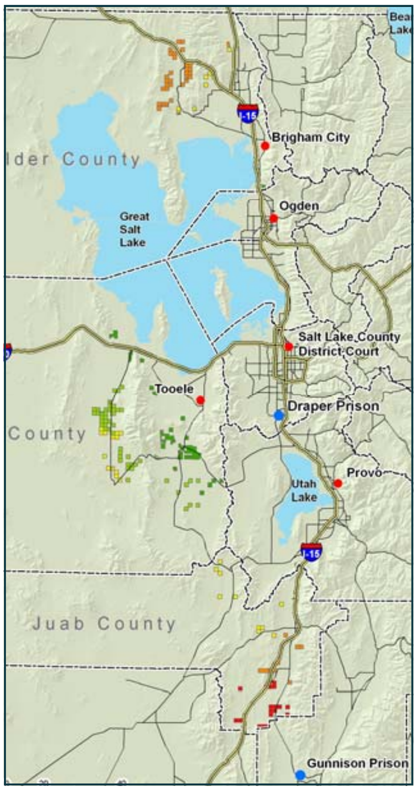
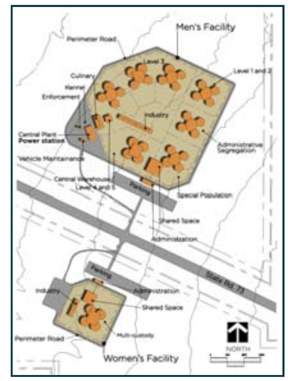
WIKSTROM

Third Prison Site Location Study

Utah Department of Corrections
Utah Division of Facilities Construction and Management

January 2009





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GSBS ARCHITECTS

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Stantec

Weber Sustainability

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THIRD PRISON SITE LOCATION STUDY

Utah Department of Corrections
Utah Division of Facilities Construction and Management

Project Team:
Wikstrom Economic and Planning Consultants, Inc.
GSBS Architects
Parametrix
Stantec Consulting, Inc.
Spectrum Engineers, Inc.
Weber Sustainability Consultants

January 2009

INTRODUCTION

The Utah Department of Corrections ("DOC") has undertaken this study in order to plan for the growth of its prisoner population, which will need a significant amount of new space in the next few years. Currently there are approximately 6,700 inmates in the State's prison system. According to the Department of Corrections roughly 190 prisoners enter the system every year. This means in about seven years another prison the size of the Central Utah Correctional Facility, which can accommodate 1,340 prisoners, will be needed. Given that it takes approximately 4 years to design and build a prison, now is a good time to secure a site in advance of the planning process.

Some of the groundwork for this study was laid in 2006 when the State of Utah published a study entitled "Evaluation of the Feasibility of Relocating the Utah State Prison." This study was a response to popular interest in the removal and relocation of the State Prison in Draper to another site in a more rural area. The relocation study identified eastern Box Elder County, northeastern Juab County, and Rush Valley in Tooele County as areas that could be suitable for a new prison. The State has now asked the project team to build on the previous study's site suitability analysis by identifying the most suitable site for a new prison in the previously identified areas. In addition, the project team was asked to create conceptual plans and cost estimates for the construction of the prison on the selected site. Finally, the team was charged with comparing the cost of a 6,000 bed facility at a new site to the cost of constructing the same facility on vacant land next to the Draper Prison.

This report first explains the site selection process and briefly describes the preferred site. The report then presents a conceptual program and site plan along with preliminary infrastructure planning. Finally, the report lays out the associated costs along with a comparison of costs between a new site and expansion on the existing site.

Wikstrom Economic & Planning Consultants, Inc., is a Salt Lake City based economic, planning and real estate advisory services firm. Wikstrom offers services in economic consulting, planning, real estate development, feasibility studies, market analysis and fiscal analysis.

Executive Summary

SITE SUITABILITY ANALYSIS AND SELECTION

The 2006 prison relocation study identified three general areas that would be suitable for a new state prison. These areas included Rush Valley in Tooele County, eastern Box Elder County and northeastern Juab County. Several factors were considered in the selection process including:

- Parcel size
- Topography
- Access to water
- Distance to a hospital with emergency care
- Distance to police
- Natural resources and hazards including:
  - Existence of wetlands
  - Liquefaction potential
  - Flooding potential
- Size of surrounding employment base
- Distance to Salt Lake City (courts and University of Utah Medical Center)
- Distance to highway
- Proximity to residential areas
- Ownership

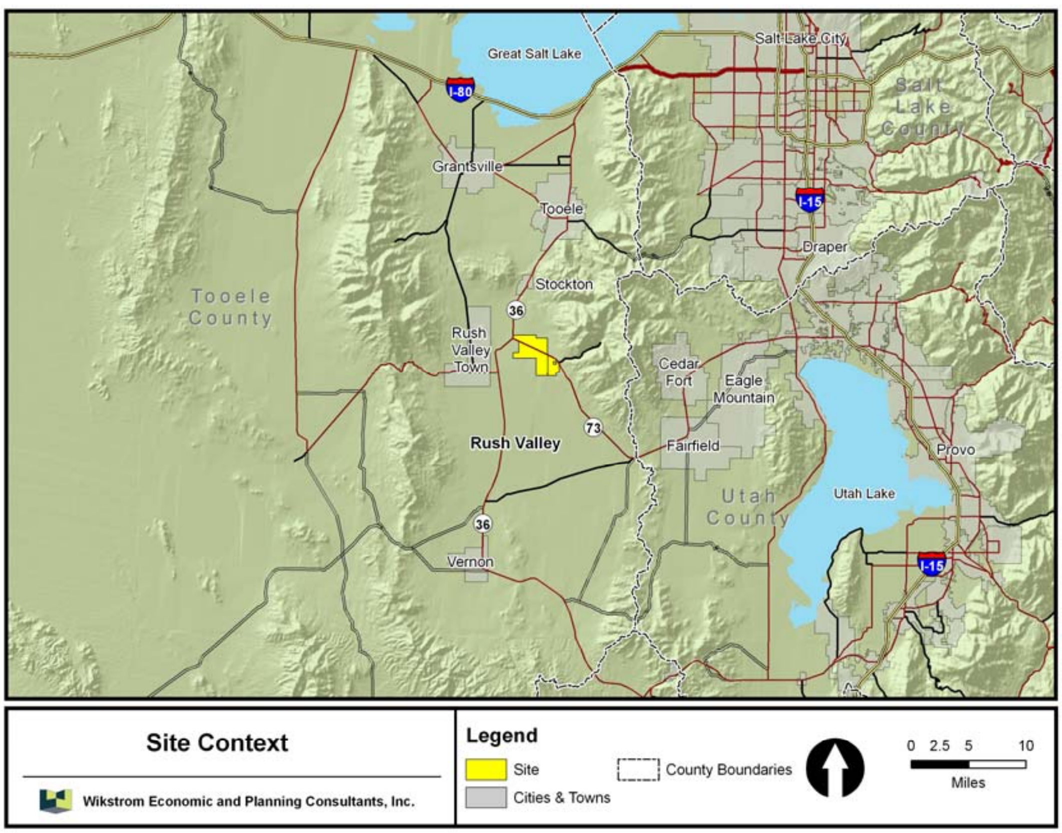


Figure S.1

These factors were used to compare the three general areas to each other and to rank individual parcels in relation to each other. The result of the analysis was to name Rush Valley as the clear winner between the three areas identified by the 2006 study. There were several parcels within Rush Valley to choose between, but one parcel, shown in its context in Figure S.1, stood out as clearly superior to all others in the valley because of its accessibility, size, and topography. The site sits at the intersection of State Highways 36 and 73 in northern Rush Valley. The selection process for this site is described in detail in Section 1 of this report.

The consultants were also asked to evaluate the possibility of locating a new prison near the Salt Lake County Landfill. The consultants found several major obstacles to locating a prison in the area. Appendix X is a report on the evaluation of the Landfill area.

ARCHITECTURAL PLANNING

An architectural planning effort has been undertaken to define the major project parameters of a prison with capacities of 6,000 and 10,000 beds. The 6,000 bed facility reflects replacement of the 4,000 beds at the Draper facility plus expansion. The 10,000 bed facility reflects the ultimate available capacity at the Draper site. Of those total bed counts, approximately 85 percent are for men and the remaining 15 percent are for women inmates. Physically separated facilities between genders are anticipated in the analysis.

The primary purpose of the planning effort is to determine the amount of land necessary to locate a prison complex and the general configuration requirements of that land. For the 6,000 bed facility, 245 acres are required for the men's prison and 85 acres are required for the women's prison. To increase the capacity to 10,000 beds requires a total of 380 and 127 acres respectively.

The planning process evaluated the inmate populations and the required segregations to safely house the planned population. Those requirements were aggregated into housing complexes and arranged on the site along with the necessary support spaces to provide a fully functional prison facility. Figure S.2 is the conceptual site plan for the preferred site. It includes all anticipated structures and facilities.

WATER AND WASTEWATER INFRASTRUCTURE

Culinary Water

Water demands for the new prison site were estimated for 6,000 bed and 10,000 bed facilities. Demands were estimated based on a usage of 115 gallons per bed per day. Using this number, demands were estimated to be:

- 400 gallons per minute (gpm) for a 6,000 bed facility.
- 800 gpm for a 10,000 bed facility.

A single water well drilled at the site could potentially produce water at flow rates of 400 to 800 gpm. (There are several wells near the proposed site that are capable of

Figure S.2: *Master Site Plan*

discharges as great as 2,250 gpm.) The site will likely require more than one well to ensure adequate supply. According to available groundwater quality data, the proposed site has total dissolved solids (TDS) concentrations of between 350 and 2,180 milligrams per liter (mg/L). TDS values greater than 1000 mg/L are likely to cause consumer complaint. Because the actual TDS value of a future well on site is unknown, the groundwater at the site will require further detailed investigations to ensure that it has a TDS level below 1,000 mg/L. The conceptual water supply infrastructure includes:

- 2(or more) wells approximately 300-600 feet deep with a 10-12 inch casing. Elevation: 5,520 feet.
- Well flow of approximately 500-800 gpm.
- 2 tanks with 750,000 gallons of storage each. Elevation: 5,540 feet.
- 12 inch water supply line. Length: 7,200 feet. Elevation drop: 160 feet.
- A water supply loop inside the fence in each complex.
- The prison complex at an elevation range of 5,400 feet to 5,300 feet.

Sanitary Sewer and Wastewater

Two major wastewater treatment alternatives were investigated in this study. These include:

- An Oxidation Ditch Process with Biologic Sludge Reduction.
- Membrane Bio-Reactor (MBR) Process with Mechanical Sludge Dewatering.

Both of these options are capable of producing irrigation reuse water. An MBR system would produce irrigation water usable on food crops without any additional processes. An oxidation ditch system would produce irrigation water usable for food crops only if a filtration and disinfection step were added at the end of the process.

The conceptual wastewater system includes:

- A wastewater treatment plant with a flow rate of 0.7 million gallons per day (MGD) for a 6,000 bed facility or 1.15 MGD for a 10,000 bed facility. Elevation: 5,280 feet.
- A 15-acre, 15-foot deep wastewater storage pond for a 6,000 bed facility or a 25-acre, 15-foot deep pond for a 10,000 bed facility. Elevation: 5,240 feet.
- A gravity flow irrigation line that is approximately 4,900 feet long.
- An irrigated area of approximately 350 acres. Elevation: 5,140 feet to 5,060 feet.

Storm Drainage

Storm drainage lines and detention ponds were sized to reduce post-development runoff to pre-development runoff volumes and peak flow rates. Storm water detention ponds were sized to reduce peak runoff potential to pre-development levels during a 10-year event. These pond sizes are:

- 1.9 acre-feet (5 feet deep, 140 feet x 140 feet) on the men’s side.
- 0.2 acre-feet (5 feet deep, 20 feet x 20 feet) on the women’s side.

ELECTRICAL AND COMMUNICATION INFRASTRUCTURE

Electrical Load Analysis & Power Distribution

Load Analysis

Electrical demands for the new prison site were estimated in the 10 to 15 Mega Watt Range. Those demands were estimated based on a historical analysis of usage at the Draper Facility. Using this demand, PacifiCorp can service the new campus from two locations:

- At 46 kilovolts from the Tooele Substation.
- At 15 kilovolts from the Rush Valley Substation.

Under either option, service will require extensions to the new site with upgrades to the existing off-site utility infrastructure.

Power Distribution

Secondary Campus Power should be delivered from a Department of Corrections substation at 15 kilovolts with redundant feeder duct-banks throughout the campus. The main physical plant should have Co-Generation capabilities for redundancy of electrical distribution. A Combined Heat and Power Plant design would provide optimal energy conservation. Campus illumination should employ high mast lighting techniques in the 3 footcandle range for optimal nighttime security considerations.

Data & Communications

To the Site

Primary delivery of communications services to the prison site should be via fiber from the nearest utility provider. Qwest has a main switch facility in Tooele and fiber is already to the site.

Within the Site

Communications infrastructure within the site will be placed in an underground duct bank, which would encircle the site. The duct bank would include vaults for installation and maintenance.

Security Systems

Perimeter Fence

Fence protection using sensor cable on the fence fabric and microwave detection zones between the dual rings of fence should be the primary method of detection. This method is currently deployed by the State in its other facilities.

Perimeter Towers & Gate Control

Two towers should control the central vehicle entrance with an additional tower at each change in direction by the fence, thus maintaining a “visual” of all fence lines.

Perimeter Cameras

Video surveillance will supplement the guard’s vision, not replace it. Cameras should be deployed to cover the same areas covered by guards; however, monitoring should be done by direct visual lookout, not by viewing video monitors, which should be relied upon primarily for their recording function.

RENEWABLE ENERGY ANALYSIS

The Rush Valley site offers significant potential for diversified renewable energy development at a 'district' energy scale. No single source similar to the geothermal resource at the present Draper Prison site, however, is likely to be identified. By applying a simultaneous strategy of 'high-performance' facility design to reduce energy demand, while developing a combination of renewable energy resources with utility grid backup, the DOC may achieve a high degree of energy self sufficiency at the Rush Valley site. As a complement to utility grid-sourced electrical and natural gas, renewable energy forms may offer a portion of the total energy demand of the prospective facility, and do so to provide some degree of energy and budget independence from future utility price fluctuations and power/fuel reliability concerns.

An inventory of potential renewable energy sources in the present analysis includes multiple forms of solar radiation capture and conversion to heat and electricity, wind electrical generation, biomass conversion to heat and electricity, geothermal heat and power, and small-scale hydroelectric generation. **Solar-thermal resources and multiple capture-conversion technologies appear, in this preliminary assessment, to promise both scale and versatility to fit the proposed project and its eventual expansion, providing both heat and electrical power, and storing a portion of thermal energy for use when needed.** Wind, biomass, geothermal and hydroelectric prospects are not understood quantitatively clearly enough to prioritize relative to other resource/technology combinations. Further, site-specific data-gathering and regional resources analyses are appropriate for these energy resources.

All possible technologies and the corresponding costs of renewable energy applications will be unique to the site, requiring further planning and engineering to define investment requirements for the various levels of renewable energy production: part of facility needs, all of facility needs, and energy production to fulfill all facility needs and to export renewable energy to the utility grid. As a hedge against future fuel price instability, planning for an excess of energy production on-site—for the DOC facility to become a 'net energy exporter,' fully utilizing the extensive property at the site—may present a State strategy worthy of serious consideration.

PROJECT COSTS

Construction Cost Comparisons

Construction costs were estimated for three different scenarios, which are described below. Two scenarios are based on the same site—in Rush Valley. The only difference between the two is the size of the facility. The purpose of the third scenario is to compare the cost of constructing identical facilities in Rush Valley versus in Draper, next to the existing prison site.

The first scenario consists of a 6,000 bed facility located in Rush Valley. The facility would have seven male housing pods and one female housing pod. The estimated cost for this scenario is $984,635,000.

The second scenario represents an expansion of the first scenario. It would provide 10,000 beds in ten male housing pods and two female housing pods. It not only includes more housing pods, but also additional support structures and site development. The estimated cost for this scenario is $1,345,505,000.

The third scenario consists of a 6,000 bed facility located just west of the existing prison in Draper. This scenario would incorporate a development program identical to the Rush Valley 6,000 bed scenario. The cost of this scenario will, therefore, be very close to the Rush Valley 6,000 bed scenario. However, this scenario will cost somewhat less due to the proximity of existing utilities. The estimated cost for this scenario is $973,069,000. While this amount is somewhat less than the Rush Valley total, the difference is only about one percent of total construction cost.

Operational Cost Comparisons

Changing the location of the main prison facility or adding a third site to the current prison system will result in additional operational costs. Prisoner transportation expenditures would be the most affected operational cost. Sufficient data was available to project changes in transportation cost if a third site were built. Other operational costs would change somewhat; however, data needed to project other cost changes besides transportation was not available. Transportation related expenditures represent approximately four percent of the Draper facility's $73.7 million budget.

The cost of providing prisoner transportation is directly related to the change in distance between the prison and the destination. Distances were modeled between potential new sites and each of the destination types: inmate placement program ("IPP"), board of pardons and parole ("BOPP"), court appointments (e.g. appeals, hearings, custody issues, etc.), medical needs, and assignment.

Two transportation scenarios were run. One compared the cost of providing transportation for Rush Valley as a replacement for the current Draper facility (Table S.1). This scenario resulted in a 30 percent cost increase. The second scenario assumed Draper would remain as the main prison facility and Rush Valley would be added as a third prison site (Table S.2). The cost of running a third site with a total of 10,000 beds (6,000 in Rush Valley and 4,000 in Draper) is less than a full location to Rush Valley but still higher than the same number of beds at Draper. See the operational cost analysis in Section 6 for additional detail.

Table S.1. Transportation Cost Comparison

Beds	Draper	Rush Valley	Difference from Draper	Percent Change from Draper
4,000	$3,767,192	$4,890,915	$1,123,722	30%
6,000	$5,515,635	$7,162,137	$1,646,502	30%
10,000	$9,012,521	$11,704,581	$2,692,060	30%

Note: Assumes all bed are filled to 95% capacity

Table S.2. Cost of 10,000 Beds As a Three Site Scenario

Location	Beds	Cost
Draper	4,000	$4,685,881
Rush Valley	6,000	$6,177,819
Total	**10,000**	**$10,863,700**

Note: Assumes all bed are filled to 95% capacity

SECTION I: SITE SUITABILITY ANALYSIS AND SELECTION

Preliminary site selection analysis was documented in the 2006 "Evaluation of the Feasibility of Relocating the Utah State Prison" study. This study included a high level analysis of the entire state. Several criteria were used in the evaluation. In order to be considered suitable, an area must:

- Have at least 30,000 people living within 30 miles;
- Be less than 30 minutes from a hospital with a full trauma center;
- Have access to potable water;
- Be less than 30 miles from a city with a reasonably-sized police department;
- Be less than 5 miles from a major state highway or interstate;
- Have land with less than 5 percent slope; and
- Not be federal land.

The 2006 study resulted in the identification of three areas that would be suitable for a new prison—Rush Valley in Tooele County, eastern Box Elder County and northeast Juab County. The following excerpts from the study summarize the reasons for the attractiveness of the various sites.

RUSH VALLEY

"The Rush Valley area of Tooele County is located in relatively close proximity to the existing prison location. This proximity maximizes the opportunity to retain existing employees and to continue to utilize the resources offered in Salt Lake County."[1]

EASTERN BOX ELDER COUNTY

"Proximity to major population centers and availability of suitable land augment the area's suitability. Relatively stagnant wages, slow economic growth and higher than average unemployment may provide some incentives to accept a relocated facility."[2]

NORTHEAST JUAB COUNTY

"This area is located relatively close to the existing facilities at Gunnison and may draw from the same labor pool, but proximity to the Wasatch Front and its attendant services make this area a highly suitable location for a full relocation. There is sufficient land that is distant from the most severe growth pressures of the Wasatch Front to remain out of the direct path of development."[3]

All of these areas are in rural counties distant enough from highly urbanized areas that they would not suffer from the same growth pressure that has beset the Draper facility. However, they are also near enough to urban areas that a prison could be staffed and maintained without undue difficulty.

The consultant team was asked to select a site from within the three areas identified in the 2006 study. This was done using a thorough process described below.

