspondingly lower. In any case, the rate derived is well below the saturated hydraulic conductivity of the soils in Bluff, so the drip irrigation fields would indeed function as "drainfields" during wet weather and periods of low ET.

DECENTRALIZED CONCEPT SYSTEM OPTIONS

Managed On-Lot Systems + Cluster Systems

This option retains individual on-lot systems where they are code-compliant and groups other properties into small-scale collective ("cluster") systems. Both on-lot and collective systems would be under active management by the BSA. This concept is expected to offer a least-cost strategy by focusing resources on providing improved systems only for wastewater generators that may represent an actual liability for public health and/or environmental values while leaving non-problematic residential properties on lower cost individual "septic" systems.

This strategy was rated most highly, as measured by the number of "highly favorable" (1 or 2) rankings received, with 24 responses ranking the option 1 or 2 for each of the two variants of this strategy. Almost every response that had one of the variants ranked 1 had the other ranked at 2. As noted below, the two variants differ by how the collected wastewater is treated in the cluster systems. Since this is essentially a technical evaluation, it is expected that what these results effectively impart is that many people in Bluff believe that managed individual on-lot systems "should" be retained and incorporated into the management system to the degree possible. However, this strategy also had a significant occurrence of "unfavorable" rankings (16 and 18 responses of 7, 8, 9 or 10 for the two variants, respectively), indicating that there may be some division in the community over the issue of retaining individual on-lot systems as part of the overall wastewater management concept.

The general ideas embodied in this strategy include:

- Not all properties require the upgrading or abandoning of their existing on-lot systems.
- As a first approximation, those properties violating well setbacks are presumed to require clustering so that effluent from these properties would be dispersed in an area outside of the well setbacks. Further investigations would be required to determine how many additional properties would require upgrading, and whether this would be "best" accomplished with an upgraded on-lot system or by routing wastewater from that lot to a cluster system.
- The "nominal" presumption is that all on-lot upgrades would be limited to a new or repaired conventional septic tank/gravity trench system, so if a code-compliant system of that type could not be located on the lot in question, that lot would have to be included in a cluster system. If "improved" on-lot systems were deemed to be needed, this would require that the BSA be given the authority to permit "alternative" systems under the Utah "on-site" code.

- Almost all the commercial wastewater generators would need to be routed to improved systems, whether clustered with other properties or a stand-alone system.
- Drip irrigation fields used for effluent dispersal would be deployed to derive an irrigation benefit from the dispersal process.

A significant uncertainty plaguing this strategy is that the total cost of implementing this system concept is somewhat indeterminate, for two reasons:

- Owners of residential properties on which a code-compliant system could be located may opt to upgrade the existing system, if required, instead of joining a cluster system. The number of such upgrades required will be unknown until all systems are investigated to determine their status.
- It is presumed that any residential property owner may join a cluster system that is within "reasonable" proximity rather than stay on an individual on-lot system, regardless of whether or not a code-compliant on-lot system can be maintained on that lot, and the number who may opt to join a cluster will not be known until it comes time for each owner to commit to one strategy or the other. A major presumption of this concept is that owners would have a fiscal incentive for remaining on individual on-lot systems because those owners would incur only a fairly low annual management fee, while those owners joining a cluster would incur some share of the capital cost and O&M costs of cluster systems. However, as detailed below, the proposed funding arrangements to be made available by the State of Utah would "cap" payments per equivalent residential unit (ERU) of flow, so how much of an incentive this would actually be is open to question.

Two variants of the managed on-lot + clusters option were formulated. One envisioned routing of septic tank effluent, with no further pretreatment, to collective dispersal fields utilizing the low-pressure-dosed (LPD) technology. This option obviates the capital and operating costs of a treatment system to upgrade the septic tank effluent prior to dispersal, so would clearly be the more cost efficient strategy. However, there is concern about pollution of the shallow aquifer into which some of the dispersed effluent would percolate, in particular about nitrates. This calls to question the regulatory acceptability of this strategy, not only initially but in the future, as further information about this aquifer is obtained.

This circumstance favored further consideration of only the other variant, which is to provide high quality pretreatment, including reduction of total nitrogen to below 20 mg/L, prior to dispersal, despite the higher cost which the treatment system entails. Because the effluent would then be clear water, it could be effectively and efficiently dispersed in a subsurface drip irrigation system instead of an LPD field. As noted previously, drip irrigation fields would allow irrigation benefits provided by the dispersal fields to be practically maximized.