Site Selection Process

INITIAL STEPS

A geographic information system ("GIS") was used to analyze suitability of each parcel within the preferred areas identified by the 2006 study. Figure 1.3 shows a graphic depiction of the site selection process, which is explained in detail in the following pages. Digital parcel information was obtained from Juab, Tooele, and Box Elder Counties. The first step was to identify parcels over 500 acres and remove all other parcels from consideration. The Department of Corrections determined that 500 acres would be the minimum sufficient area needed to accommodate a new prison with room for expansion, all associated facilities, and required perimeter open space. The removal from consideration of all parcels less than 500 acres in size put the number of possible parcels at just over 600, including approximately 400 parcels in eastern Box Elder County, 115 parcels in Juab County and 94 parcels in Rush Valley.

The next step was to apply the seven criteria from the 2006 study to the 600 parcels mentioned above. This resulted in the removal of 293 parcels for a new total of 230 parcels. Figure 1.4 shows a map of the parcels in the three counties that are greater than 500 acres in size and that meet the seven criteria from the 2006 study.

NATURAL RESOURCES AND HAZARDS

After the base criteria was applied to the parcel data, the next steps included the elimination of parcels based on a few natural resource- and hazard-related criteria. Areas removed from consideration were subject to one or more of the following:

- Flooding by the Great Salt Lake;
- Wetland coverage; or
- Liquefaction.

Great Salt Lake floodplain data was obtained from the Flood Plain Management Services Study published by the U.S. Army Corps of Engineers and digitized by the Utah Automated Geographic Reference Center ("AGRC").[4] Wetlands data was produced by the U.S. Fish and Wildlife Service as part of the National Wetlands Inventory and digitized by the AGRC and Wikstrom. Liquefaction information was produced by the Utah Geological Survey and digitized by the Utah Geological Survey and Wikstrom. Liquefaction occurs during an earthquake when ground shaking causes water-laden sandy soils to liquefy. Soil then loses it's stability and behaves like quicksand, allowing buildings to sink or tilt and utility lines to break.

Figure 1.1*: Buildings Destroyed by Liquefaction in Niigata, Japan, 1964*

Figure 1.2*. Natural Gas Line Ruptured by Liquefaction in Grenada Hills CA, 1994*

SITE SELECTION PROCESS

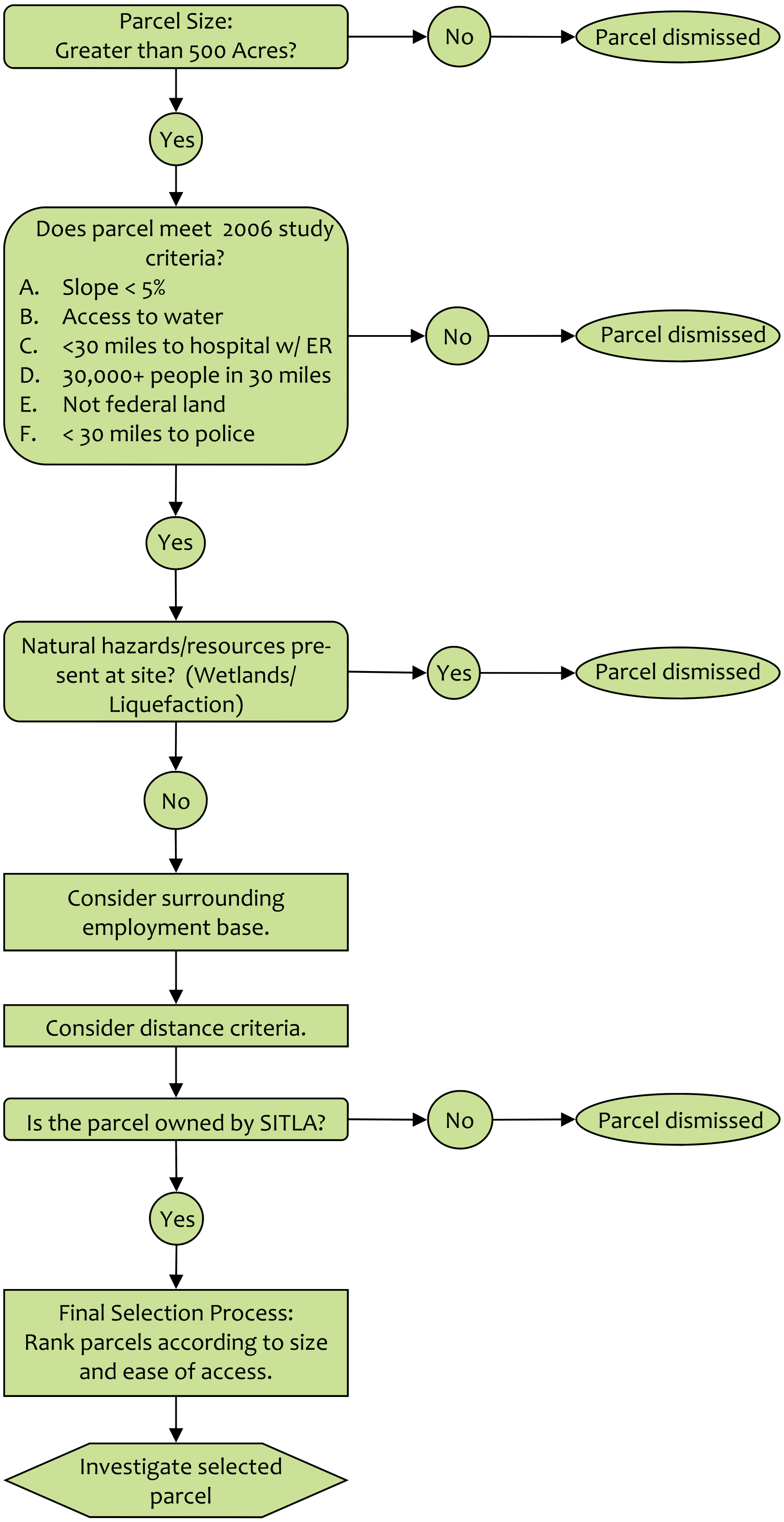


***Figure 1.3**: Site Selection Process*

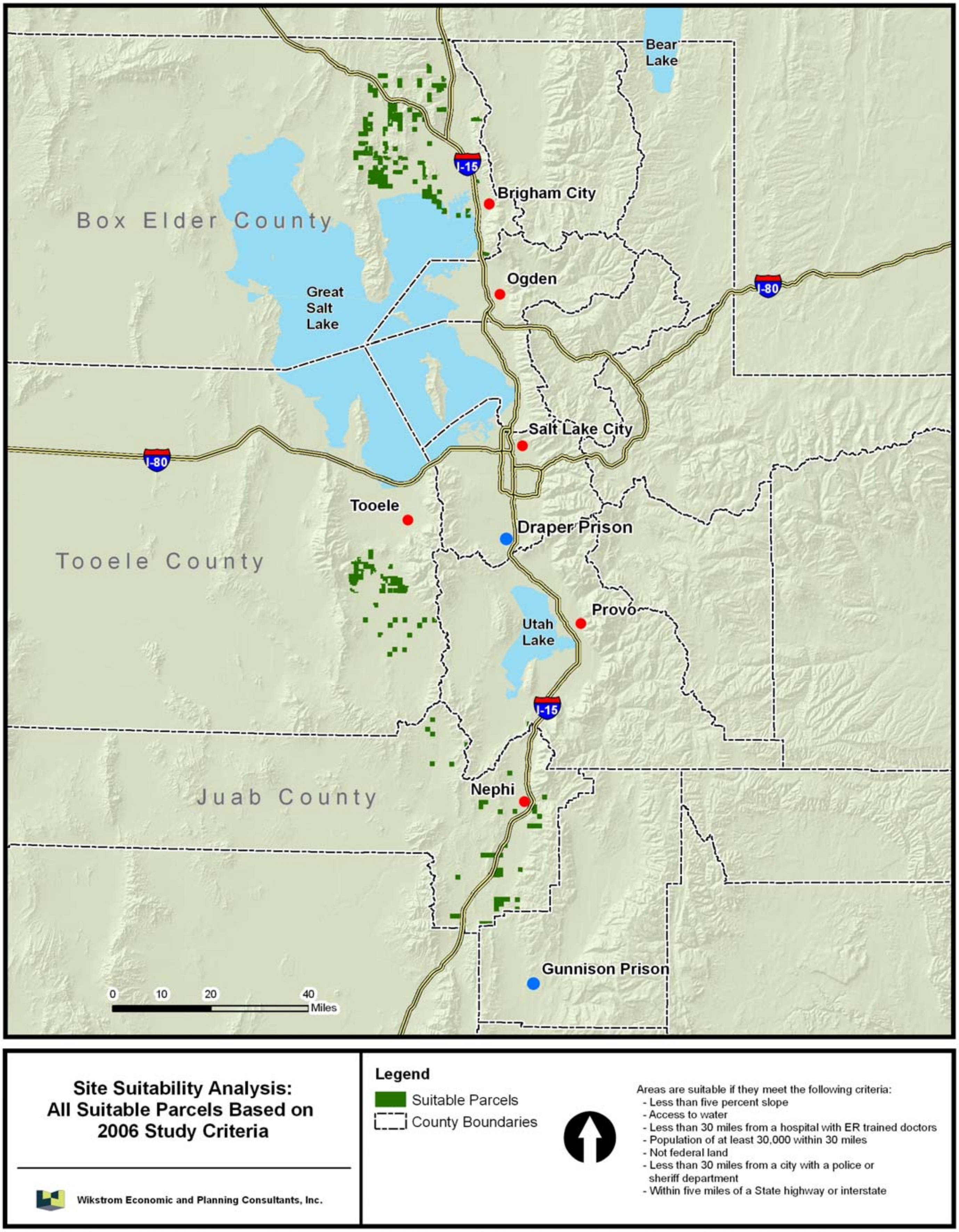

Bear Lake
I-15
Brigham City
Box Elder County
Ogden
Great Salt Lake
I-80
Salt Lake City
I-80
Tooele
Draper Prison
Tooele County
Provo
Utah Lake
I-15
Nephi
Juab County
Gunnison Prison
0 10 20 40 Miles
Site Suitability Analysis: All Suitable Parcels Based on 2006 Study Criteria
Wikstrom Economic and Planning Consultants, Inc.
Legend
Suitable Parcels
County Boundaries
Areas are suitable if they meet the following criteria:
- Less than five percent slope
- Access to water
- Less than 30 miles from a hospital with ER trained doctors
- Population of at least 30,000 within 30 miles
- Not federal land
- Less than 30 miles from a city with a police or sheriff department
- Within five miles of a State highway or interstate

Figure 1.4

Figure 1.5 shows a portion of southeast Box Elder County as an example of the application of the natural resource and hazard criteria. Wetlands, floodplain, and liquefaction potential cover much of what was considered suitable based on the high level criteria from the 2006 Study.

Figure 1.6 shows the 100 parcels still suitable after the application of the three new criteria listed above and some fine-grained adjustments for slope and other factors. The net effect of the new criteria was to substantially reduce the amount of suitable acreage in Box Elder County by removing all parcels within approximately 16 miles to the north Brigham City.

DISTANCE CRITERIA

After the application of all of the criteria discussed above, there still remained a substantial number of suitable parcels. The task then was to choose the best among them by comparing them to each other. Three important criteria were identified to further refine the selection process. These criteria included the distance to Salt Lake City courts, the distance to residential development, and the distance to a highway or freeway. These three criteria were then used to assign each parcel a rank allowing the best parcels to be identified.

Distance to Salt Lake City Courts

Figure 1.7 shows the suitable parcels and their distances in miles from the Salt Lake County District Court in Salt Lake City. This is the court most commonly used by the Department of Corrections. The distance from Salt Lake City is doubly important because the University of Utah Medical Center is also an important destination for the Department of Corrections, which sends prisoners to the Center for medical testing. The Department of Corrections contracts with the University of Utah Clinics and Hospitals to be its sole provider of specialty care, diagnostic testing and tertiary inpatient care (surgery, ICU, cardiac, etc). Because the University Medical Center is the sole provider for these services, it is important that a new prison be sited within a reasonable distance of the

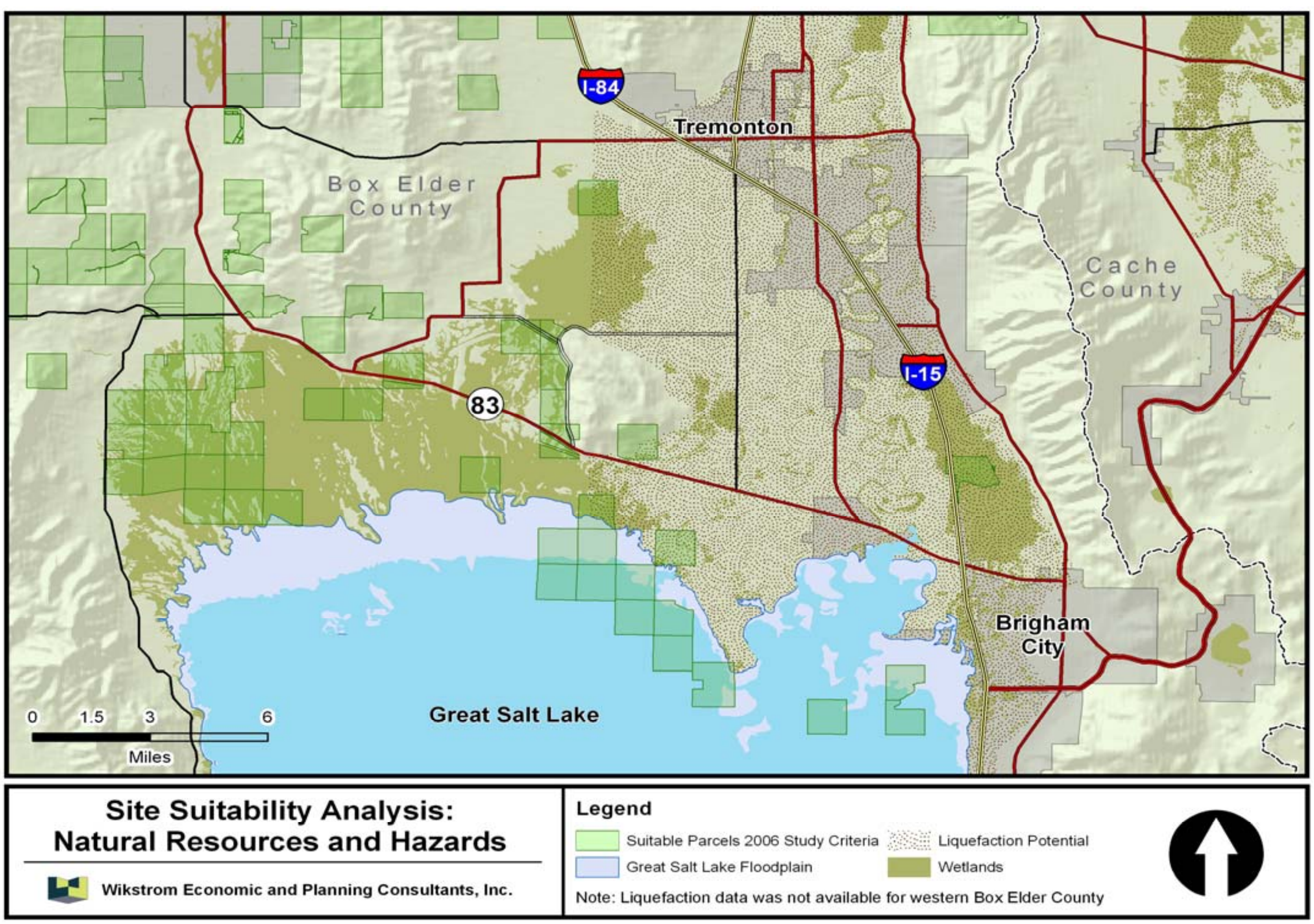
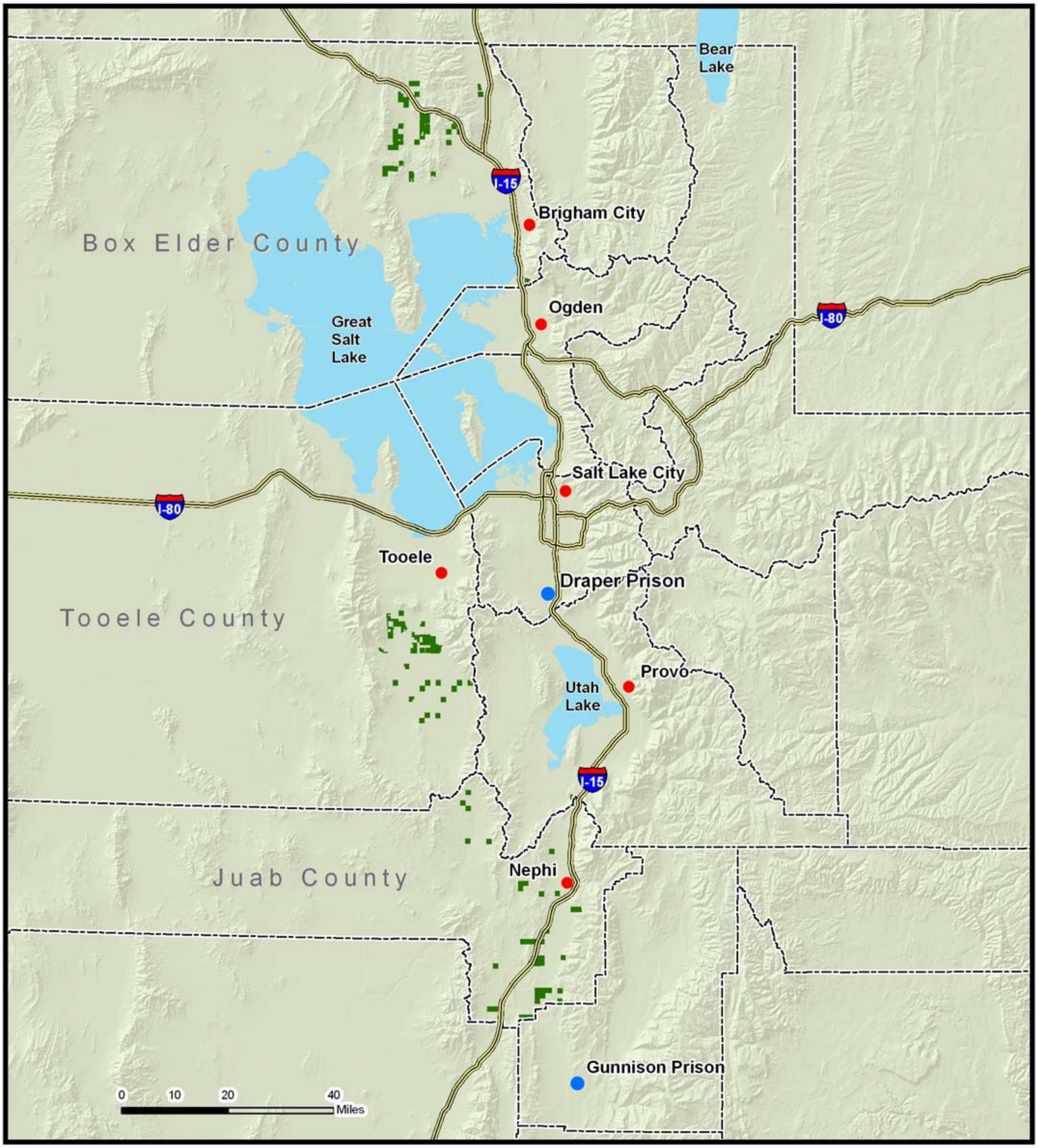


Figure 1.5



Site Suitability Analysis: All Suitable Parcels Based on 2006 Study and Additional Natural Resource and Hazard Criteria

Wikstrom Economic and Planning Consultants, Inc.

Legend

- Suitable Parcels
- County Boundaries

Areas are suitable if they meet the following criteria:
- Less than five percent slope
- Access to water
- Less than 30 miles from a hospital with ER trained doctors
- Population of at least 30,000 within 30 miles
- Not federal land
- Less than 30 miles from a city with a police or sheriff department
- Within five miles of a State highway or interstate
- Not covered by Great Salt Lake floodplain
- Not covered by wetlands
- Not subject to liquefaction

Figure 1.6

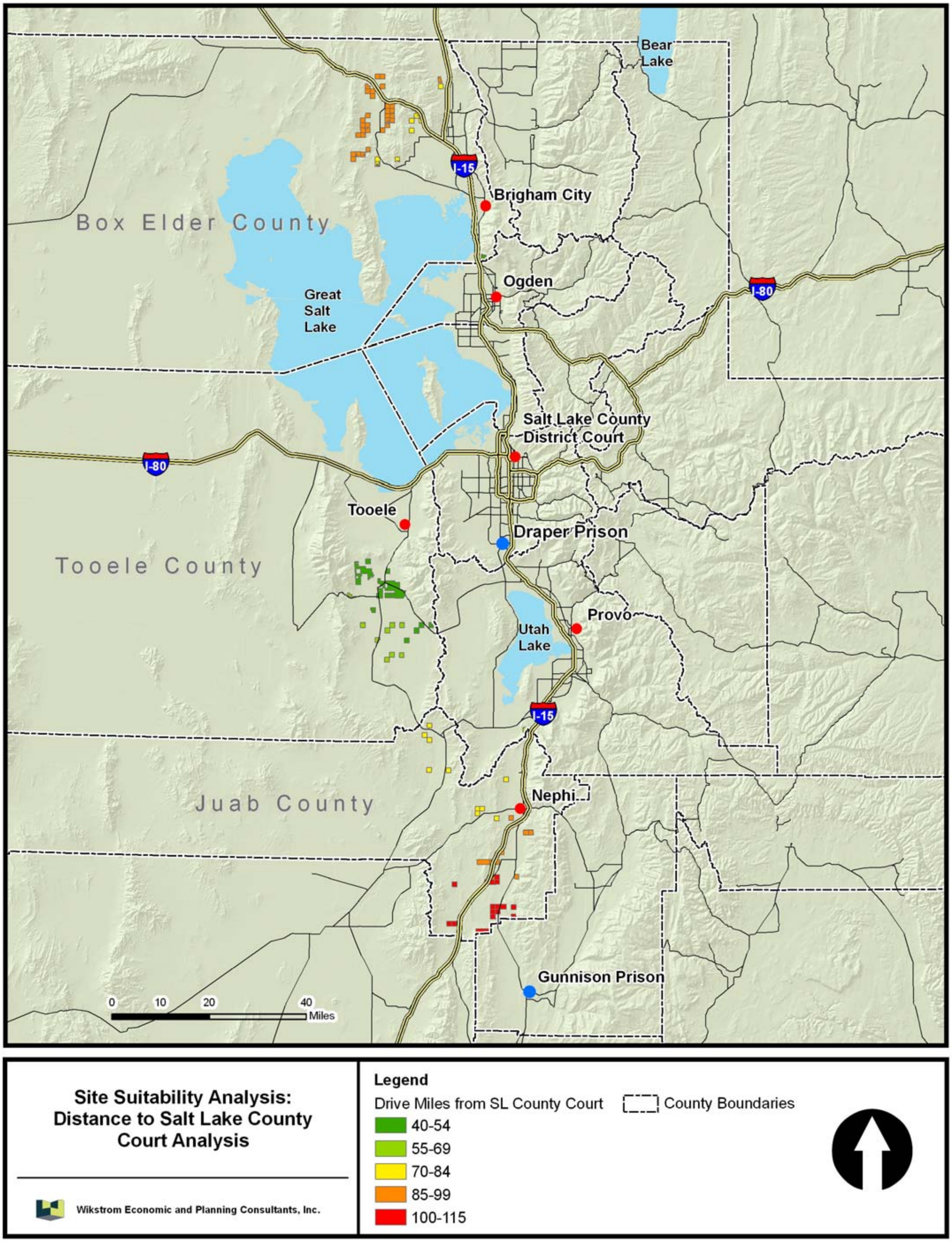

Bear Lake
I-15
Brigham City
Box Elder County
Great Salt Lake
Ogden
I-80
Salt Lake County District Court
I-80
Tooele
Draper Prison
Tooele County
Provo
Utah Lake
I-15
Juab County
Nephi
Gunnison Prison
0 10 20 40 Miles
Site Suitability Analysis: Distance to Salt Lake County Court Analysis
Wikstrom Economic and Planning Consultants, Inc.
Legend
Drive Miles from SL County Court
40-54
55-69
70-84
85-99
100-115
County Boundaries

Figure 1.7

facility. Currently the Department of Corrections assigns inmates who are more likely to need specialized medical care to the Draper site for ease of access to the University Medical Center.

Distance to Residential Areas

The relative isolation of the prison site is of critical importance when it comes to the relationship between the prison and its neighbors. Frankly, very few landowners would like to have a prison next door. There has been considerable political pressure on the State to move the Draper facility entirely in favor of uses more compatible with a large urban area. There are many reasons why a prison would be an unpopular use. In the case of Draper, the argument has been made that it is not an efficient use of urban land, which could be used for higher density commercial, employment, and residential uses to serve the entire area. In addition, nearby residents do not appreciate the light pollution, perceived security risk, negative stigma and unattractive appearance of a prison. Much like an airport, a prison is usually considered an undesirable use, affecting not just its immediate neighbors, but those for miles around. While airports have more obvious detrimental effects on nearby property, such as noise and building height limitations, a prison's impacts, such as bad aesthetics and stigma, are more subtle, but still real in the eyes of landowners, whether they be residents, business owners, or real estate investors. Given these considerations, it is easy to see why it would be advantageous to locate a prison as far away from existing population centers and neighborhoods as possible, while still being within a reasonable commuting distance for employees and visitors.

In order to compare the various site candidates by distance to existing population, land use data was obtained from the Utah Division of Water Resources, which keeps data identifying water-related land uses, including residential uses. This data was used to identify residential areas of all sizes. Residential areas were classified into three groups named Tier 1, Tier 2 and Tier 3. Tier 1 areas include communities with populations of 12,000 or greater. Tier 2 areas include communities between 3,000 and 11,999 persons and Tier 3 areas have fewer than 3,000 people. Table 1.1 shows the communities in the analysis area according to their classification and their area of influence—Box Elder County, Rush Valley, or Juab County. (Not all of the Tier 3 areas are included because they have no established names.) Communities are classified by their area of influence, not necessarily the area in which they are actually located. For example, Eagle Mountain is in Utah County, but it is listed under Rush Valley because it directly influences the potential sites in that area.

Table 1.1 Named Communities Influencing Distance to Residential Analysis

Area of Influence		
Box Elder County	**Rush Valley**	**Juab County**
Tier 1		
Brigham City	Eagle Mountain Tooele	Payson
Tier 2		
Perry Tremonton/Garland	Grantsville Stansbury Park	Delta Ephraim Manti Nephi Santaquin
Tier 3		
Bear River City Corinne Deweyville Elwood Honeyville Howell Plymouth Willard	Cedar Fort Fairfield Rush Valley Stockton Vernon	Eureka Fayette Fountain Green Levan Mona Scipio

The tier ranking system was used to account for faster growth of larger communities, which have more momentum in terms of rate of urbanization. In other words, it is generally true that growth occurs more rapidly surrounding larger communities than smaller communities. This is because larger communities have employment centers, infrastructure, retail centers, transportation networks, educational institutions and social connections, all of which people gravitate towards.

For the above reasons, location near a larger community should be considered more carefully than location next to smaller residential areas, where fewer people would be impacted by a prison. While it is important to locate near population centers for the convenience of prison operations and visitation, this consideration must be balanced with the need for a certain degree of isolation.

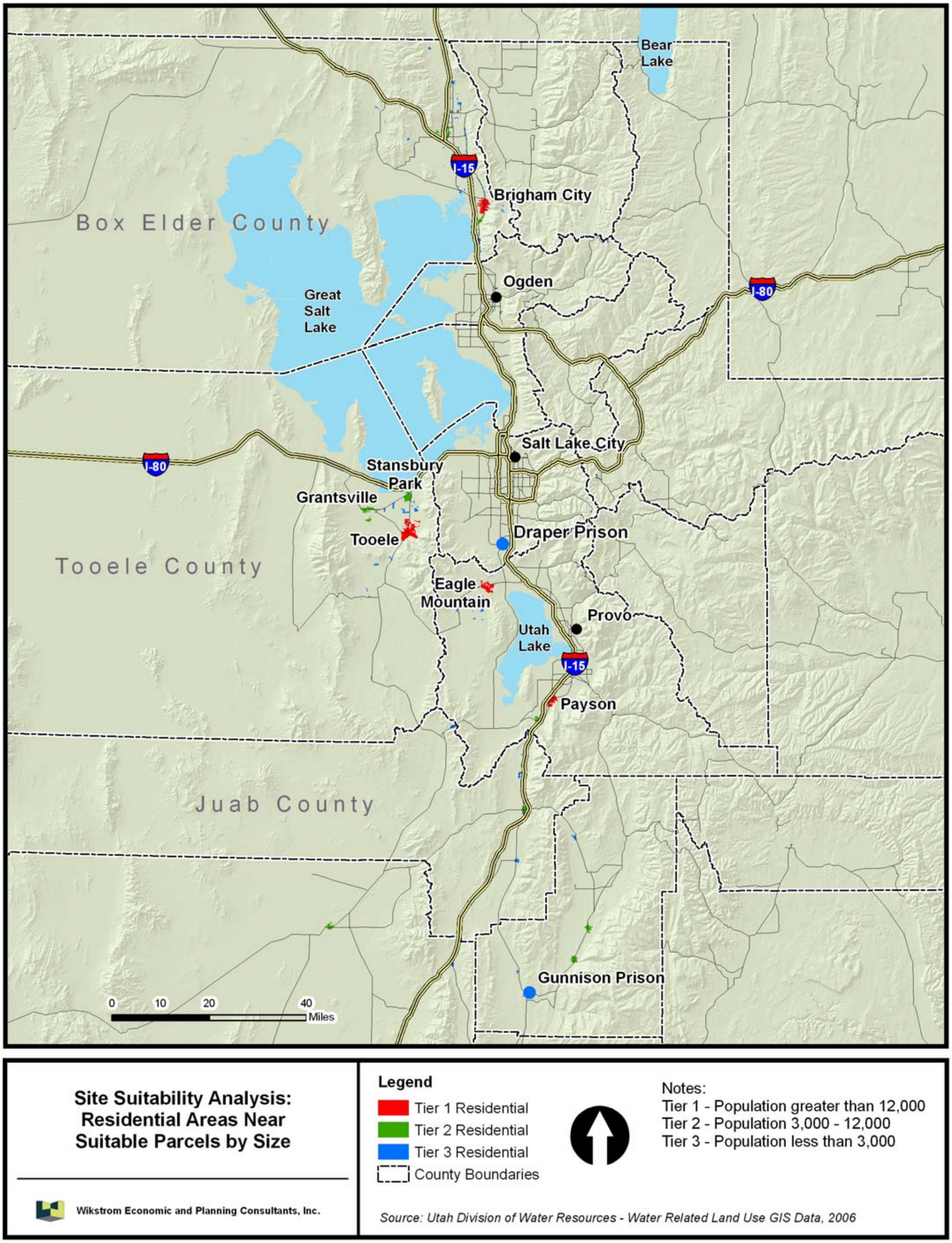

Bear Lake
Brigham City
Box Elder County
Ogden
Great Salt Lake
Salt Lake City
Stansbury Park
Grantsville
Tooele
Draper Prison
Tooele County
Eagle Mountain
Provo
Utah Lake
Payson
Juab County
Gunnison Prison
I-15
I-80
0 10 20 40 Miles
Site Suitability Analysis: Residential Areas Near Suitable Parcels by Size
Wikstrom Economic and Planning Consultants, Inc.
Legend
Tier 1 Residential
Tier 2 Residential
Tier 3 Residential
County Boundaries
Notes:
Tier 1 - Population greater than 12,000
Tier 2 - Population 3,000 - 12,000
Tier 3 - Population less than 3,000
Source: Utah Division of Water Resources - Water Related Land Use GIS Data, 2006

Figure 1.8

Distance to Highway or Freeway

The final distance-related comparison criteria was the candidate parcel's distance to a highway or freeway. The nearer a parcel is to a freeway or highway the easier it is to access and the less likely major road improvements would need to be made to access the prison complex. This measurement was done using a GIS analysis which automatically assigned each parcel a number representing the distance to the nearest highway or freeway.

Parcel Rankings

Parcels were ranked according to their relative suitability based on their distance to a major highway or freeway, their distance to residential areas (Tiers 1,2, and 3) and their distance to Salt Lake City, which is important because it is the location of the Matheson Courthouse and the University of Utah Medical Center, where inmates are sent for medical testing. The ranking system assigned a weight to each criterion and assigned a final score to each potential parcel. Figure 1.9 shows each criterion and its associated weight or, in other words, its relative importance. The chart is explained below.

50 percent of a parcel's score was based on its distance to Salt Lake City. The Department of Corrections feels that this criterion is of paramount importance due to the amount of prisoner transports to and from the University of Utah Medical Center and the amount of transports to Salt Lake County courts. Of all prisoner transports, roughly one quarter (about 5,700 trips in 2007) are transports to or from the Medical Center. The most common reason for transporting prisoners is for appearances at court (33 percent). State prisoners must make appearances at their courts of conviction. Nearly 40 percent of all prisoners were convicted in Salt Lake County, making it by far the most important county in terms of prisoner origination. (The next highest percentage is Weber County, which accounts for 20 percent of prisoners.) Because prisoner transport is a major expense it is important to minimize distance where possible. Because so many prisoners come from Salt Lake County it stands to reason that a new site should be as close as possible to the courts in Salt Lake City.

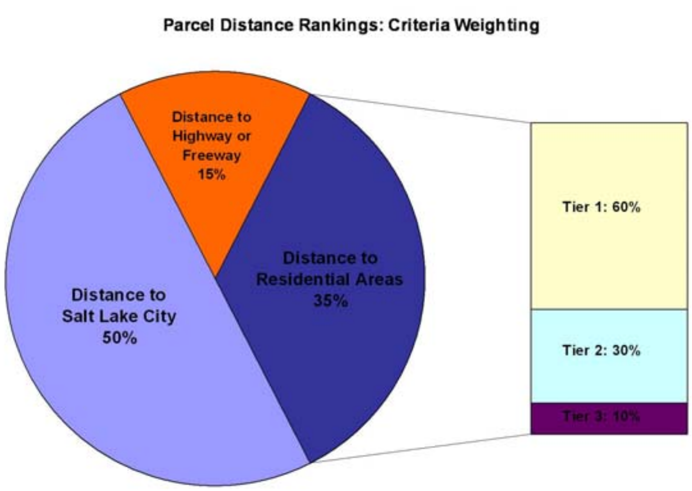


***Figure 1.9**: Parcel Distance Rankings*

35 percent of a parcel's score was based on its distance to residential areas. As mentioned before, it is important to avoid conflict with neighboring land uses as much as possible to minimize negative visual and other perceived impacts on neighboring property owners.

The Department of Corrections realizes that "nobody wants a prison in their backyard," hence this criterion's high weighting. This criterion is broken out into three tiers as mentioned previously. Tier 3 areas (the smallest) represent 10 percent of the "distance to residential areas" score. Tier 2 areas represent 30 percent, and Tier 1 areas (the largest) represent 60 percent. Tier 1 areas are most important because they have the most growth inertia; that is, they consume land more quickly as development occurs. A prison within a mile of a Tier 1 community has a greater danger of urban encroachment that if they were within a mile of a Tier 2 or Tier 3 community.

The last criterion—distance to highway or freeway—represents 15 percent of a parcel's total score. This access criterion further refines a similar criteria from the first study, which was that a feasible parcel must be located within five miles of a major highway or freeway.

A state prison sees a heavy amount of traffic and must be easily accessible. New roads can be built to access a site, but they are expensive—approximately $2 million per mile for a two land road according to Parametrix.

Figure 1.10 maps the results of the distance ranking analysis. The top ten sites are all located in Rush Valley.

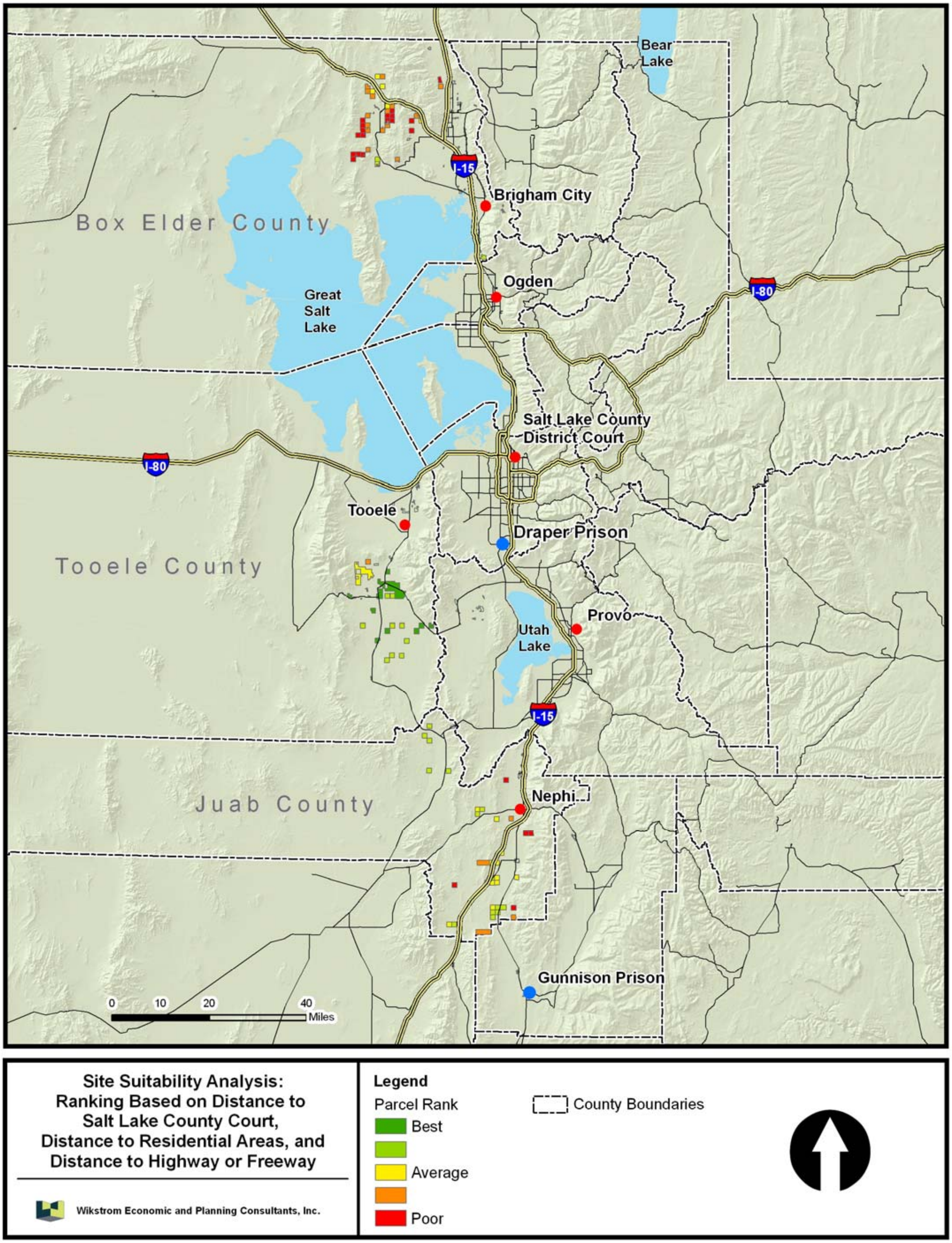

Bear Lake
I-15
Brigham City
Box Elder County
Ogden
I-80
Great Salt Lake
Salt Lake County District Court
I-80
Tooele
Draper Prison
Tooele County
Provo
Utah Lake
I-15
Nephi
Juab County
Gunnison Prison
0 10 20 40 Miles
Site Suitability Analysis: Ranking Based on Distance to Salt Lake County Court, Distance to Residential Areas, and Distance to Highway or Freeway
Wikstrom Economic and Planning Consultants, Inc.
Legend
Parcel Rank
Best
Average
Poor
County Boundaries

Figure 1.10

PROXIMITY TO EMPLOYMENT BASE

A 6,000 bed prison would require close to 2,000 employees. With such a high number of employees it is critical that the prison be located such that it can access a large labor pool. It is therefore useful to compare Box Elder County, Juab County and Rush Valley in terms of the size of labor pool within a reasonable distance. A comparison between probable commute areas for each proposed area was conducted to estimate the number of persons accessible under the GOPB's 2008 Sub-county Population Projections. In order to do this hypothetical sites were chosen in northern Rush Valley, southeast Box Elder County and Northeast Juab County. In addition to clarifying the general accessibility of each site to possible employees, the population analysis also gives an indication as to the availability of services, and accessibility to the visiting public.