As noted, a critical factor bearing on further evaluation of this concept is arriving at a "reasonable" guess at the number of residential lots that would continue to use individual on-lot systems and how many would require replacement or repair of the present systems. The "nominal" configuration of the cluster systems used to evaluate this option hook up 41 residential lots determined to be problematic for on-lot systems due to well setback issues. The estimated total number of existing residential services is 114, so the number of houses remaining on individual on-lot systems would be 114 – 41 = 73. It is estimated that 40 of those would require a major repair or replacement of the existing system. This estimate is taken from the presentation made by the Utah regulatory system to the BSA in March 2006. It is unknown how many of these 40 properties might be included in cluster systems, but lacking a survey of actual conditions, it provides the best available basis for evaluation of this option at this point.

The design flow rates, treatment plant size (based on the design noted previously) and drip irrigation field size (based on a loading rate of 0.15 gpd/sq. ft.) for each of the seven cluster systems in the "nominal" configuration are listed below. The design flow rates utilize the estimates for commercial generators and for residences which were derived from water use records and agreed to for the purposes of this analysis by the Utah regulatory system.

TREATMENT CENTER No. 1 – 10,925 gallons/day
- Nominal treatment plant size = 12,500 gallons/day
- Nominal drip irrigation field area = 72,833 sq. ft.

TREATMENT CENTER No. 2 – 8,810 gallons/day
- Nominal treatment plant size = 10,000 gallons/day
- Nominal drip irrigation field area = 58,733 sq. ft.

TREATMENT CENTER No. 3 – 8,575 gallons/day
- Nominal treatment plant size = 10,000 gallons/day
- Nominal drip irrigation field area = 57,167 sq. ft.

TREATMENT CENTER No. 4 – 8,255 gallons/day
- Nominal treatment plant size = 10,000 gallons/day
- Nominal drip irrigation field area = 55,033 sq. ft.

TREATMENT CENTER No. 5 – 4,050 gallons/day
- Nominal treatment plant size = 5,000 gallons/day
- Nominal drip irrigation field area = 27,000 sq. ft.

TREATMENT CENTER No. 6 – 3,245 gallons/day
- Nominal treatment plant size = 5,000 gallons/day
- Nominal drip irrigation field area = 21,633 sq. ft.

TREATMENT CENTER No. 7 – 8,100 gallons/day
- Nominal treatment plant size = 10,000 gallons/day
- Nominal drip irrigation field area = 54,000 sq. ft.

REQUIRED TREATMENT CAPACITY IN CLUSTER SYSTEMS = 51,960 gallons/day
TOTAL TREATMENT CAPACITY IN CLUSTER SYSTEMS = 62,500 gallons/day
TOTAL DRIP FIELD AREA FOR CLUSTER SYSTEMS = 346,399 sq. ft.

As these numbers show, each treatment center would have some "spare" capacity, resulting in considerable "slack" to accommodate additional houses joining the cluster systems in the future. The total number of commercial ERU's served by these systems is estimated at 219. Adding the 41 houses served by the cluster systems, a total of 260 ERU's are served by the cluster systems. Another 77 ERU's would be served by individual on-lot systems under this option.

Cost estimates for this option, shown in Tables 1 and 2, indicate the total capital cost of this strategy to be $2,294,421 (cluster systems) plus $172,000 (on-lot system upgrades), for a total of $2,466,421. Adding in the net present worth of 20 years of estimated O&M costs, the total net present worth of this option is estimated to be $2,576,519 (cluster systems) plus $210,536 (on-lot systems), for a total of $2,787,055. The capital cost per ERU for the cluster systems is $8,825—over twice the estimated $4,300 per house (= 1 ERU) for replacement on-lot systems—and the overall capital cost per ERU of the entire option is $8,221 (based on 260 ERU's in cluster systems, and the 40 individual on-lot system upgrades).

The average annual O&M cost is estimated to be $22,839 (cluster systems) plus $3,280 (on-lot systems), for a total of $26,119. The resulting monthly O&M cost is $7.32/ERU for the cluster systems, implying this would be the O&M cost per house connected to a cluster system. For the on-lot systems, the monthly O&M cost is $3.55/house (ERU). Note that these O&M costs do not include any "overhead" for BSA. This will apply—presumably fairly equally—among all options, so the relative values derived from the present calculations should provide a fair comparison among options despite those costs not being explicitly evaluated at this point.