Commute areas were defined based on two scenarios: travel distance and travel time. Thus, the area of land that could be reached with 30 minutes travel time, or conversely, within 30 miles of travel distance along the existing network of roads was used as a point of comparison for general accessibility of each of the three hypothetical sites. Six commute areas for each site were created to account for travel within 30, 60, and 90 minutes of the site and 30, 60, 90 miles of travel from each site. Commute areas were created through a GIS analysis of travel along the existing road network. Travel impedances were estimated conservatively for each major class of roads (i.e. Interstate Highways would experience average travel speeds of 65 mph and major arterials would allow average travel speeds of 45 mph).

The GOPB's sub-county projections are created for every municipality in the state and the remaining balance of population living within unincorporated areas of the counties. This information was used in conjunction with the existing municipal boundaries and unincorporated county lands to create a map of population density. This map was created by excluding public lands and lands not considered within a classification of land uses that assesses access to urban, residential or irrigation water facilities developed by the Utah Division of Water Resources. It is assumed these areas not excluded by the criteria above will accommodate the majority of future population growth. The boundaries of commute areas were then overlaid and the total population within these boundaries calculated.

The table below shows that Rush Valley is the most accessible site in terms of the overall population both now and in the future. This is particularly true for the 30 minute/30 mile and 60 minute/60 miles commute area boundaries, where most employees will come from. The Rush Valley site has the advantage of having nearly two and a half times as many people within a 60 minute commute as the Box Elder County site and four and a half times as many as the Juab County site.

The Rush Valley area is within a half hour commute of several communities including Tooele, Grantsville, and Stansbury Park as well as the sparsely populated area to the south that includes Rush Valley and the extreme western portion of Utah County. An hour’s commute time opens up the accessible area considerably and includes all of the area along the Wasatch Front from Bountiful in Davis County to Lindon in Utah County.

Table 2. Projected Population within Service Areas (Designated by Travel Time and Distance) 2010 and 2020

		2010			2020		
		30	**60**	**90**	**30**	**60**	**90**
Distance (Miles)	Box Elder County	45,000	613,000	1,374,000	53,000	739,000	1,610,000
	Juab County	46,000	505,000	1,656,000	71,000	633,000	2,043,000
	Rush Valley	**124,000**	**1,693,000**	**2,327,000**	**174,000**	**2,032,000**	**2,839,000**
Time (Minutes)	Box Elder County	19,000	553,000	1,672,000	22,000	664,000	1,960,000
	Juab County	20,000	301,000	1,442,000	31,000	383,000	1,783,000
	Rush Valley	**42,000**	**1,381,000**	**2,288,000**	**60,000**	**1,682,000**	**2,780,000**

Source: Wikstrom, Governor's Office of Planning and Budget

SITLA SELECTION

A final criterion for selection was that the property be owned by the state of Utah, and specifically by the School and Institutional Trust Lands Administration ("SITLA") for ease of acquisition. An internal transaction between SITLA and the Department of Corrections would ensure the best outcome for the state. SITLA has provided detailed data regarding the selected site, but has not yet been formally approached regarding a potential transfer of ownership.

By excluding all non-SITLA land the number of candidate sites was reduced drastically from 100 to 15. There were no SITLA parcels in Box Elder County that met the necessary criteria and only two SITLA parcels in Juab County met the criteria. Only one of the Juab County sites was reasonably accessible in comparison with other candidate sites. The remaining 13 parcels were located in Rush Valley.

FINAL SELECTION

When considering all of the distance factors, the availability of SITLA land and the number of employees within the reach of the various areas (Box Elder County, Juab County, and Rush Valley) the weight of preference falls squarely on Rush Valley. Figure 1.11 shows a close-up of the five top ranked sites, which are all located in Rush Valley. (These sites scored closely enough that the scoring differential between them is immaterial.) Any of these five sites could potentially accommodate a prison, however, the selected site (site A on the map) is the best for two main reasons. It is by far the largest, and it is the most accessible.

Parcel Size

A larger parcel is beneficial for a few reasons. First, it allows more flexibility for facility expansion and placement. Second, it allows for utilization of sustainable technologies, such as irrigated land for disbursement of treated wastewater. Third, a large site allows for adequate water pressure to serve the facilities without the construction of water towers, which are more expensive to build and operate than ground-level storage tanks. The large site thus allows both significant elevation change, which allows the site to be self sustaining in terms of water usage, and a gentle slope with minimal topography (important for security reasons). In the case of the preferred site wells can be placed on the eastern edge of the site, creating pressure for use at the prison complex further to the west. Wastewater can then be gathered, treated, and stored for use on irrigated farmland onsite to the west of the main prison building. This farmland can be worked by lower security prisoners. All of this would not be possible on smaller sites in Rush Valley. An additional benefit of having an extraordinarily large site is that unused land can act as a buffer between neighboring land and the prison complex, thus reducing the negative impact of a prison.

Accessibility

The selected site (A) is most preferable in terms of accessibility because of its location at the intersection of two highways running into the valley from Tooele and from Utah County. Of the final candidates, it strikes the best balance between accessibility for employees and being located a comfortable distance from residential areas. The preferred site also benefits from having a low-traffic highway bisect the site. This road, although public, could essentially act as an internal road, allowing fast and easy access to multiple separate facilities on the site such as the men's prison, the women's prison, water tanks, irrigated land, wastewater treatment facilities, and others.

Site B has three problems. First, it is closer to the town of Rush Valley than the preferred site. Second, railroad tracks run between the usable portion of the site and highway 32, which would be used to access the site. Third, the site has some topography that could be a security issue.

Site C is located nearly a mile from Highway 32, necessitating the construction of an access road (which would cross railroad tracks) at a cost of roughly $1.8 million. Additionally, Site C would be a much farther drive coming from either Tooele or Utah County.

Site D is closer to the employment base in Utah County, but farther from Tooele, the likely future location of many prison employees. Site D also suffers from an irregular shape, which includes an odd island of BLM property in the middle of the parcel. A final drawback to Site D is that it sits squarely in the middle of the Five Mile Pass Recreation Area, a popular ATV recreation area managed by the Bureau of Land Management.

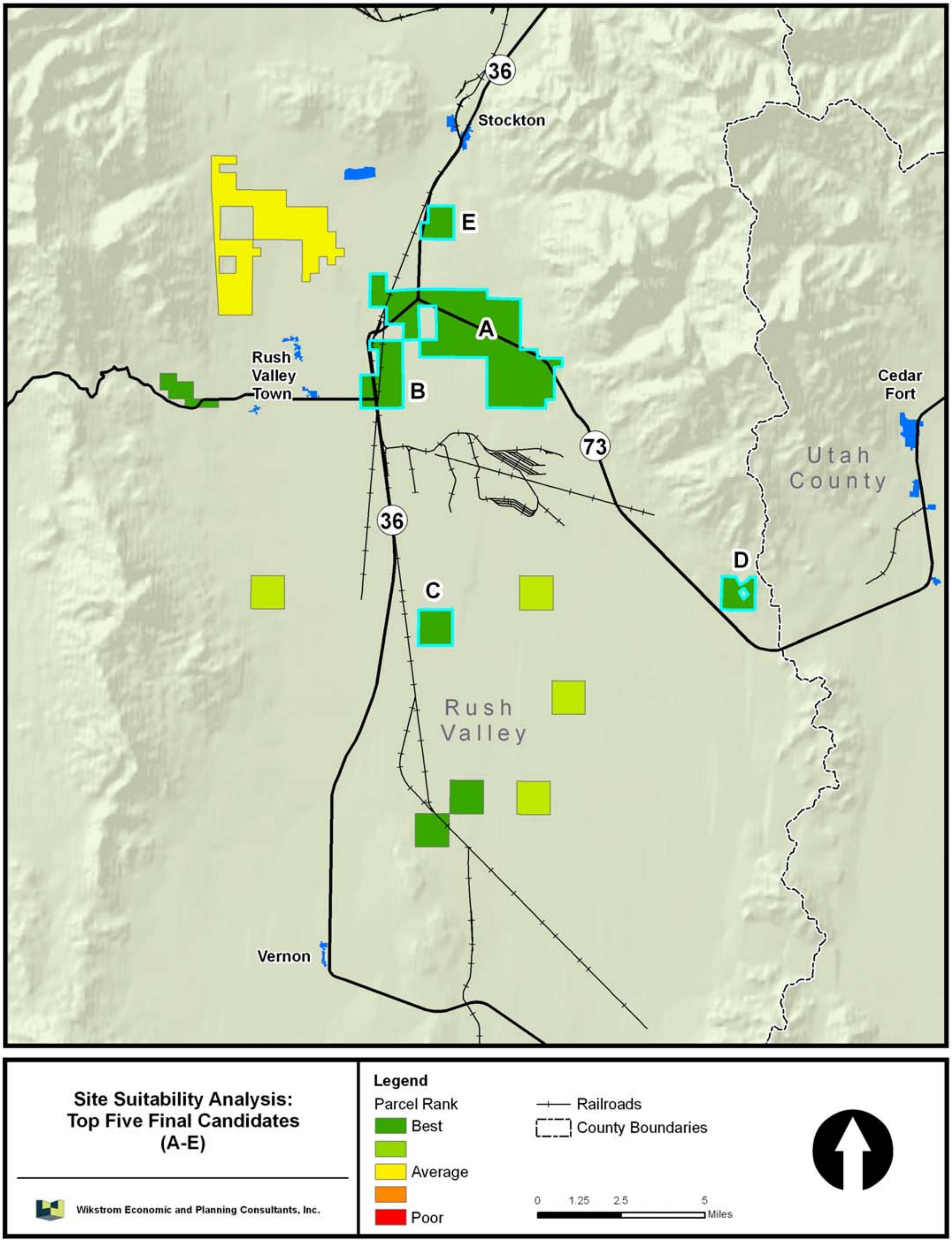

36
Stockton
E
A
Rush
Valley
Town
B
Cedar
Fort
73
Utah
County
36
D
C
Rush
Valley
Vernon
Site Suitability Analysis:
Top Five Final Candidates
(A-E)
Wikstrom Economic and Planning Consultants, Inc.
Legend
Parcel Rank
Best
Average
Poor
Railroads
County Boundaries
0 1.25 2.5 5
Miles

Figure 1.11

Site E is closer to Tooele, but farther away from Utah County. Site E is also uncomfortably close to the small town of Stockton.

SELECTED SITE

PROPERTY LOCATION

The selected site is located in Rush Valley, which is a very sparsely populated area south of the city of Tooele. The site itself is about nine and a half miles south of Tooele. There are three small municipalities in the valley: Rush Valley, Stockton, and Vernon. The valley has a population of roughly 1,600 people according to estimates published by the Tooele County Planning and Economic Development Division. The closest town is Rush Valley, the residential areas of which are about 3.5 miles from the site in a straight line. Distance along roads would be approximately 5.5 miles. The next closest town to the site is Stockton, the residential areas of which are about 4.5 miles north (travel distance) from the site. To the south the site borders the Deseret Chemical Depot, which is discussed later in the Property Investigation section. Figure 1.12 is a photograph of the property taken from Highway 73 looking east.

Figure 1.12

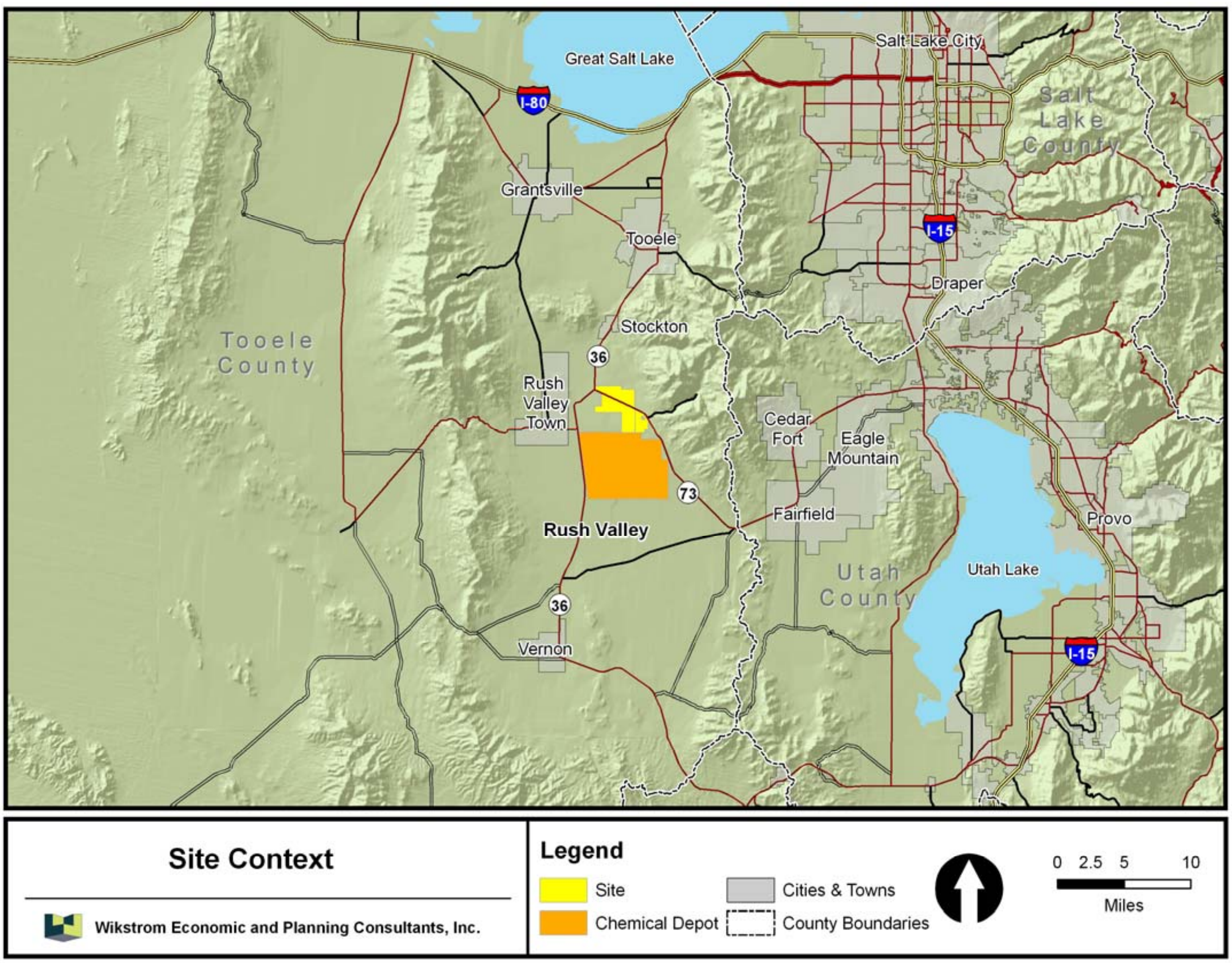


Figure 1.13

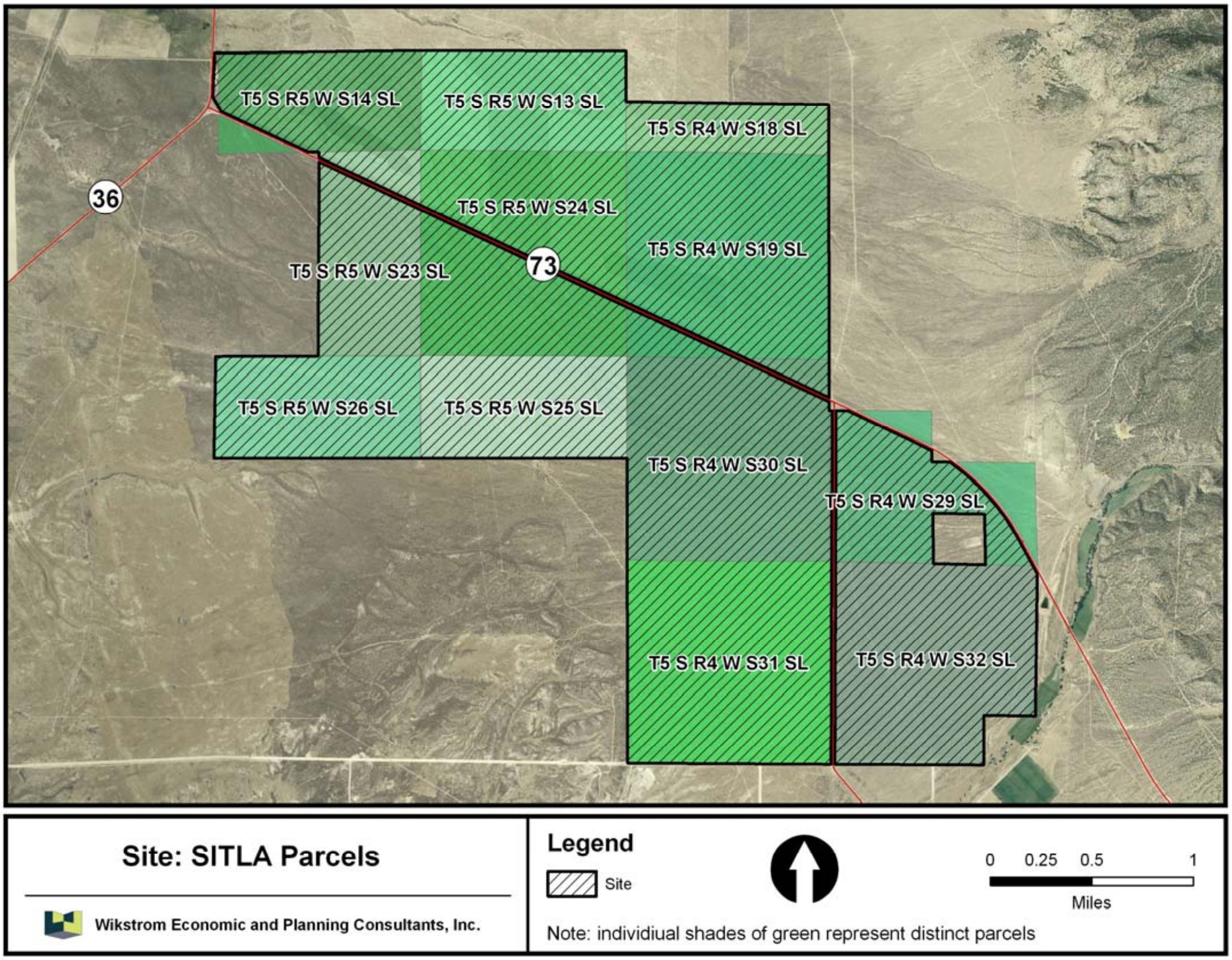


Figure 1.14

Figure 1.13 shows the site in a regional context. The map brings into sharp focus the locational benefit of the site, which is the fact that it is close to the State's largest employment base, yet located in a very rural location surrounded by natural barriers.

The property itself if owned by SITLA, which parcels its land according to a geographical system that includes townships ranges and sections. Figure 1.14 shows the individual parcels within the defined site. All but two of the parcels shown fall completely within the site. Table 3 contains a detailed description of the site in its entirety. It is composed of 12 distinct parcels and contains approximately 5,161 acres.

Table 3. Parcels Identified for Prison Site

Parcel ID (Township, Range, Section, Meridian)	Legal Acres Entire Parcel	Estimated Acres Within Site for Partial Parcels	Portion Included in Site
T5 S R5 W S14 SL	320.00	287	Portion north of SR-73
T5 S R5 W S13 SL	320.00		All
T5 S R4 W S18 SL	160.10		All
T5 S R5 W S23 SL	320.00		All
T5 S R5 W S24 SL	640.00		All
T5 S R4 W S19 SL	640.02		All
T5 S R5 W S26 SL	320.00		All
T5 S R5 W S25 SL	320.00		All
T5 S R4 W S30 SL	640.16		All
T5 S R4 W S29 SL	360.00	274	Portion south of SR-73
T5 S R4 W S31 SL	640.35		All
T5 S R4 W S32 SL	600.00		All
Total Acreage		**5,161**	

Source: SITLA, Wikstrom

Property Investigation

The Utah School and Institutional Trust Lands Administration ("SITLA") was interviewed in September of 2008. SITLA indicated there were no water rights associated with the subject property.[5] It was not aware of any problems associated with the property that could inhibit construction of buildings. SITLA allows grazing on some properties by permit; however, these permits can be revoked simply by giving 30 days notice to the permit holder. The property is not currently being leased to any organization. As mentioned previously, as of the publication of this document SITLA has not been formally made aware of the Department of Corrections' interest in the selected site.

Water

As part of the site selection process a preliminary analysis of water availability and quality was performed. A detailed discussion of water availability and quality is given in Section 3 of this report. In summary, the water available at the selected site is normal and would require no unusual treatment in order to make it potable.

Substantial water rights would need to be purchased in order to locate a prison in Rush Valley. The challenge in this case is that Rush Valley is a closed basin; new water rights in the magnitude needed for a prison cannot be issued by the State, but must be purchased from current owners. According to research done by Wikstrom and Stantec, the DOC could expect to pay between $10,000 and $15,000 per acre-foot. Using an average of $12,500 per share, the price for water rights for a 6,000 bed facility would be approximately $9.6 million.

Infrastructure

A fiber optic line runs along Highway 73. A natural gas line with sufficient capacity to serve the prison also parallels Highway 73. Rocky Mountain Power intends to run a major new power corridor through Rush Valley in the next few years. The corridor would provide sufficient power and redundancy to the site.

Deseret Chemical Depot

The Deseret Chemical Depot is located immediately to the south of the site on a plot of land nearly 20,000 acres in size. There are two main access roads to the Depot—one on the north and one on the east. As shown on Figure 1.15 the northern access road travels through the selected site for about 1.75 miles before reaching the Chemical Depot property.

The depot has stored chemical weapons since the 1940's and has been destroying the weapons since 1996. In 1997 the United States agreed to destroy all its chemical weapons by 2007, but in 2007 the goal was far from achievement. In April of 2006 the Organization for the Prohibition of Chemical Weapons granted a five-year extension for the U.S. to destroy all chemical weapons.[6] The Deseret Chemical Depot is ahead of this schedule and anticipates the destruction of all its chemical weapons by August of 2011, at which time the closure process will begin.[7] While the Deseret Chemical Depot is on schedule to meet the 2012 deadline, other facilities in the U.S. are not. A congressional mandate that all chemical weapons be destroyed by 2017 triggered a response from Pentagon that this could only be done by transporting chemical weapons.[8] This has fueled speculation that additional weapons could be brought in from other states to be incinerated at the Deseret Chemical Depot; however, this is highly unlikely because transportation of chemical weapons is politically unpopular and currently against federal law.[9] In addition, the 2005 Base Closure and Realignment Report stated, "there is no additional chemical demilitarization workload slated to go to Deseret Chemical Depot."[10] It appears the Deseret Chemical Depot will cease operations well before a new prison would begin operating.

After the Deseret Chemical Depot has closed the Depot property will continue to be used by the U.S. Army as a storage facility for conventional weapons. In fact, the Tooele Army Depot has already started using a portion of the site for conventional weapons storage.[11] In 2005 the Defense Base Closure and Realignment (BRAC) Commission made some recommendations affecting the Tooele Army Depot and Deseret Chemical Depot. First, BRAC recommended the Deseret Chemical Depot be closed and that its storage buildings be used by the Tooele Army Depot. Second, BRAC recom-

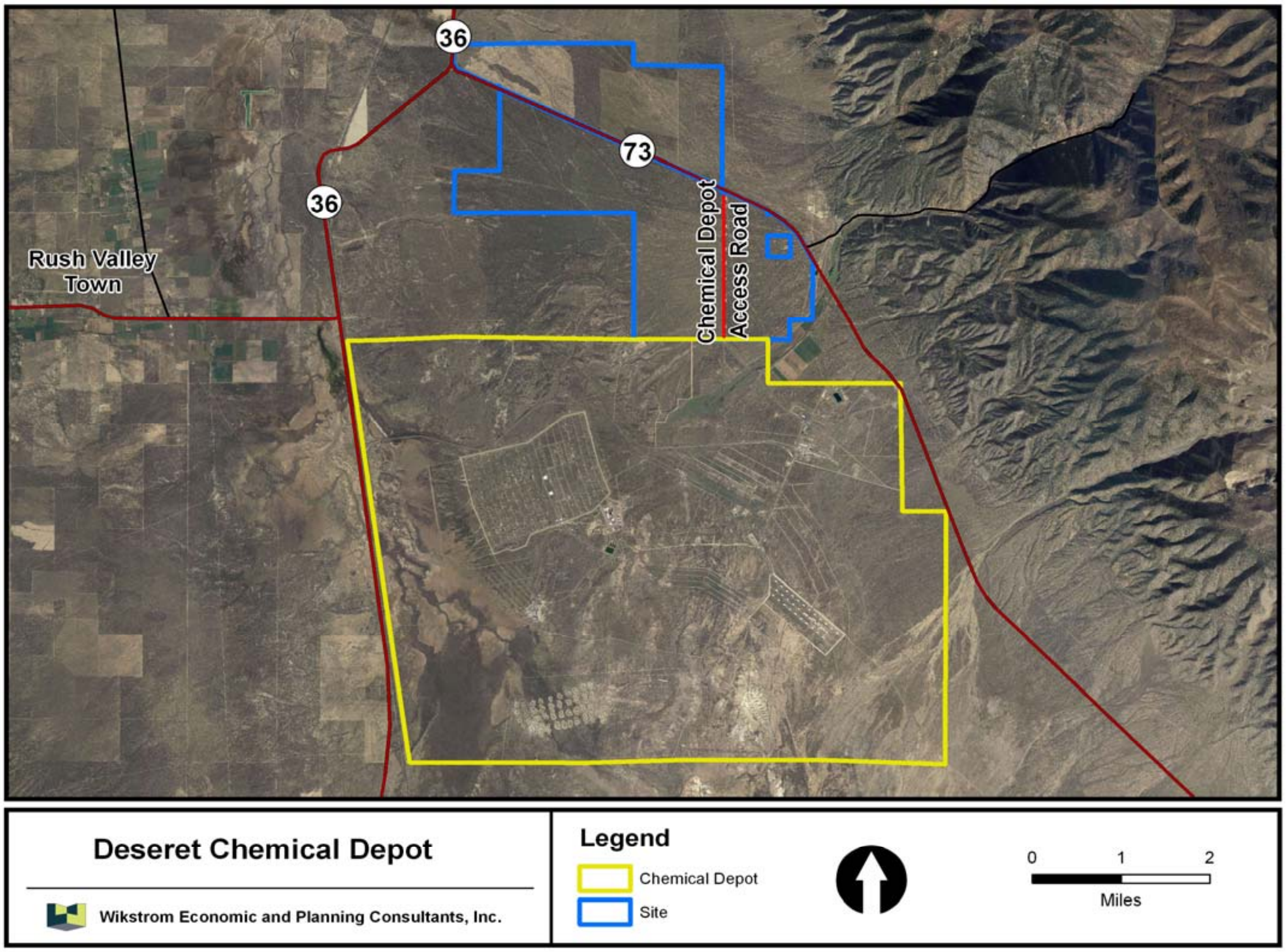


Figure 1.15

mended weapons storage operations from two facilities (Sierra Army Depot, CA and Hawthorne Army Depot, NV) be relocated to the Tooele Army Depot to increase efficiency.[12] BRAC's actions seem to indicate the Tooele Army Depot is increasing in importance and that the current Deseret Chemical Depot site will be used as a conventional weapons storage facility for a long time to come.

Land Use Regulations

The State is not bound by local land use regulations; however, local land use regulations can be helpful in identifying potential issues and hazards that may arise with development. Some communities have enacted laws to mitigate impacts of neighboring hazardous uses. For example, West Valley City enacted an "Overpressure Zone," which requires new construction within a certain radius of the ATK Launch Systems complex to use windows strong enough to withstand shock waves and fragments. The Tooele County Planning and Zoning Division was contacted and asked if there were any special regulations for building next to the Deseret Chemical Depot or the Tooele Army Depot, which has begun using the Deseret Chemical Depot's empty storage buildings for conventional weapons storage. The Division responded that there were no special regulations for building next to either the Deseret Chemical Depot or the Tooele Army Depot.[13]

SECTION I - FOOTNOTES

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[2] State of Utah. Division of Facilities Construction and Management, Department of Administrative Services, Department of Corrections. *Evaluation of the Feasibility of Relocating the Utah State Prison*. Salt Lake City. 2006.
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[4] United States. Army Corps of Engineers Sacramento District. *Great Salt Lake Flood Plain Management Services Study*. 1997.
[5] Burton, Kay. SITLA. personal interview. 12 September, 2008.
[6] U.S. Army Chemical Materials Agency. *Tooele Deseret Chemical Depot.* Aberdeen Proving Grounds Edgewood Area, Maryland.
[7] Blauser, Amy. Tooele Chemical Stockpile Outreach Office. personal Interview. 9 September, 2008.
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[9] Grieser, Alaine. Deseret Chemical Depot Public Affairs. personal interview. 15 September, 2008.
[10] United States. Department of Defense. *Base Closure and Realignment Report*. May 2005.
[11] Grieser, Alaine. Deseret Chemical Depot Public Affairs. personal interview. 15 September, 2008.
[12] United States. Department of Defense. *Base Closure and Realignment Report*. May 2005.
[13] Hilderman, Matthew. Tooele County Planning and Zoning Division. 12 September, 2008.

SECTION II: ARCHITECTURAL PLANNING

METHODOLOGY

This study is based on an initial prison population of approximately 6,000 and a final population of approximately 10,000. Initial discussions were conducted with Utah Department of Corrections (UDOC) representatives to determine the gender mix and management segregations for each of those population totals. Based on those discussions, it was determined that the gender targets would be 5,000 male beds and 1,000 female beds for the first phase and linear extension of those counts for the second phase. Phase one represents a complete replacement of the existing facilities in Draper. Phase two represents estimated population growth over the 50 to 100 year life of a new facility.

A conceptual building program has been developed to determine the scope of the two phases of the project. The determining factor to develop the program is the number of secure beds served, which leads to the amount of support, both secure and non-secure, administration, and program spaces necessary. Once the bed counts are established, the management segregation and housing type can be determined and a housing scenario can be developed.

HOUSING CONFIGURATION

The basic housing planning modules used for the study are the 192 bed cell module and the 288 bed dorm module currently being utilized in the expansion at the Gunnison site. The 192 module consists of 6 units, each comprised of 16 double-bunked cells and supporting outdoor recreation space (Figure 2.1). The 288 module is comprised of 6 units, each with 4 – 12 bed dorm cells and an exercise room (Figure 2.2). Application of the 192 versus the 288 module is based on management segregation requirements. UDOC uses Levels 1 through 5 to describe the behavioral characteristics of the inmate population, where Level 1 are the least manageable and present the highest risk to staff, other inmates and themselves, and Level 5 is the lowest risk. Level 1 inmates have the fewest privileges and are held in the closest confinement, while Level 5 inmates have greater privilege and live in less confinement. Thus, Levels 1, 2 and some 3's are housed in cells. The rest of the 3's, Level 4 and Level 5 inmates are housed in dorms.

Housing modules are grouped by fours into housing complexes, with support spaces common to all housing forming a core around which the modules are arranged. A housing complex is best suited for a single management segregation or segregations that are closely aligned. For example, Level 1's and 2's are often considered together, and although inmates of those two levels would not cohabitate in a housing unit, they might share a module, and would certainly be acceptable as individual modules within a complex. Thus, the 192 and 288 modules can be arranged in any combination to form housing complexes that provide the right segregation mix for the intended population (Figure 2.3).

In addition to the General Population Housing, counts for residential medical beds, mental health beds and administrative segregation were added to the totals to establish a total bed count. For the sake of this study these beds are illustrated within the 192/288 module parameters. It is likely that some of this population's housing, particularly residential medical and acute mental health, would be organized somewhat differently than illustrated. However, for the purposes of establishing the amount of site needed for the proposed facility and estimating costs, the 192/288 modules provide a reasonable approximation.

Once the gross bed counts were established, the populations were divided utilizing management segregations based on existing UDOC standards. Those break downs are described in Table 2.1.

Utilizing these guidelines, the bed count for each gender population was distributed into appropriate management segregations and housing types mathematically. These raw calculations were then adjusted to match the bed count of the basic unit of the assigned housing type. For example, single bunked cells occur in 16 bed units, double bunked cells occur in 32 bed units and dorms in 48 bed units.

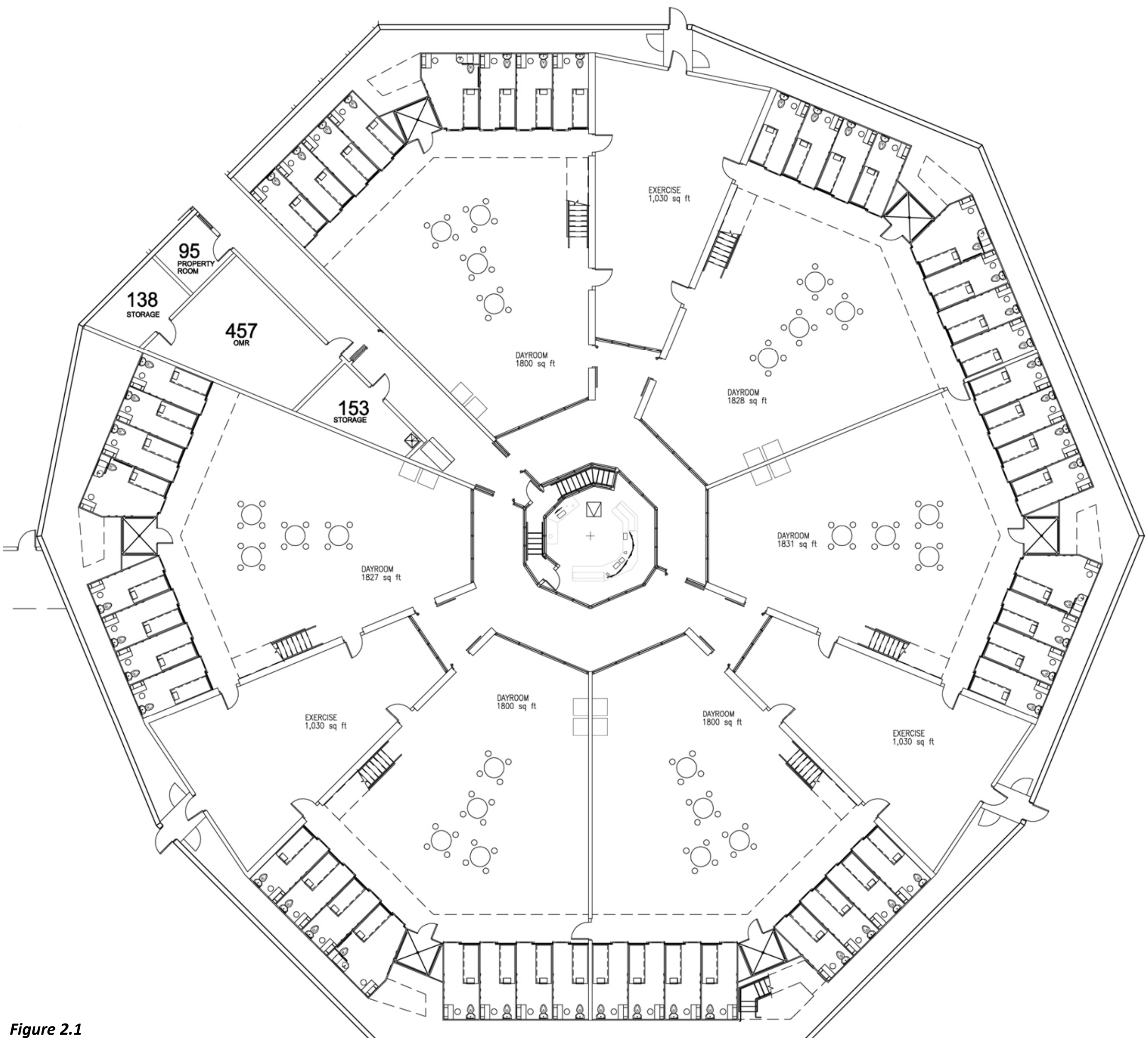


Figure 2.1

Table 2.1						
Male:	**% of Total**	**Housing Unit Type**	**Female:**	**% of Total**	**Housing Unit Type**
Level 1	20%	Cell/192 Module	Level 1	5%	Cell/192 Module
Level 2			Level 2		
Level 3	40%	Cell/192 50% Dorm/288 50%	Level 3	95%	Dorm/288 Module
Level 4	20%	Dorm/288 Module	Level 4		
Level 5			Level 5		

The next step in the process was to aggregate the units into modules. Each prototypical housing module is comprised of 6 units of either cells or dorms. In general, it is not good practice to mix populations within a module, so we would not allow a module to contain four units of Level 1 & 2 inmates and two units of Level 3 inmates. Thus, the bed counts were adjusted again to reflect the module configurations. Note that there are specific instances where separate populations are allowed to share the same module, specifically Intake/Classification with Mental Health Observation.