Two funding scenarios for these facilities are reviewed. The first is financing over 20 years at a "market" rate, presumed to be the discount rate of 4.875% provided by the Utah regulatory system. As displayed in Table 1, the monthly payment would be $57.63/ERU for the cluster system clients and $28.08 for on-lot system owners. Adding the estimated monthly O&M charges, the monthly cost for cluster system clients would be $64.95/ERU, and the monthly cost for on-lot system users would be $31.63. Both of these are in excess of the $26/ERU "cap" on charges that is envisioned under a state-sponsored funding program. This implies that, if an upgrade is required, staying on an individual on-lot system would impart no fiscal advantage to property owners who do so and this has implications for the ultimate evaluation of this system.

As Table 1 shows, if user payments were "capped" at $26/ERU/month, deducting the O&M costs leaves $26 – $7.32 = $18.68/ERU/month available for a loan payment for the cluster system clients and $26 – $3.55 = $22.45/house/month available for a loan payment for the individual on-lot system users. While funding arrangements might not impose this sort of differential, these figures are used to estimate the amount of grant funding and loan funding required for this option. Grants would need to cover the "excess" above $18.68/ERU/month for cluster system clients and above $22.45/house/month for on-lot system users. Table 1 shows the total loan amount for both cluster and on-lot system would be $881,192. With the total cost of this option being $2,466,421, grants would need to cover capital costs in the amount of $1,585,229.

The second scenario, displayed in Table 2, is a no-interest loan over 30 years, which may be offered by the State of Utah. In this case, the required monthly payments would be the cost divided by 360 (30 years x 12 months/year). For cluster system clients, the monthly payment would be $8,825/360 = $24.51/ERU. Adding the O&M cost, the total payment for cluster system clients would be $31.83/ERU. For on-lot system owners, the monthly payment would be $4,300/360 = $11.94, and with the O&M cost added, the total payment would be $15.49/house.

In this case, with the total payment "capped" at $26/ERU/month, there would be a difference between the two classes of system users, in the amount of $10.51/month, or $126.12/year.

Table 2 shows that a loan of $1,748,448 would be available for the 260 ERU's presumed to be covered by the cluster systems. Deducting this from the $2,294,421 total cost of the cluster systems yields a required grant amount of $545,973. For the on-lot system users, the available loan payment exceeds the total capital cost of $172,000, so all improvements would be covered by loans, reducing the owners' costs somewhat below $26/month, as noted above. As Table 2 shows, the actual total loan amount would be $1,920,448 for this option. Under this scenario, installation of the cluster systems would be partially grant subsidized while on-lot upgrades would be entirely loan-funded, raising an equity issue.

Small-Scale Collective System

Two variants of fully collectivized decentralized concept systems were entertained. The first is the small-scale collective system, entailing a number of smaller cluster systems dispersed around the community, similarly to the previous option, but with all houses included in the cluster systems. This option was rather highly favored in the community evaluation process. It received 35 responses ranking it "highly favorable" (1 or 2) or "favorable" (3 or 4). Of these, 9 responses were 1 or 2, with the other 26 being 3 or 4. Most who ranked this option 3 or 4 had ranked the managed on-lot + clusters options at 1 and 2, indicating that this option may have been viewed as the "fallback" by those people if the regulatory system determined it could not support a strategy including managed individual on-lot systems. Among those who ranked this option 3 or 4, a large majority—22 out of 26—ranked this option 3, indicating the highest favorability of any of the fully collectivized options, in particular a preference for this option over the large-scale collective option described below. The "unfavorable" rankings of 7, 8, 9 or 10 for this option appeared on only 8 responses, the lowest total of any option. There were 9 responses in the "neutral" range of 5 or 6, for a total of only 17 responses below the "favorable" range.

This option was originally evaluated with the presumption that effluent would be discharged into washes. At the public meetings and in the evaluation survey, the community expressed a sentiment that discharge is to be avoided if at all practical due to various concerns, and that the effluent "should" be routed to beneficial reuse as much as practical. This dictated that this option would be evaluated with soil dispersal, in subsurface drip irrigation fields, as the fate of the effluent. Discussions with the regulatory system indicated their unfamiliarity with—and thus concern about—drip dispersal, so it was determined that an "emergency" discharge pipe would be included. So, as discussed in the cost analysis, a surface discharge option is readily evaluated simply by eliminating the costs associated with drip irrigation dispersal.