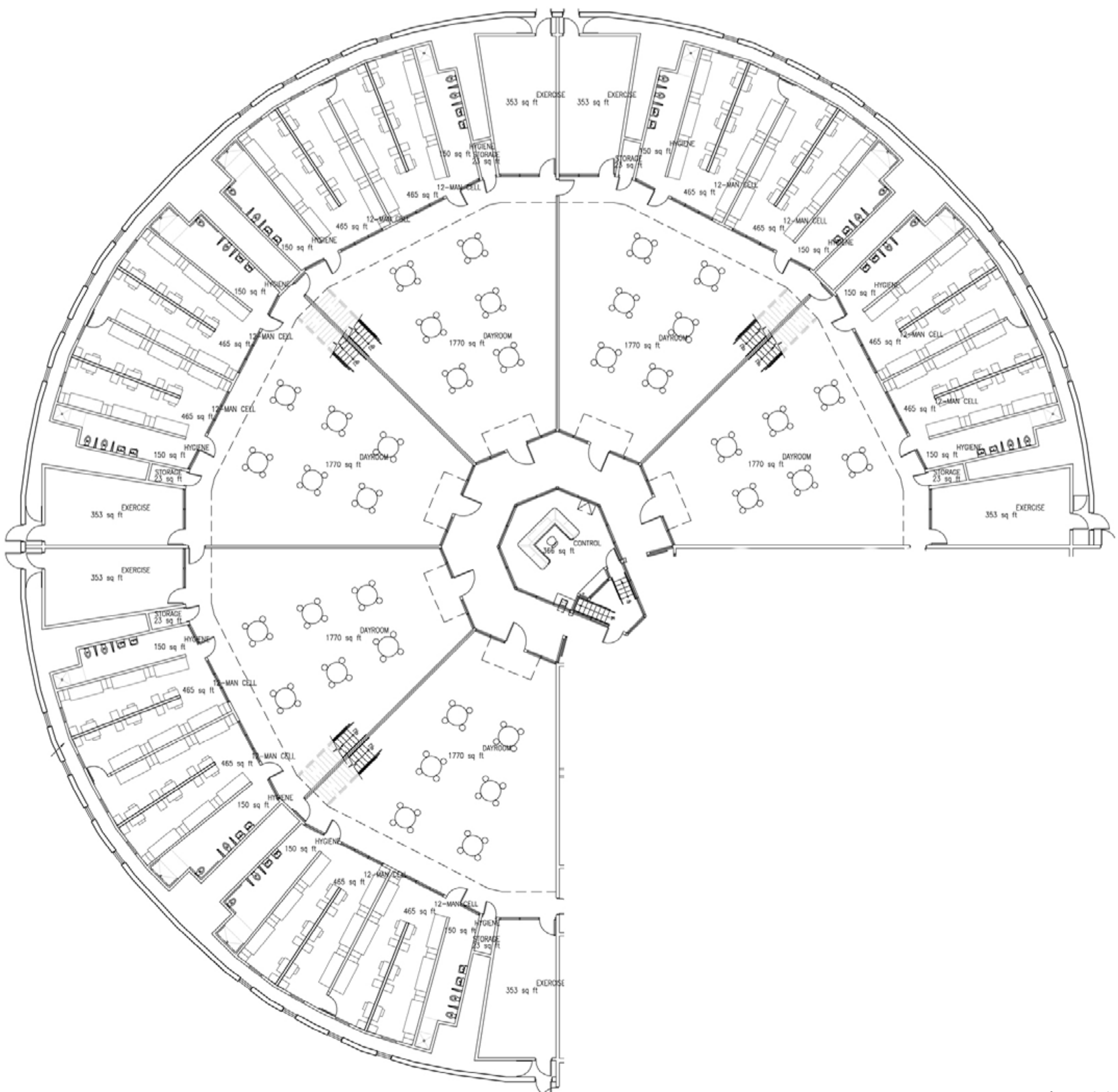


Figure 2.2

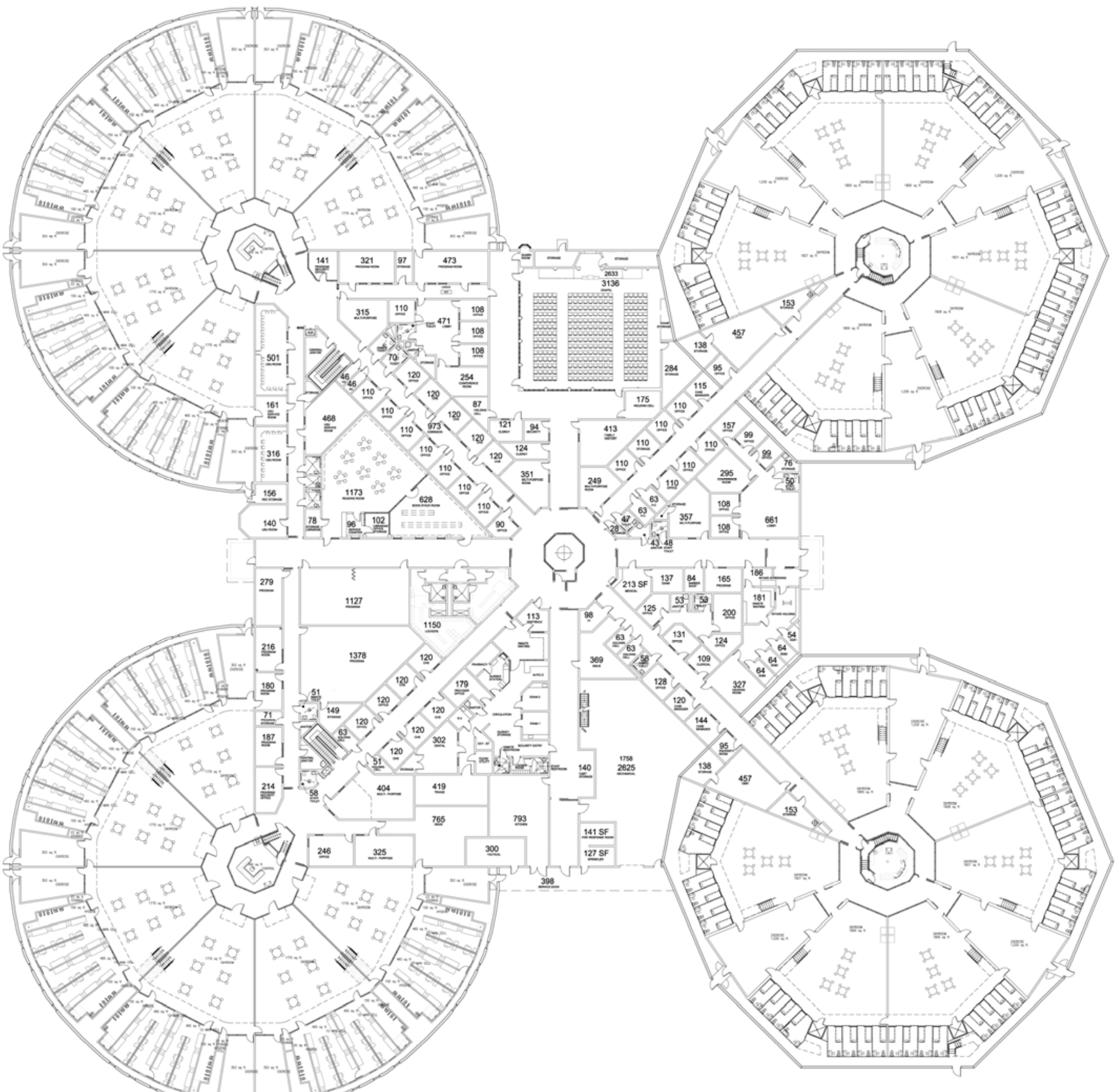


Figure 2.3

The next adjustment in the bed count came as the modules were formed into housing complexes. Each complex is comprised of four housing modules and an associated supporting core of functional spaces. As with the previous steps, sound, secure facility design practice dictates that, where possible, basic segregations not share a complex. Ideally, each management segregation forms its own prison within the larger prison complex and should be as self-contained as possible.

The study began with the assumption that at the conclusion of each phase, the project will be 100% built-out, meaning that each complex has four completed modules. This assumption leads to a final adjustment in bed counts to reflect a fully completed housing concept. So, what started as 5,000 male beds and 1,000 female beds at the conclusion of phase 1, became 5,424 male beds and 988 female beds reflecting all of the discussed adjustments. For phase 2 the bed counts are 7,776 and 1,668 as compared to 8,333 and

1,667 respectively. Graphical representation of each management segregation and the deployment of the required beds into units, modules and complexes is included in the Appendix X.

Lastly, note that the female population does not meet the 100% built-out expectation at the end of phase 2. An additional module to complete the phase 2 complex would have resulted in an excess bed count of almost 20% beyond the linear growth model. Because the phase 2 bed count requirement is so far in the future when management practices, population characteristics and statutory requirements may change significantly, it was decided to adhere to the growth model and ignore the "completeness" criteria.

NON-HOUSING FACILITIES

Non-housing facilities are based on serving the populations outlined previously. These facilities are divided as follows:

- Perimeter Control
- Miscellaneous Improvements
- Outside the Secure Perimeter
- Inside the Secure Perimeter

Perimeter Control

Functional Characteristics: Perimeter control facilities include a site traffic station to control access to the property, a vehicle sally-port to allow secure transfer of vehicles into and out of the secure perimeter and security towers at strategic points along the secure fence line. The planning of the security towers anticipates point to point visual control of the perimeter fencing system. In addition to these building elements, there are additional features of the perimeter control system that are described in the site development section of this report.

Construction Typology

Perimeter control facilities are designed to withstand the highest levels of potential attack because they occur at the interface point between the public and the secure environments. Bullet and blast resistant glazing, concrete, concrete masonry and steel are appropriate building materials for these facilities.

Miscellaneous Improvements

Functional Characteristics: Miscellaneous improvements include the Sewage Treatment Facility and Culinary Water Facility to provide those services to the remote site. Also included are staff and visitor parking lots, and kennels and training area for the working dogs. Visitor parking has been reduced based on the anticipated usage of video visitation systems. Contact visitation normally generates the highest volume of public traffic.

Construction Typology

Miscellaneous improvements are designed to meet the utilitarian functions contained within those facilities. Industrial building types are appropriate for these facilities.

Outside Secure Perimeter

Functional Characteristics: Facilities included outside of the secure perimeter are those that do not require, or would be negatively impacted by direct inmate access. These include the administration facilities, the enforcement center, vehicle pool facilities, a central plant and warehousing. It is anticipated that the male and female facilities would, to some extent, have their own administrative facilities, but that the balance of the facilities in this category would be shared by the two prisons.

Construction Typology

Buildings constructed outside the secure perimeter may be designed of materials suitable for that building type in a non-justice facility.

Inside Secure Perimeter

Functional Characteristics

Facilities included within the secure perimeter are those that service direct inmate needs or are accessed by inmates on a regular basis. Inmate services include contact visitation, court facilities, education, religious worship and education, central library facilities, mental health, medical care and industry programs. Also included are the central laundry, culinary, and refuse management facilities. Lastly, inmate reception and orientation facilities are included in this group. With the exception of the culinary program, all of these facilities are required in both prison campuses. UDOC anticipates utilizing a single cook-chill plant, shown as a part of the men's prison, to produce the food for both populations.

Construction Typology

Buildings constructed inside the secure perimeter, with the exception of housing facilities, may be designed of materials suitable for that building type in a non-justice facility. Housing facilities are constructed of durable, abuse and attack resistant materials suitable to the inmate type housed. Housing facilities are designed to keep the inmates securely confined. The UDOC secure facility standards describe appropriate materials.

Concept Program

The previous discussions are summarized in a concept development program, included as in Appendix X. The program document lists all of the major functions required for a prison. Gross square footage has been assigned to each of the functions, and then appropriate functions are grouped together to describe required buildings. In addition to the building areas, developed site area requirements are also summarized in the program document.

The characteristics of the programmed facility are:

- Phase 1
  Male Facility
  Beds – 5,424
  Programmed Gross Square Feet – 1,790,625
  (includes shared facilities)

- Female Facility
  Beds – 988
  Programmed Gross Square Feet – 286,496

- Phase 2
  Male Facility
  Beds – 7,776
  Programmed Additional Gross Square Feet – 644,600

- Female Facility
  Beds – 1,668
  Programmed Additional Gross Square Feet – 173,567

Site Development

Based on the concept program, building masses have been developed and arranged on the preferred site. The arrangement of the buildings is based on the model developed in Gunnison, with the Administration Building serving as the gateway into the secure facility for pedestrian traffic. The Administration Building is connected via a corridor or tunnel to the secure portion of the facility. Housing complexes are arranged into segregation zones that isolate each inmate type from the others. Some functions, culinary, for example, are located in proximity to the inmate population that will staff them.

A non-secure fence line will define the full extent of the prison property, including utility plants, agricultural activities and treatment facilities. The secure areas of the prison are contained within a double fence-line with 25 feet between the two lines. The characteristics of the secure fence are described in the UDOC Secure Facility Standards. The secure fence must be located a minimum of 300 feet from a public road, and 250 feet from the non-secure fence line. Housing units are then located no closer than 150 feet from the inside line of the security fence system.

Drawings of the anticipated improvements are included on the following pages. These drawings illustrate the following:

Master Site Plan, illustrating the intended usages of the entire available parcel at the conclusion of phase 2.

Phase 1 Site Plan, illustrating the end-state improvements of the phase 1 program supporting 6,412 beds specifically in the area of prison development.

Phase 1 aerial views:

- Men's Facility – view looking to the northeast.
- Men's Facility – view looking to the southwest.
- Women's Facility – view looking to the northeast.
- Women's Facility – view looking to the southwest.

Phase 2 Site Plan, illustrating the end-state improvements of the phase 2 program supporting 9,444 beds specifically in the area of prison development.

Phase 2 aerial views:

- Men's Facility – view looking to the northeast.
- Men's Facility – view looking to the southwest.
- Women's Facility – view looking to the northeast.
- Women's Facility – view looking to the southwest.

Figure 2.4: *Master Site Plan*

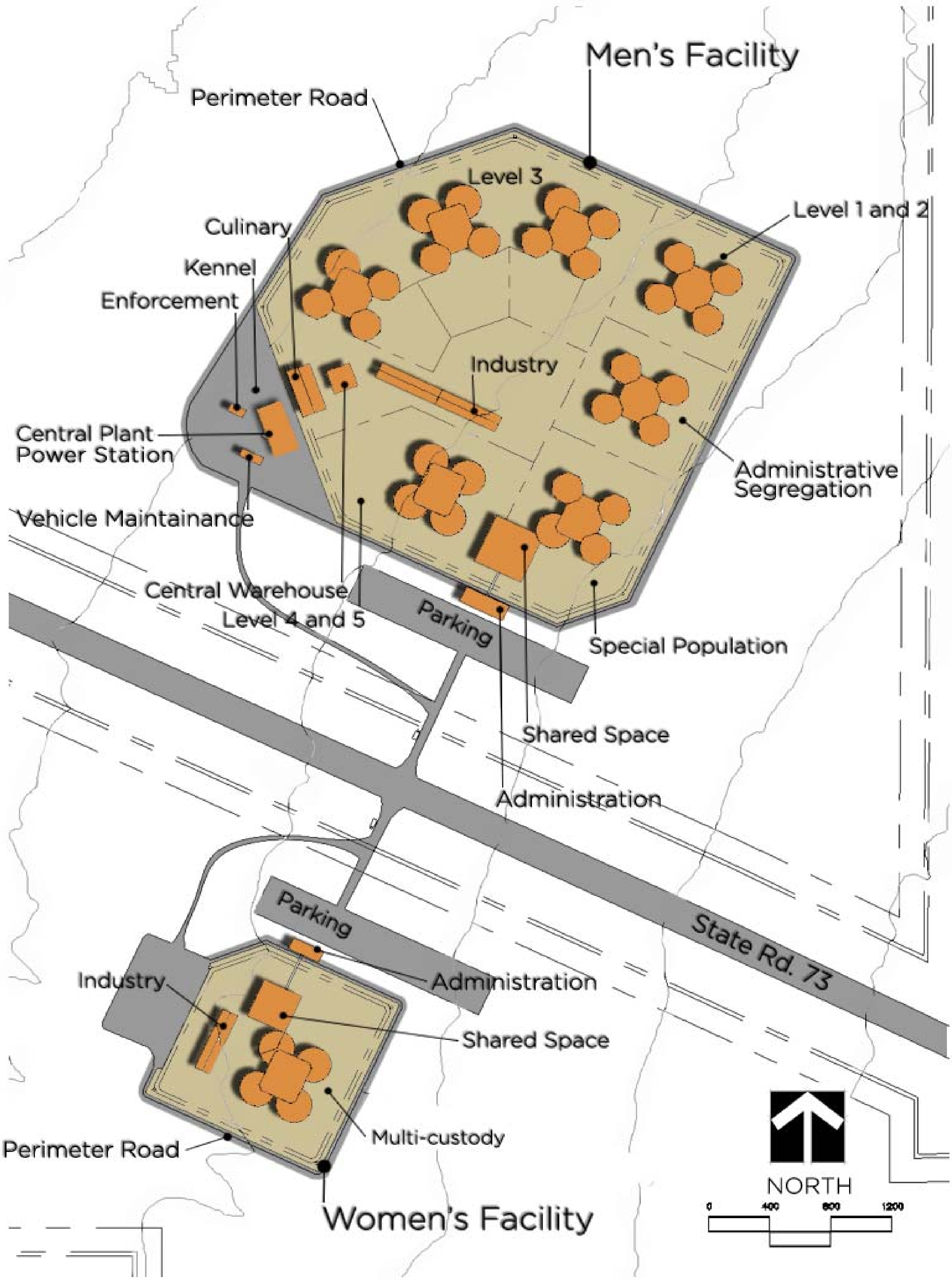


Figure 2.5: *Phase 1 Site Plan*

Figure 2.6: *Men's Facility Phase 1 NE View*

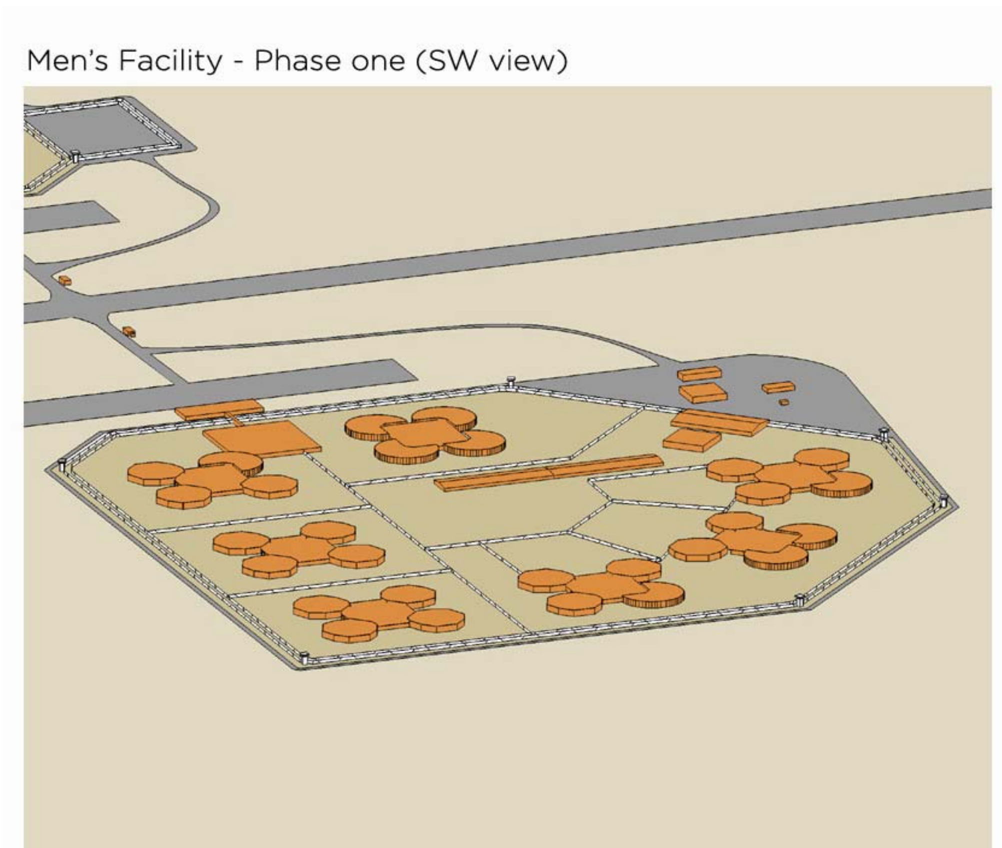


Figure 2.7: *Men's Facility Phase 1 SW View*

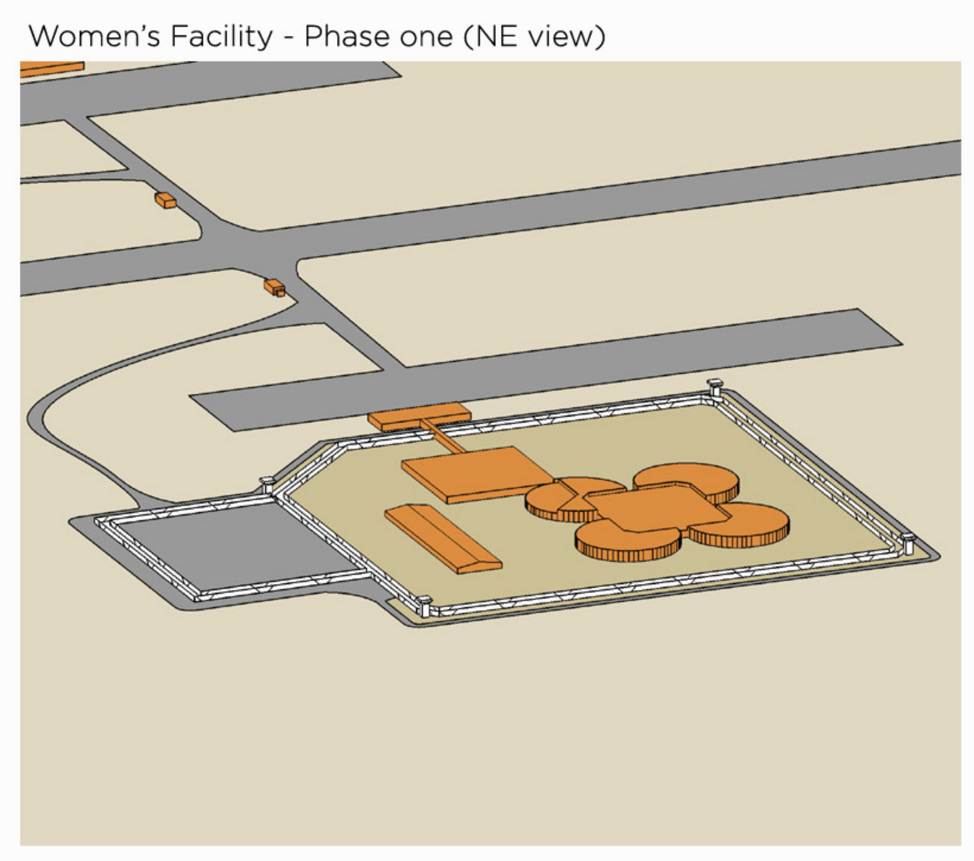


Figure 2.8: *Women's Facility Phase 1 NE view*

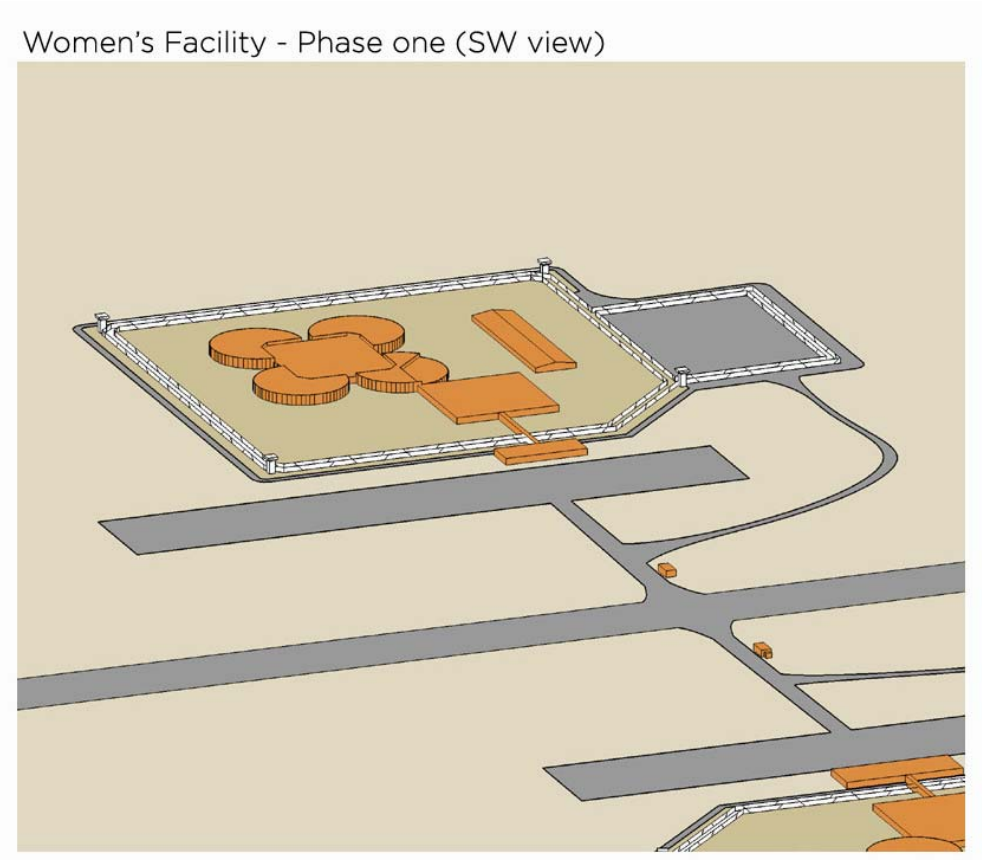


Figure 2.9: *Women's Facility Phase 1 SW view*

Figure 2.10 *Phase 2 Site Plan*

Figure 2.11: *Men's Facility Phase 2 NE View*

Figure 2.12: *Men's Facility Phase 2 SW View*

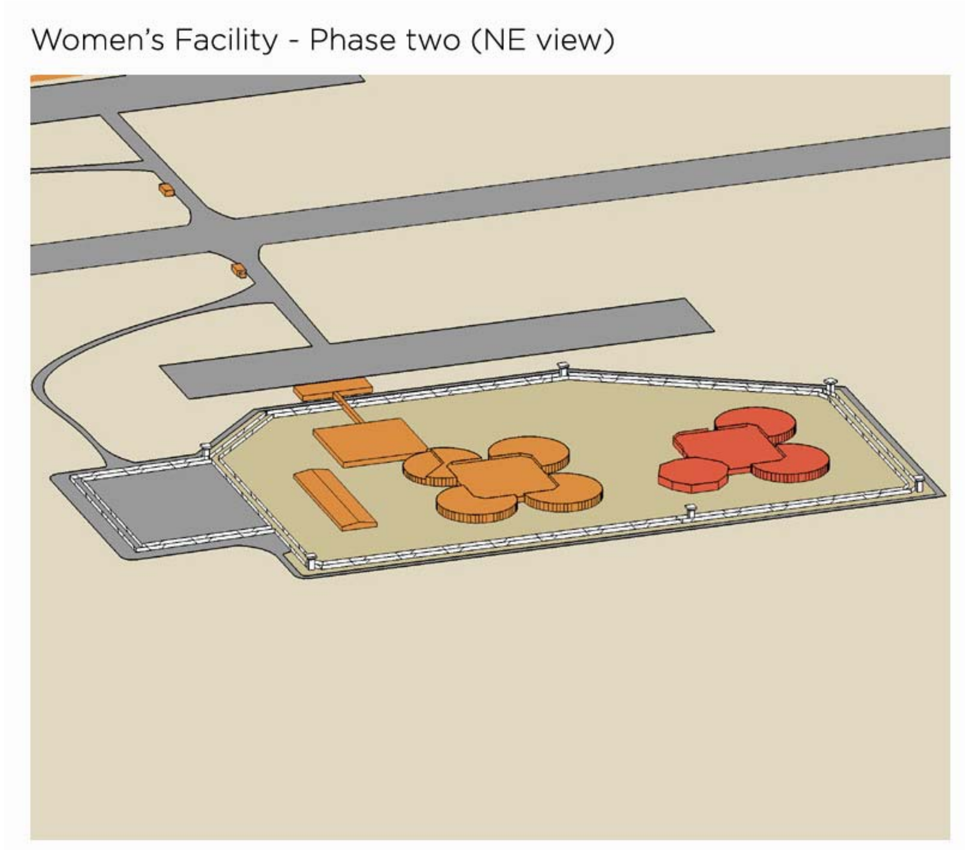


Figure 2.13: *Women's Facility Phase 2 NE View*

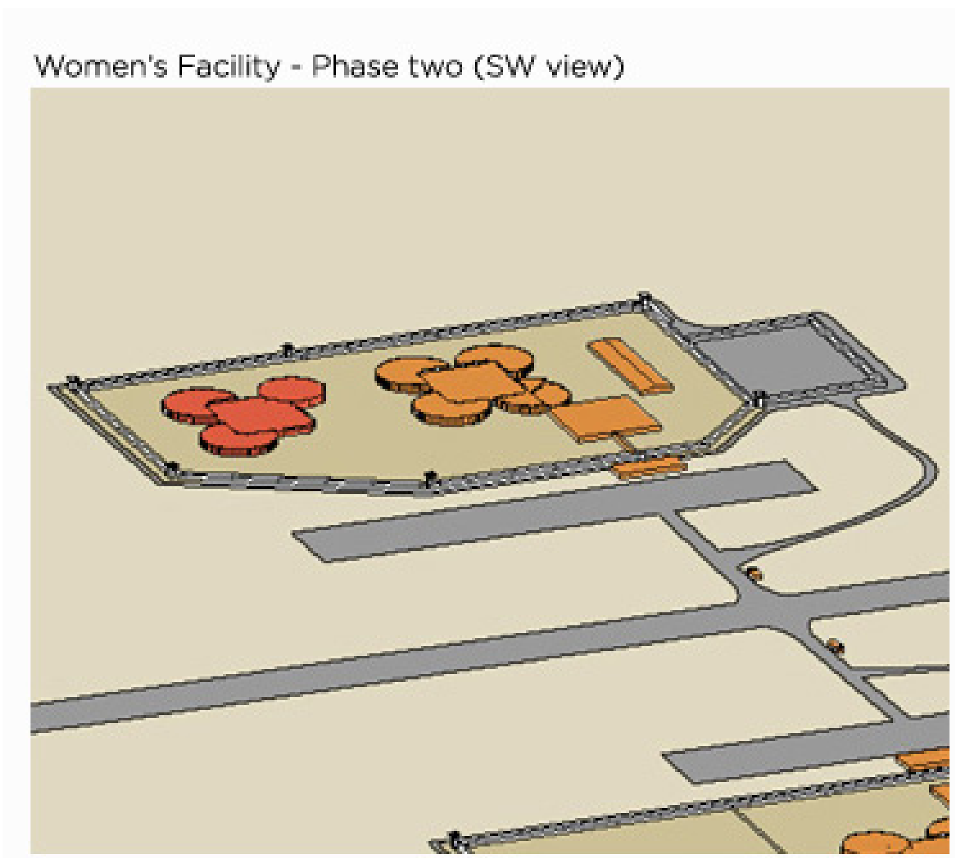


Figure 2.14: *Women's Facility Phase 2 SW View*

SECTION III: WATER AND WASTEWATER INFRASTRUCTURE ANALYSIS

The proposed prison site location has been studied to determine potential fatal flaws in providing the required water, wastewater, gas supply, and storm drainage infrastructure. The analysis approximated the requirements for a 6,000 bed facility and a 10,000 bed facility. The study included an investigation of culinary water sources, sanitary sewer, wastewater treatment, natural gas supply, storm drainage, facility placement, and geologic conditions. This study is a fatal flaw analysis as well as a budgeting analysis. It should be used for planning purposes only. See Figure 3.1 for a site map of the major water infrastructure.

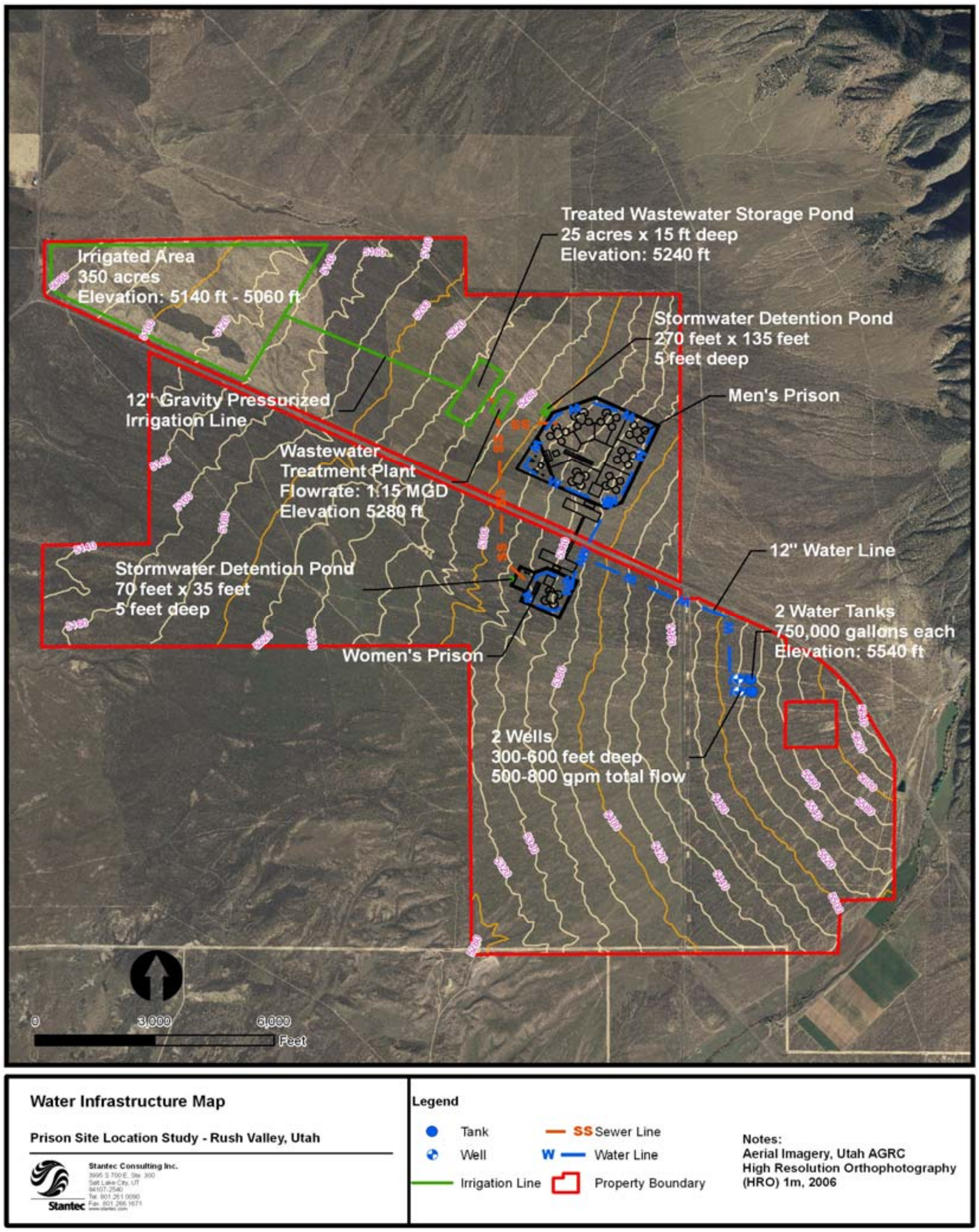


Figure 3.1: *Water Infrastructure Map*

CULINARY WATER ANALYSIS

The culinary water analysis included an investigation of water supply and infrastructure requirements. The study included a water demands analysis , a preliminary investigation of the availability of water rights appropriations, a preliminary groundwater quality analysis, a preliminary water rights analysis, a preliminary hydrogeologic review of potential groundwater sources, and an engineering analysis of major water distribution infrastructure requirements. A preliminary hydrogeologic analysis was conducted to determine the feasibility of drilling wells adequate to supply the site.

Water Demands Analysis

Data from the existing Draper facility was used to determine the water demands for the future prison site. Demands at the Draper site were reported by the Department of Corrections to be:

- 115 gallons per prisoner bed per day.

This demand was used to estimate a total demand for a 6,000 bed facility to be:

- 0.7 MGD (million gallons per day), this is equivalent to approximately: 400 gpm (gallons per minute)

Total demand for a 10,000 bed facility would be:

- 1.15 MGD, this is equivalent to approximately: 800 gpm.

This flow rate was used to establish the required flow rate from the source wells.

A peaking factor of 2x was used to determine the peak day demand and as well as an assumed fire flow of 1,500 gpm.

- The peak flow rate for the 6,000 bed facility is 2,300 gpm.
- The peak flow rate for the 10,000 bed facility is 3,100 gpm.

The fire flow of 1,500 gpm was assumed, further investigation into this value will be required.

Preliminary Groundwater Quality Analysis

A preliminary groundwater quality analysis was conducted for the parcel in the Rush Valley area. The data that were utilized include:

- Technical publications by the Utah Division of Water Rights (UDWR), including Technical Publication No. 23 and Technical Publication No.18;
- UDWR database search for existing points of diversion; and
- Data obtained from studies by Stantec Consulting Inc.

It is important to note that the water quality data obtained from the published reports are from the late 1960's and water quality in the region may have changed since these data were published. No attempts were made to obtain water quality records for public supply wells in the region from the Utah Division of Drinking Water (UDDW) through the Government Records Access and Management Act (GRAMA) process.

For the purposes of this investigation, the primary water quality parameter that was investigated is Total Dissolved Solids (TDS). The primary standard set forth by the UDDW for TDS is 1,000 milligrams per liter (mg/l) unless the supplier can satisfactorily demonstrate that no better water is available. The secondary standard for TDS is 500 mg/l, which means that levels in excess of this value will likely cause consumer complaint.

In the vicinity of the proposed prison parcel, the concentration of total dissolved solids (TDS) ranges from 350 to 2,180 ppm [Technical Publication 23]. See Figure 3.2 for a diagram of the distribution of dissolved solids in ground and surface waters from Technical Publication 23 [Technical Publication 23]. Most of the water in Rush Valley contains more than 181 ppm of hardness as calcium carbonate and is classed as very hard by the United States Geological Survey. Edges of the Ophir Canyon fan, near these parcels, may yield large quantities of groundwater to wells, but it is unknown how much.

Preliminary Water Rights Analysis

Rush Valley is restricted for new appropriations to small water rights appropriations only. No new appropriations are greater than 4.73 acre-feet per year. See Figure 3.3 for a map of groundwater appropriations policy. Water usage for the prison site was estimated to be between 770 and 1,290 ac-ft per year. This volume of water rights could not be obtained from new appropriations, but would need to either be purchased or transferred from another basin. The Utah Department of Corrections (UDC) owns water rights shares in the Salt Lake Valley. The UDC could potentially transfer rights from this basin to the Rush Valley Basin; however, moving water rights from one basin to another basin is very difficult. It is beyond the scope of this analysis to determine the feasibility of transferring existing water rights from another basin to Rush Valley. Stantec recommends that a water rights attorney be consulted in order to assess the feasibility of moving rights from another basin to this piece of property.

If water rights are purchased, the cost would be between $10,000 and $15,000 per acre-foot according to research done by Wikstrom and Stantec. The cost of water rights for a 6,000 bed facility would be approximately $9.6 million assuming an average of $12,500 per share.