Organizing principles for determining where treatment centers should be placed include:

- All generators should flow by gravity to a treatment center.
- Wastewater lines should not cross washes.
- Highway crossings are to be avoided as much as practical.
- Long runs of unloaded sewer lines are to be avoided as much as practical.

This results in the "nominal" layout of the system again in seven clusters. A few houses may remain on individual on-lot systems as "outliers" under this option. With the configurations presumed, however, all 114 houses addressed by the previous option are included in the clusters.

Other ideas embodied in this strategy include:

- Most properties require the upgrading or abandoning of their existing on-lot systems, and this is most cost efficiently accommodated with collective treatment and dispersal systems.
- All individual on-lot systems which remain would be actively managed by the same entity that manages the cluster systems.
- Drip irrigation fields would be deployed to derive an irrigation benefit.
- It is presumed that a judgment has been rendered that the shallow aquifer needs to be protected from nitrate pollution, which is the basis for providing high quality pretreatment with nitrogen reduction prior to soil dispersal.

The design flow rates, treatment plant size, and drip irrigation field size, all derived on the same basis as for the previous option, for each of the seven cluster systems in the "nominal" configuration are listed below.

TREATMENT CENTER No. 1 – 1,800 gallons/day
Nominal treatment plant size = 2,500 gallons/day
Nominal drip irrigation field area = 12,000 sq. ft.
TREATMENT CENTER No. 2 – 4,190 gallons/day
Nominal treatment plant size = 5,000 gallons/day
Nominal drip irrigation field area = 27,933 sq. ft.
TREATMENT CENTER No. 3 – 22,135 gallons/day
Nominal treatment plant size = 25,000 gallons/day
Nominal drip irrigation field area = 147,567 sq. ft.
TREATMENT CENTER No. 4 – 11,175 gallons/day
Nominal treatment plant size = 12,500 gallons/day
Nominal drip irrigation field area = 74,500 sq. ft.
TREATMENT CENTER No. 5 – 9,855 gallons/day
Nominal treatment plant size = 10,000 gallons/day
Nominal drip irrigation field area = 65,700 sq. ft.
TREATMENT CENTER No. 6 – 5,650 gallons/day
Nominal treatment plant size = 6,250 gallons/day
Nominal drip irrigation field area = 37,667 sq. ft.
TREATMENT CENTER No. 7 – 12,145 gallons/day
Nominal treatment plant size = 12,500 gallons/day
Nominal drip irrigation field area = 80,967 sq. ft.

REQUIRED TREATMENT CAPACITY IN CLUSTER SYSTEMS = 66,950 gallons/day
TOTAL TREATMENT CAPACITY IN CLUSTER SYSTEMS = 73,750 gallons/day
TOTAL DRIP FIELD AREA FOR CLUSTER SYSTEMS = 446,334 sq. ft.

As the calculations show, each treatment center has some "excess" capacity to accommodate additional flow, which may derive from infill development or new lots on the periphery of each cluster system service area. It is also noted that actual average daily flow rate (based on metered water usage) for a house in Bluff is much closer to 100 gpd than the 200 gpd presumed in the sizing calculations, so there is some "slack" in the total design flow rate for residential services.

The number of ERU's served is the estimated total of 223 commercial ERU's plus the estimated 114 residential services, for a total of 337 ERU's. The capital cost, shown in Tables 1 and 2, is estimated to be $3,439,939, yielding a capital cost per ERU of $10,208. The net present worth of O&M costs over 20 years is estimated at $377,338, bringing the total net present worth of this option to $3,817,277. The average annual O&M cost is estimated at $30,764, which yields an estimate of $7.61/ERU as the monthly O&M cost.

The two funding scenarios are again considered. Financing over 20 years at an interest rate of 4.875% is reviewed in Table 1. The required loan payment per ERU would be $66.66/month. Adding O&M costs, the total payment would be $74.27/ERU/month. With payments capped at $26/ERU/month, a total loan amount of $948,969 would be available for the 337 ERU's presumed to be covered by this option. Deducting this from the total cost, a grant amount of $2,490,970 would be required for this option.

Under the 30-year no-interest loan scenario, reviewed in Table 2, the required loan payment would be $28.35/ERU/month. Adding O&M costs, total payment per ERU would be $35.96/month. With payments capped at $26/ERU/month, the total loan amount would be $2,231,075. Deducting this from the total cost of this option, the grant amount required to fund it would be $1,208,864.

As noted previously, costs to implement this option with direct stream discharge can also be readily evaluated by deducting the costs of the facilities required for drip dispersal fields and delivery of effluent to them, and adding the cost of UV disinfection units. The estimated capital cost of this sub-option is $2,399,705. This cost results in an estimated capital cost of $7,121/ERU for the 337 ERU's presumed to be covered. The net present worth of 20 years of estimated O&M costs is $352,089. The estimate for the average annual O&M cost is $28,624. This yields an estimate of $7.08/ERU for the monthly O&M cost.

The total estimated net present worth of this sub-option is $2,399,705 + $352,089 = $2,751,794. As expected, the cost would be significantly less than the soil dispersal option, but this neglects the value of the water and of the nutrients remaining in the effluent as a fertilizer resource. So besides the intrinsic value to the community of avoiding discharge into the San Juan River, a factor to be evaluated is how effectively the reclaimed water could be routed to beneficial reuse, rather than simply "disposing" of this water without obtaining value by serving irrigation demands. That is a matter to be addressed as the BSA reviews its options for a secondary water system to serve irrigation demands from non-potable water sources.

Financial analysis of the stream discharge sub-option is also reviewed in Tables 1 and 2. If financed over 20 years at an interest rate of 4.875%, Table 1 shows the required loan payment would be $46.50/ERU/month. Adding O&M costs, the total payment to be $53.58/ERU/month. With the payment capped at $26/ERU/month, a total loan amount of $976,318 would be available. Deducting this from the total cost yields a required grant amount of $1,423,387 to fund this sub-option. Based upon these estimates, total grant funds required for this sub-option would be $1,067,583 less than for the soil dispersal sub-option.

These costs compare favorably for the least cost fully centralized option—an MBR plant mated with an effluent sewerage system. For that option, a loan of only $671,018 could be financed, due to more of the $26 cap being consumed by higher O&M costs, leaving a required grant amount of $2,053,503, almost $1 million greater than for this decentralized concept option.

Under the no-interest loan scenario, reviewed in Table 2, the required monthly loan payment would be $19.78/ERU. Adding the O&M costs brings the payment to $26.86/ERU/month. Capping the payment at $26/ERU/month, the available loan amount would be $2,295,374. Deducting this from the total option cost, the grant amount required to fund this option would be only $104,331. In this case, grant funds required for this sub-option would be $1,119,092 less than for soil dispersal. Under this scenario, the least cost fully centralized option would yield a loan amount of $1,571,256 and require a grant of $1,153,265, which is over $1 million greater than for this decentralized concept option. Again, this neglects the value of the water and nutrients and the intrinsic value of circumventing discharge into the San Juan River.

Large-Scale Collective System

The second variant of the fully collectivized decentralized concept system is the large-scale collective system. This strategy was also rather highly favored in the community evaluation process, receiving 38 responses ranking it "highly favorable" (1 or 2) or "favorable" (3 or 4), the most of any option. Of these, 12 were rankings of 1 or 2. Again, most who ranked this option 3 or 4 had ranked the managed on-lot + clusters options at 1 and 2, indicating that this option too may have been viewed as the "fallback" if retaining managed individual on-lot systems could not be supported by the regulatory system. Among those who ranked this option 3 or 4, the majority—21 out of 26—ranked it at 4, the opposite to the rankings in the "favorable" range of the small-scale collective option. The "unfavorable" rankings of 7, 8, 9 or 10 for this option appeared on only 9 responses, second lowest of any option. There were 6 responses in the "neutral" category (rankings of 5 or 6), yielding a total of 15 responses below the "favorable" range, the fewest of any option.

This option was also evaluated for both drip irrigation dispersal and surface discharge on the same basis as the small-scale collective option. The "nominal" layout of the overall system is in the two cluster systems, one on each side of Cottonwood Wash, the major wash which bisects the community. A few houses may remain on individual on-lot systems as "outliers" under this option also. However, with the configuration presumed, 114 houses are included in the clusters for this option also, and no houses are explicitly identified as outliers.

This strategy embodies the same general ideas as the small-scale collective option, with simply a higher degree of collectivization. This would minimize monitoring costs, which would offset the increased collection system costs entailed in a higher degree of collectivization to fewer treatment centers, on a life-cycle cost basis.

The design flow rates, treatment plant size, and drip irrigation field size for the two cluster systems are listed below. The design flow rates again utilize the estimates for commercial generators and for residences which were derived from water use records and agreed to for the purposes of this analysis by the Utah regulatory system.

TREATMENT CENTER No. 1 – 28,125 gallons/day
Nominal treatment plant size = 30,000 gallons/day
Nominal drip irrigation field area = 187,500 sq. ft.

TREATMENT CENTER No. 2 – 39,025 gallons/day
Nominal treatment plant size = 40,000 gallons/day
Nominal drip irrigation field area = 260,167 sq. ft.

REQUIRED TREATMENT CAPACITY IN CLUSTER SYSTEMS = 67,150 gallons/day
TOTAL TREATMENT CAPACITY IN CLUSTER SYSTEMS = 70,000 gallons/day
TOTAL DRIP FIELD AREA FOR CLUSTER SYSTEMS = 447,667 sq. ft.

As these numbers show, each treatment center again has some “excess” capacity to accommodate additional flow, which may derive from infill development or new lots on the periphery of the overall service area of the community system. It is also noted that actual average daily flow rate (based on metered water usage) for a house in Bluff is much closer to 100 gpd than the 200 gpd estimate used in the above calculations, so there is further “slack” in the design flow rate for residential services.

The estimated capital cost for this option, shown in Tables 1 and 2, is $3,468,918, slightly more than the small-scale collective option capital cost, due to greater collection system and effluent dispersal pipe costs. With 337 ERU’s presumed to be covered by this option, this results in a capital cost per ERU of $10,294. The net present worth of estimated O&M costs over 20 years is $320,173, somewhat less than the small-scale collective option, as expected due to significantly lower monitoring costs. This brings the total net present worth of this option to $3,789,091, which is only $28,186 less than for the small-scale collective option. Given the uncertainties in cost factors at this point, these two options should be considered to have essentially equivalent net present worth, with higher capital costs traded out for lower O&M costs. The average annual O&M cost is estimated at $26,188, which yields an estimate of $6.48/ERU as the monthly O&M cost. Again, these O&M cost estimates do not include “overhead” for BSA.

Considering the “market rate” financing option, Table 1 shows that if this option were financed over 20 years at an interest rate of 4.875%, the required loan payment per ERU would be $67.22/month. Adding the O&M cost, the total payment would be $73.70/ERU/month. With payments capped at $26/ERU/month, the total available loan amount would be $1,007,279. Deducting this amount from the total capital cost leaves $2,461,639 to be funded by grants.

With a 30-year no-interest loan, Table 2 shows that the required monthly loan payment would be $28.59/ERU. Adding the O&M costs, the total payment would be $$35.07/ERU/month. Capping payments at $26/ERU/month, the total available loan amount would be $2,368,166. Deducting this from the total capital cost yields a required grant amount of $1,100,752.

The capital cost estimate for this option with stream discharge is $2,324,035, resulting in a capital cost per ERU of $6,896, in this case slightly lower than the small-scale collective option with stream discharge. Using soil dispersal instead of discharge under this option adds an estimated $1,144,883 to the capital cost of this option. The net present worth of estimated O&M costs over 20 years is $296,455, again significantly lower than the small-scale collective option due to lower monitoring costs. Adding the O&M costs brings the total net present worth of this option to $2,620,490. The average annual O&M cost is estimated at $24,280, which yields an estimate of $6.00/ERU as the monthly O&M cost.

The "market rate" financial analysis of the stream discharge sub-option, shown in Table 1, indicates that financing over 20 years at an interest rate of 4.875%, the required payment would be $45.04/ERU/month. Adding O&M costs, the total payment would be $51.04/ERU/month. With payments capped at $26/ERU/month, the total available loan amount would be $1,032,049. Deducting this from the capital cost for this sub-option yields a required grant amount of $1,291,986. This compares with an available loan of $671,018 and a required grant of $2,053,503—over ¾ million greater—for the least cost fully centralized option.

Based on these estimates, the total grant funds required for this sub-option would be $1,169,653 lower than for the soil dispersal sub-option. As noted in the small-scale collective option discussion, this must be weighed against the intrinsic value of avoiding discharge to the San Juan River and the value of the water for beneficial reuse.

Under the no-interest loan scenario, Table 2 shows the total required monthly payment to be $19.16/ERU. Adding on the O&M costs, the total payment would be $25.16/ERU/month. Capping payments at $26/ERU/month, the total available loan amount would be $2,426,400. This is larger than the total capital costs, implying that the loan would completely cover capital costs of this sub-option under the no-interest loan scenario, so the required loan payment would be a bit less than $20.00/ERU/month. In this case, grant funds for the soil dispersal sub-option would be $1,100,752 greater than for the discharge sub-option. Again, the least cost fully centralized option would provide for a loan amount of $1,571,256 and require a grant of $1,153,265.

<u>REVIEW AND DISCUSSION</u>

Previous reviews of the wastewater planning process for Bluff have indicated that some form of decentralized concept strategy is broadly preferred as the most appropriate response to the conditions in Bluff. The foregoing has provided the background/justification of the methods proposed and the physical and fiscal details of specific options in a decentralized concept wastewater management system for Bluff. This all provides the basis for a discussion among the Board, within the community, and with the regulatory system which is necessary in order for the

BSA, acting on behalf of the citizenry, to discern the specific approach that would be most beneficial and sustainable in regard to the various criteria that may be applied—fiscal, institutional, and environmental. Due to the page limit on proceedings papers, just a brief summary of the issues to be confronted and surmounted is set forth below.

- Whether or not to retain a significant number of on-lot systems within the community wastewater management system is a central issue, with potentially great impact on the amount of loans that would be needed to finance implementation of the system. The regulatory acceptance of BSA management of on-lot systems is critical to the very ability to entertain this option further.
- The "level of service" expected to be provided is another issue impacting on retaining any significant number of conventional on-lot systems within the community wastewater management system. It must be determined if these do in fact provide the "appropriate" level of service.
- Certain funding conditions under the managed on-lot plus cluster systems option may create an equity issue between owners receiving on-lot system upgrades vs. those joining collective systems, as the latter would have their implementation costs defrayed by grants but the former would pay the full implementation costs through loans. Is this a problem, and how could it be resolved if it is?
- An explicit evaluation of the "overhead" cost for the BSA to set up and run a community management system remains to be done. This will be impacted by the form and function of the management system chosen, so has been deferred until those matters are resolved.
- Under the managed on-lot plus cluster systems option, how should that "overhead" be distributed between on-lot systems and collective systems?
- Under the managed on-lot plus cluster systems option, what would be the standard for determining need to upgrade an on-lot system? What would be the cost of making that determination? How will these costs impact on the overall cost of that option? How would the standard that is used impact on the likelihood of additional on-lot upgrades being required within the planning period? What arrangements could be made for funding assistance of upgrades deemed to be required in the future? What standards would be applied when installing on-lot upgrades?
- Retention of all the commercial generators in Bluff is not guaranteed throughout the life of any loans obtained to finance system installation. Can this issue be addressed so that the community-at-large does not become saddled with significantly higher than anticipated debt payments in the future, should one or more of these businesses cease to exist?
- Is the effluent produced by treatment systems a resource, to be husbanded and beneficially utilized to the maximum practical extent, or is it a nuisance, to be "disposed" of as cost efficiently as possible, subject to duly addressing public health and environmental quality concerns?
- If treated effluent is deemed to be a reclaimed water resource, should it be integrated into the community's secondary water system so that it may be most beneficially utilized? If so, how? What additional regulatory issues might this raise? What would be the cost implications? How could these impacts be blunted? How would winter flows be addressed under such a scheme?

- If it is deemed a nuisance, would the "premium" cost to "dispose" of the effluent via subsurface drip irrigation "drainfields" be deemed worthy of funding? Or would stream discharge be "imposed" by the regulatory/funding system?
- Would stream discharge at the points in the dry washes and in the volumes envisioned by the proposed system plans actually impact on the flowing waters of the San Juan River? If so, to what degree? How does one evaluate any hazard relative to the additional costs of avoiding stream discharge?
- If stream discharge were the option chosen (or imposed), would dispersing the discharges as envisioned under the small-scale collective option impart less potential to impact the flowing waters of the San Juan River than the more concentrated discharge into Cottonwood Wash as envisioned under the large-scale collective option? Would whatever "premium" cost this imposed be merited by any decrease in hazard?
- Would stream discharge need to be avoided, would it be an issue, if reclaimed water were somehow integrated into a secondary water system? Might winter-only discharge be deemed acceptable in regard to whatever hazards due to stream discharge might be identified?
- Could the shallow aquifer be used in essence as storage for reclaimed water—which could then be drawn into the secondary water system—by routing treated effluent into infiltration galleries? What quality requirements would this strategy impose on the treatment systems? What would be the cost impacts of this strategy?
- Would regulatory requirements for oversight and, most particularly, for water quality monitoring vary depending on the size of a treatment center and/or depending on whether the effluent is routed to stream discharge vs. soil dispersal? How would this impact on the operating costs of the small-scale collective option vs. the large-scale collective option?
- What are the prospects for getting the entire installation funded in one "chunk"? If this appears problematic, does this imply an advantage for the small-scale collective option over the large-scale option, as it could be implemented one treatment center at a time over multiple years, if need be?
- How is the intrinsic value of dispersing risk evaluated by the community, and does this factor impart any advantage to the small-scale collective option over the large-scale collective option by distributing treatment capacity to 7 locations instead of 2 locations? Given the nature and design details of the type of treatment technology proposed, however, is risk already dispersed regardless of the total size of any given treatment center?

It is anticipated that the community will have resolved these issues and chosen an option by the time this paper is presented at the 2008 NOWRA Conference, and the way the relevant factors were addressed would be reviewed.

TABLE 1

FINANCIAL ANALYSIS WITH "MARKET RATE" LOAN

Discount rate = 4.875%

Option Description	No. of ERU's in Option	Total Capital Cost	Capital Cost/ERU	Monthly O&M Cost/ERU	Loan Pmt per ERU w/o Grants	Total Pmt per ERU w/o Grants	With Total Payment "capped" at $26/ERU/month: Available Loan Payment/ERU	Available Loan Amt/ERU	Total Available Loan Amount	Required Grant Amt
OPTION: On-lot + clusters, with treatment & drip dispersal										
Cluster systems	260	$2,294,421	$8,825	$7.32	$57.63	$64.95	$18.68	$2,860	$743,687	$1,550,734
On-lot systems	40	$172,000	$4,300	$3.55	$28.08	$31.63	$22.45	$3,438	$137,504	$34,496
OPTION TOTALS	300	$2,466,421	$8,221						$881,192	$1,585,229
OPTION: Small-scale collective system										
With drip irrigation dispersal	337	$3,439,939	$10,208	$7.61	$66.66	$74.27	$18.39	$2,816	$948,969	$2,490,970
With stream discharge	337	$2,399,705	$7,121	$7.08	$46.50	$53.58	$18.92	$2,897	$976,318	$1,423,387
DIFFERENCE BETWEEN SUB-OPTIONS		$1,040,234								$1,067,583
OPTION: Large-scale collective system										
With drip irrigation dispersal	337	$3,468,918	$10,294	$6.48	$67.22	$73.70	$19.52	$2,989	$1,007,279	$2,461,639
With stream discharge	337	$2,324,035	$6,896	$6.00	$45.04	$51.04	$20.00	$3,062	$1,032,049	$1,291,986
DIFFERENCE BETWEEN SUB-OPTIONS		$1,144,883								$1,169,652

TABLE 2

FINANCIAL ANALYSIS WITH NO-INTEREST LOAN

Option Description	No. of ERU's in Option	Total Capital Cost	Capital Cost/ERU	Monthly O&M Cost/ERU	Loan Pmt per ERU w/o Grants	Total Pmt per ERU w/o Grants	With Total Payment "capped" at $26/ERU/month: Available Loan Payment/ERU	Available Loan Amt/ERU	Total Available Loan Amount	Required Grant Amt
OPTION: On-lot + clusters, with treatment & drip dispersal										
Cluster systems	260	$2,294,421	$8,825	$7.32	$24.51	$31.83	$18.68	$6,725	$1,748,448	$545,973
On-lot systems	40	$172,000	$4,300	$3.55	$11.94	$15.49	$22.45	$8,082	$323,280	$0
OPTION TOTALS	300	$2,466,421	$8,221						$2,071,728	$545,973
								Actual loan amount =	$1,920,448	
OPTION: Small-scale collective system										
With drip irrigation dispersal	337	$3,439,939	$10,208	$7.61	$28.35	$35.96	$18.39	$6,620	$2,231,075	$1,208,864
With stream discharge	337	$2,399,705	$7,121	$7.08	$19.78	$26.86	$18.92	$6,811	$2,295,374	$104,331
DIFFERENCE BETWEEN SUB-OPTIONS		$1,040,234								$1,104,534
OPTION: Large-scale collective system										
With drip irrigation dispersal	337	$3,468,918	$10,294	$6.48	$28.59	$35.07	$19.52	$7,027	$2,368,166	$1,100,752
With stream discharge	337	$2,324,035	$6,896	$6.00	$19.16	$25.16	$20.00	$7,200	$2,426,400	$0
DIFFERENCE BETWEEN SUB-OPTIONS		$1,144,883								$1,100,752