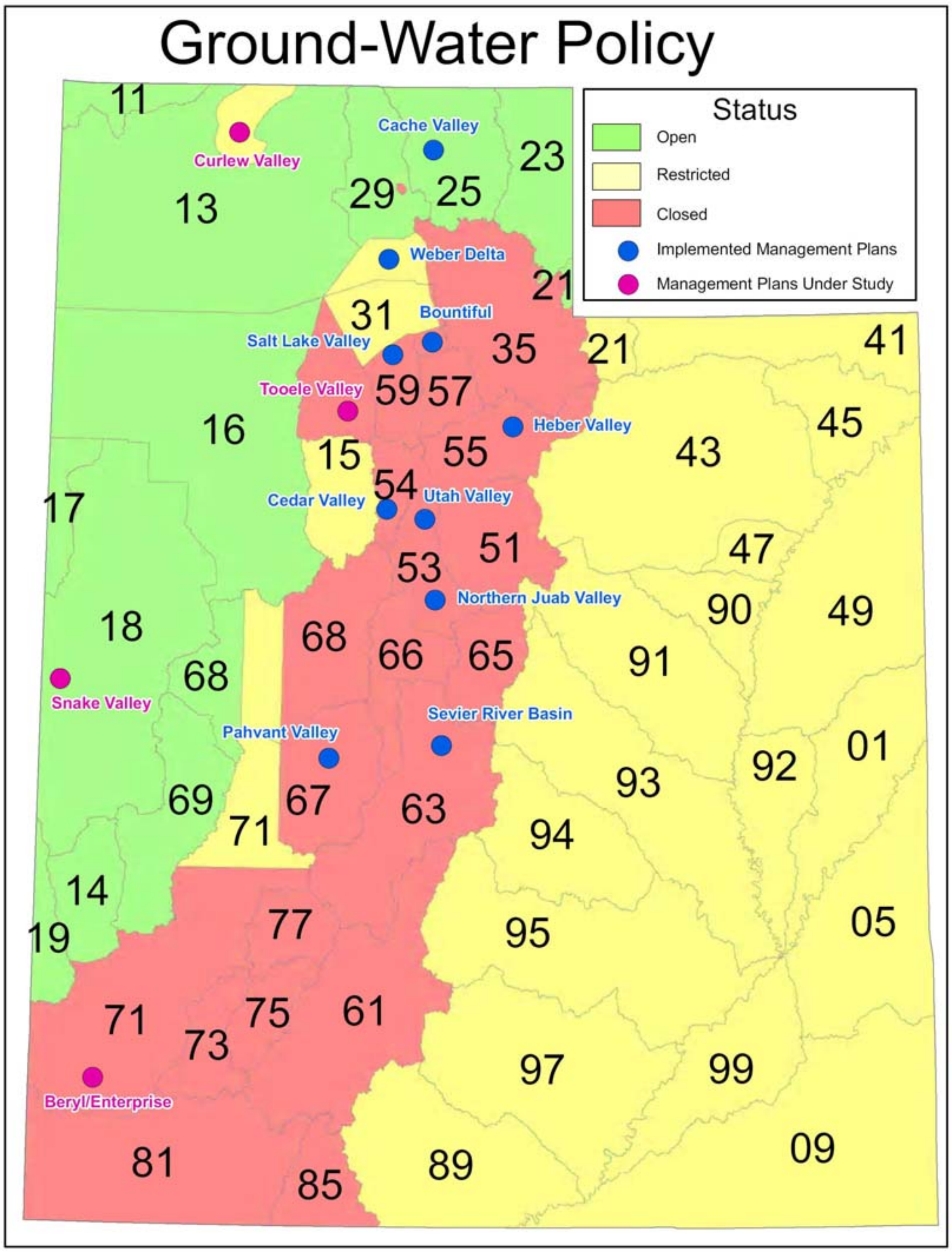


Figure 3.2: *Groundwater Water Rights Appropriations Map*

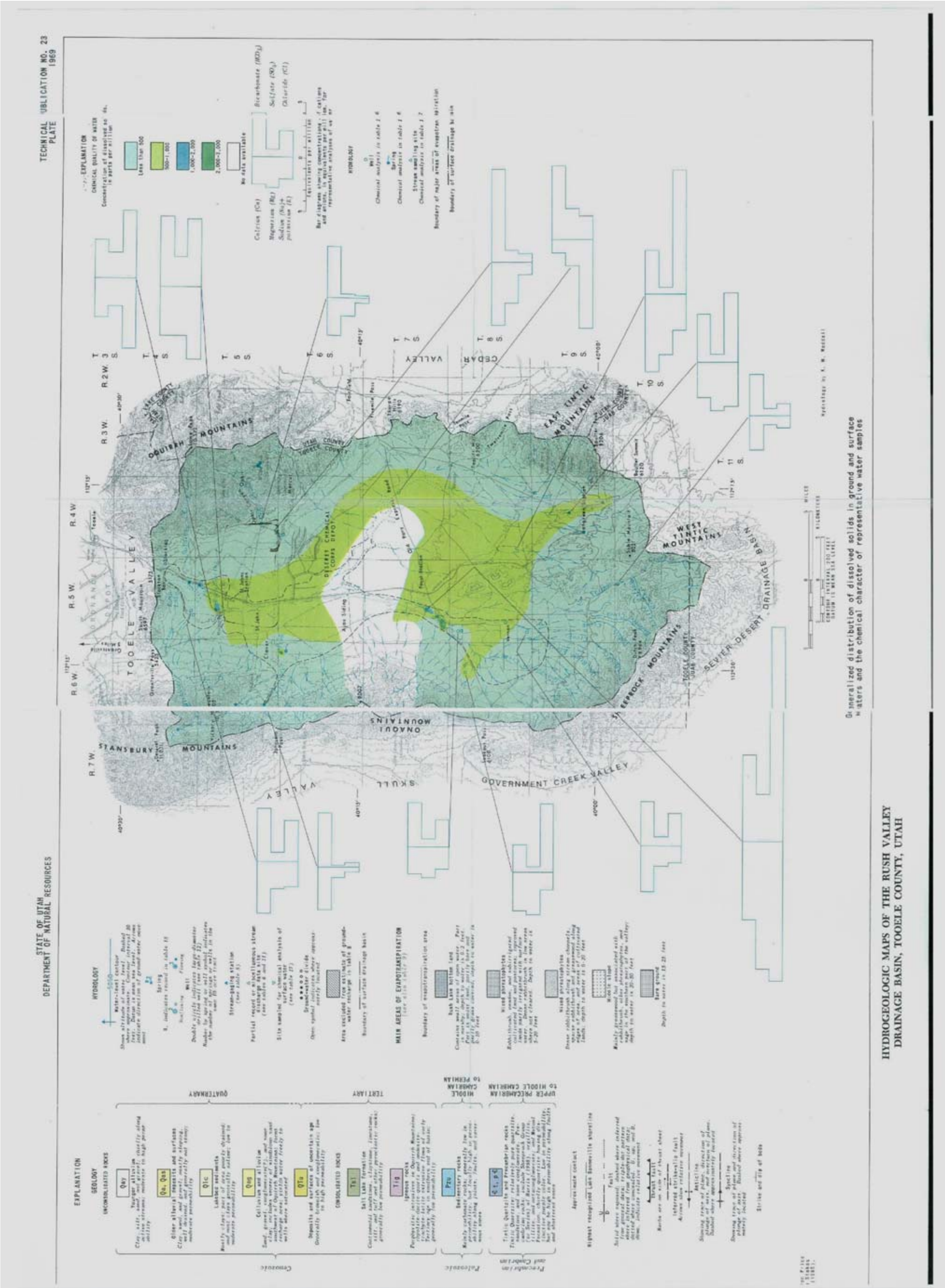


Figure 3.3: *Distribution of Total Suspended Solids in Groundwater in Rush Valley*

PRELIMINARY HYDROGEOLOGIC ANALYSIS

The preliminary hydrogeologic review studied the areas surrounding the proposed prison site including the areas located several miles south of the town of Stockton and directly east of the town of Rush Valley. The purpose of the review was to examine the production capabilities of groundwater sources in the vicinity of the proposed prison site with respect to meeting the future water demand of 500 – 800 gallons per minute (gpm). The preliminary hydrogeologic analysis used the following sources of information:

- Existing published geologic and hydrogeologic information for the region.
- Technical Publications authored by the Utah Department of Natural Resources Division of Water Rights and the U.S. Geologic Survey.
- Well Logs from existing wells
  - 1 meter aerial photographs from the National Agricultural Imagery Program (NAIP) from 2006.

Physiographic and Hydrogeologic Setting

Rush Valley covers approximately 250,000 acres and is a closed basin typical of the Basin and Range Physiographic Province [Technical Publication 18]. The mountains that surround Rush Valley are folded and faulted sedimentary, metamorphic and igneous rocks. These include the Oquirrh and East Tintic Mountains on the East, the Stansbury and Onaqui chains on the west and the Sheeprock and West Tintic Mountains to the south.

Consolidated rocks form the mountains surrounding Rush Valley. The consolidated rocks can be divided as follows:

1 Metasedimentary rocks of Precambrian Age and the Tintic Quartzite of Cambrian Age. The Precambrian rocks and Tintic Quartzite crop out only in the Sheeprock Mountains and the quantity of water stored is small.

2 Paleozoic sedimentary rocks which are mainly carbonates. The Paleozoic sedimentary rocks are exposed in the mountains and underlie younger rocks in parts of Rush Valley. Some formations of Paleozoic age yield large quantities of water including the Manning Canyon Shale and the Oquirrh Formation. The Oquirrh Formation yields large quantities to two wells owned by Tooele City drilled north of Vernon, with rates estimated at 4,100 gpm and 8,600 gpm, respectively. These two wells were drilled on the trace of a covered fault and another well drilled west of the fault trace yielded much less. Therefore large well yields appear to depend on localized favorable conditions. These wells are approximately 14 miles south of Parcels 2 and 3.

3 Tertiary igneous rocks, and the Salt Lake Formation of Pliocene age. Both the Tertiary igneous rocks and the Salt Lake Formation have low permeability and do not have much potential to yield water.

Although groundwater may be locally available from bedrock formations, the main groundwater reservoir in Rush Valley is in the unconsolidated rocks of late Tertiary and Quaternary age. The source of all water in Rush Valley is precipitation that falls on the mountains. The normal annual precipitation in Rush valley is less than 10 inches in the lowlands to more than 40 inches in the Oquirrh and Stansbury Mountains. In the vicinity of the Prison Parcels, the unconsolidated rocks consist of 20-100 feet of coarse-grained deposits that rest on a thick section of pre-Lake Bonneville lacustrine clay. The majority of wells surrounding Parcels 2 and 3 yield less than 50 gpm except those that will be discussed in more detail in the following section.

Existing Wells

Based on a Utah Division of Water Rights (UDWR) database search around the proposed prison site, although most nearby wells yield less than 100 gpm, several wells were found that yield quantities of water in excess of 100 gpm. These wells are illustrated in Figure 3.4 and details about each well follow.

1 Sep-Stockton LLC Wells (WR 15-2972)

The Sep-Stockton Wells include several existing and abandoned wells. The first well drilled in 1987 flowed artesian and was capable of 1,350 gpm with 60 feet of drawdown. This well was drilled to a depth of 340 feet and was later abandoned. A second well was drilled in 1990 to a depth of 315 feet and was capable of 1,000 gpm with 90 feet of drawdown. This well was also later abandoned. A third well was drilled in 2000 to a depth of 425 feet and flowed artesian at a rate of approximately 12 gpm. This well was never developed or tested, and was later abandoned. A fourth well was drilled in 2005 to a depth of 900 feet. According to the Well Driller's Report (Appendix X), this well encountered quartzite bedrock at an approximate depth of 517 feet. This well was later pumped at a rate of 2,250 gpm with 271 feet of drawdown.

2 USA Department of the Army – Tooele Army Depot (WR 15-73)

The United States Army has two wells at the Deseret Chemical Depot. Both wells were drilled in 1942 to depths of 404 feet and 428 feet, respectively. Both were completed in gravels and are capable of approximately 370 gpm with 5 to 10 feet of drawdown (see Well Driller's Report in Appendix X).

3 Hogan Brothers Inc (WR 15-136 and 15-137)

The Hogan Brothers Wells include three well sources. Two have no information on production potential while a third that was drilled in 1973 to a depth of 209 feet is capable of 1,140 gpm with 77 feet of drawdown. According to the Well Drillers Report (Appendix X) this well was completed in unconsolidated sands and gravels.

4 Georgia Monroe – formerly Snyder Mines Inc (WR 15-2330)

Two wells formerly owned by Snyder Mines Inc were drilled in 1937 to depths of 86 feet and 90 feet, respectively (see Well Driller's report in Appendix X). The first is capable of 146 gpm with 15.5 feet of drawdown. The second is capable of 178 gpm with 15.5 feet of drawdown.

5 Joe Sandino (WR 15-163)

This well was completed to a depth of 300 feet in 1963 and flowed artesian. Based on the Well Driller's Report (Appendix X), the well was estimated to flow 650 gpm in 1963 when it was drilled. The well appears to be completed in unconsolidated sands and gravels.

Hydrogeologic Summary and Recommendations

Based on a review of the Utah Division of Water Rights database there are several wells in the vicinity of the proposed prison site that are capable of discharge rates greater than 100 gpm and as great as 2,250 gpm. The well that yielded 2,250 gpm was drilled to a depth of 900 feet and encountered bedrock conditions. All other wells investigated target unconsolidated sands and gravels.

Based on the information provided in this hydrogeologic review, it may be possible to drill several wells in the unconsolidated sands and gravels on the proposed prison site that could supply the required demand of 500 – 800 gpm. It is unclear if the required demand could be supplied by only one well. It is likely that more than one well would need to be drilled to supply the required demand. It also may be possible to target a bedrock aquifer(s), but a more detailed well siting study would be required. Regardless of the target formation, if wells are drilled in the area a test well program is recommended. A test well program would provide the additional data needed to further evaluate the groundwater resource.

WATER SUPPLY INFRASTRUCTURE ANALYSIS

The water supply infrastructure analysis developed approximate sizes of the major infrastructure components only. The main water supply infrastructure components includes: the multiple well system, well pumps, water storage tanks, the main water distribution lines, and the water distribution loops. This infrastructure analysis was conceptual and does not include minor equipment such as control valves, altitude valves or pressure reducing valves.

The water supply conceptual analysis assumed that the required groundwater supply was available from the multiple well system. The conceptual water supply infrastructure includes:

- 2(or more) wells approximately 300-600 feet deep with a 10-12 inch casing. Elevation: 5520 ft.
- Well flow of approximately 500-800 gpm.

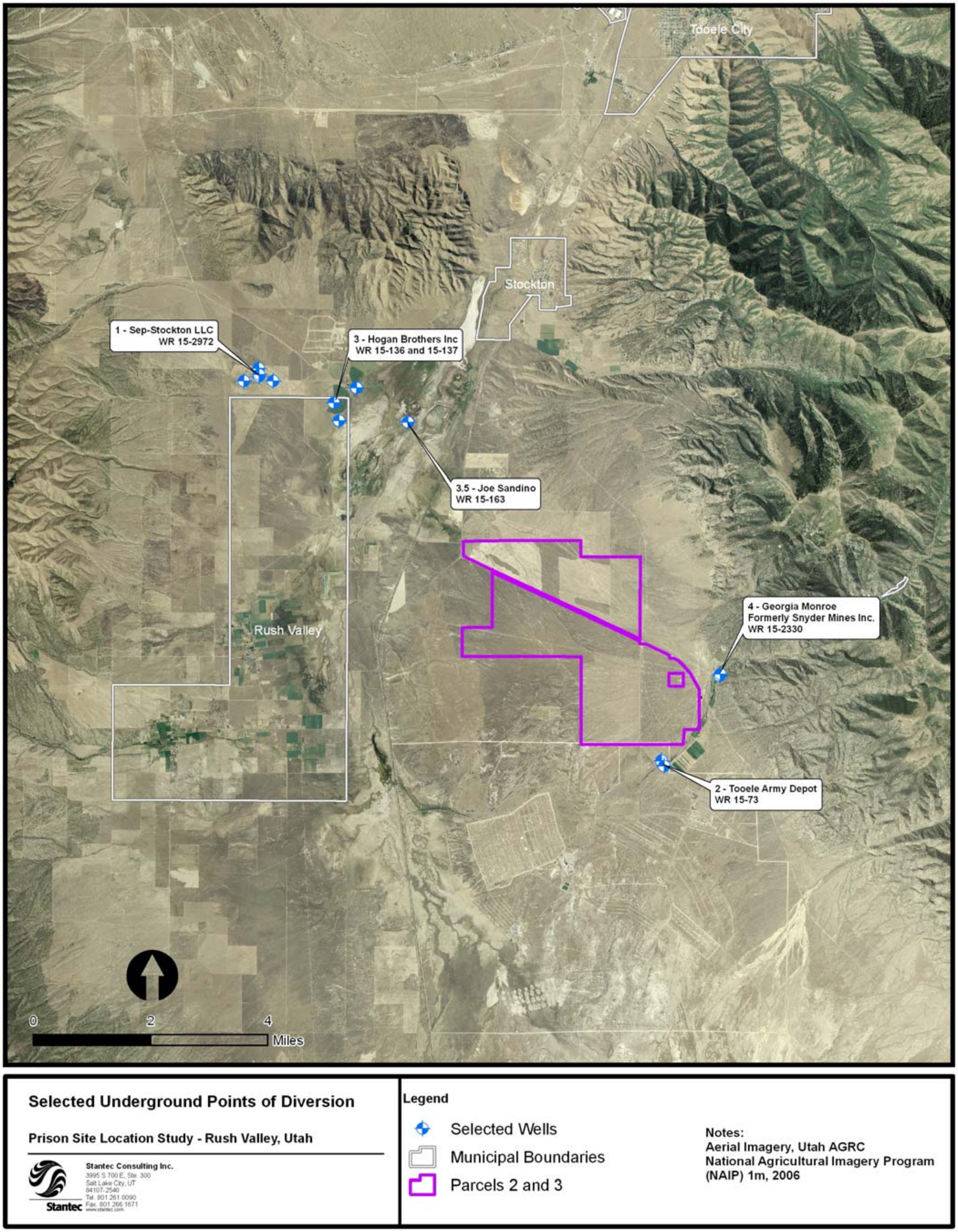


Figure 3.4 *Water Rights Map – Selected Underground Points of Diversion*

- 2 tanks with 750,000 gallons of storage each. Elevation: 5540 ft.
- 12 inch water supply line, Length: 7,200 feet, Elevation drop: 160 feet.
- A water supply loop inside the fence in each complex.
- The prison site at an elevation range of: 5400 ft to 5300 ft.

The system can potentially be served by gravity flow if the site is arranged with the elevations and pipe sizes recommended above.

The water storage tanks were sized to provide a 1 day supply of stored water and adequate water storage to provide a fire flow 1500 gpm for 2 hours.

The water supply line was sized to provide a peak service flow of 1,600 gpm and allow for service pressure of 50 to 80 psi at the prison site through gravity flow. Pipeline head loss calculations for the main water supply line were based on High Density Polyethylene (HDPE) pipe material (roughness coefficient, C, of 145), a flow rate of 1,600 gpm, an elevation loss of 160 feet, and a total pipe length of 7,200 feet. Input variables and output pressure values are shown in Table S2.

Table 3.1 Main Water Supply Line Headloss

Roughness, C	145
Length, L	7,200 feet
Flowrate, Q	1,600 gpm
Inside Diameter, D	12 inches
Head Loss, h_L	36 feet
Service Pressure	Upper Prison (Elevation 5380), 54 psi
	Lower Prison (Elevation 5300), 80 psi

Water supply distribution infrastructure is shown in Figure 3.1.

Water System Recommendations

This preliminary fatal flaw and water supply analysis has identified the major water supply systems that will be required for the prison site. More detailed studies of these systems will need to be performed. These future studies include:

- A detailed water demands analysis to determine design demands for water capacity and storage requirements.
- A detailed hydrogeologic study including a well siting study and a test well program.
- A detailed site layout with grading plans and infrastructure designs.

SANITARY SEWER AND WASTEWATER ANALYSIS

The sanitary sewer and wastewater analysis included an investigation of the site constraints and potential for a slow percolation system and the production of crops from recycled wastewater. Preliminary major sewer collection lines have been drawn and a proposed treatment plant site location has been shown in Figure 3.1. Wastewater flow rates have been determined based on a 6,000 bed facility and a 10,000 bed facility. A conceptual wastewater system has been determined.

The conceptual wastewater system includes:

- Major wastewater collection lines (approximately 6,300 feet in total length).
- A wastewater treatment plant with a flow rate of 0.7 MGD for a 6,000 bed facility and 1.15 MGD for a 10,000 bed facility. Located at an elevation of 5280 ft.
- A wastewater storage pond that is 15 acres for a 6,000 bed facility and 25 acres for a 10,000 bed facility and 15 feet deep in total. Elevation: 5240 ft.
- A gravity flow irrigation line that is approximately 4,900 feet long.
- An irrigated area of approximately 350 acres. Elevation: 5140 ft to 5060 ft.

The wastewater storage pond was sized to allow adequate storage for the non-irrigation season.

Wastewater Treatment Alternatives

Two major wastewater treatment alternatives were investigated in this study. These include:

- An Oxidation Ditch Process with Mechanical Sludge Dewatering.
- Membrane Bio-Reactor (MBR) Process with Mechanical Sludge Dewatering.

- Both of these options are capable of producing Type I water, which can be used to irrigate food crops.

MBR Plant Process Outline

The MBR Plant depicted in Figure 3.5 and Figure 3.6, consists of:

- Influent Pump Station.
- Headworks with Grit Collector and Bar Screen.
- Anoxic Tank for De-Nitrification.
- Aerated Activated Sludge with Membrane Filter System.
- Waste Sludge Handling.
- Chlorination Disinfection.
- Sludge Handling Equipment.
- Recycled Water Storage Pond.
- Recycled Water System.

The influent lift station consists of submersible pumps or screw pumps to run the raw water through the headworks of the plant. The pumps would need to be capable of handling 4” solids and provide enough head to pump the influent. The headworks are usually placed after the influent lift station and include a bar screen system to remove larger solids and a grit collector tank to settle out finer solids.

After the passing through the headworks, the water flows into the process tanks. In a typical MBR system, there are three major processes: an anoxic tank, an aerobic tank, and a membrane filtration system. The anoxic tank is typically the first step, followed by an aeration basin, followed by membrane filtration. The solids in the MBR tank are recycled back to the anoxic basin through a return line. MBR systems are typically run at mixed liquor suspended solids (MLSS) concentrations of 10,000 mg/L, which are higher than more conventional methods of wastewater treatment. This feature allows the plant to produce the same level of treatment in a smaller footprint.

The anoxic tank is typically well mixed but is not aerated. The suspended solids recycle line feeds into this tank. The solids are recycled from the membrane filtration process. The anoxic tank is essential for de-nitrification, a process that removes nitrate from the water and improves effluent quality. The aerobic tank provides aerobic breakdown of the wastewater as well as nitrification. This tank provides the breakdown of treatment by converting organic matter to substrate. The membrane filters provide the final filtration step that removes sludge and solids from the final effluent. This is the last step in the membrane system. Effluent is typically pumped by permeate pumps on the suction side of the filters and the effluent is sent to the storage pond or chlorine disinfection step. The membranes are constantly scoured by an aeration system within the filter casing to keep the filters clear of solids and the solids suspended in solution. The suspended solids are pumped back to the anoxic tank through Return Activated Sludge (RAS) pumps.

The plant also requires a sludge de-watering system and a sludge disposal method. There are many techniques for dewater sludge such as a belt press system, or a screw press system. Waste sludge can be sent to the landfill, composted on-site, or put into an anaerobic digester system. Due to the size of the prison site, composting of waste sludge would likely be the best option.

MBR plants combine clarification and tertiary filtration into one step. This feature allows the plant to be placed on a smaller footprint than a conventional plant. Plant flow rates are limited by the hydraulic capacity of the pump and piping systems, not the nutrient or BOD loading.

Membrane systems are costly and require replacement approximately every 10 years. Although no tertiary filters are required, disinfection must be incorporated into the process design to produce Type I, Recycled Water.

Oxidation Ditch Plant Process Outline

The Oxidation Ditch system shown in Figure 3.7 and Figure 3.8 consists of:

- Influent Pump Station.
- Headworks with Grit Collector and Bar Screen.
- Anoxic Region for De-nitrification.
- Oxidation Ditch with Aerated Activated Sludge.
- Conventional Circular Clarifiers.
- Waste Sludge and Return Activated Sludge System (RAS).
- Tertiary Filters.
- Chlorination Disinfection.

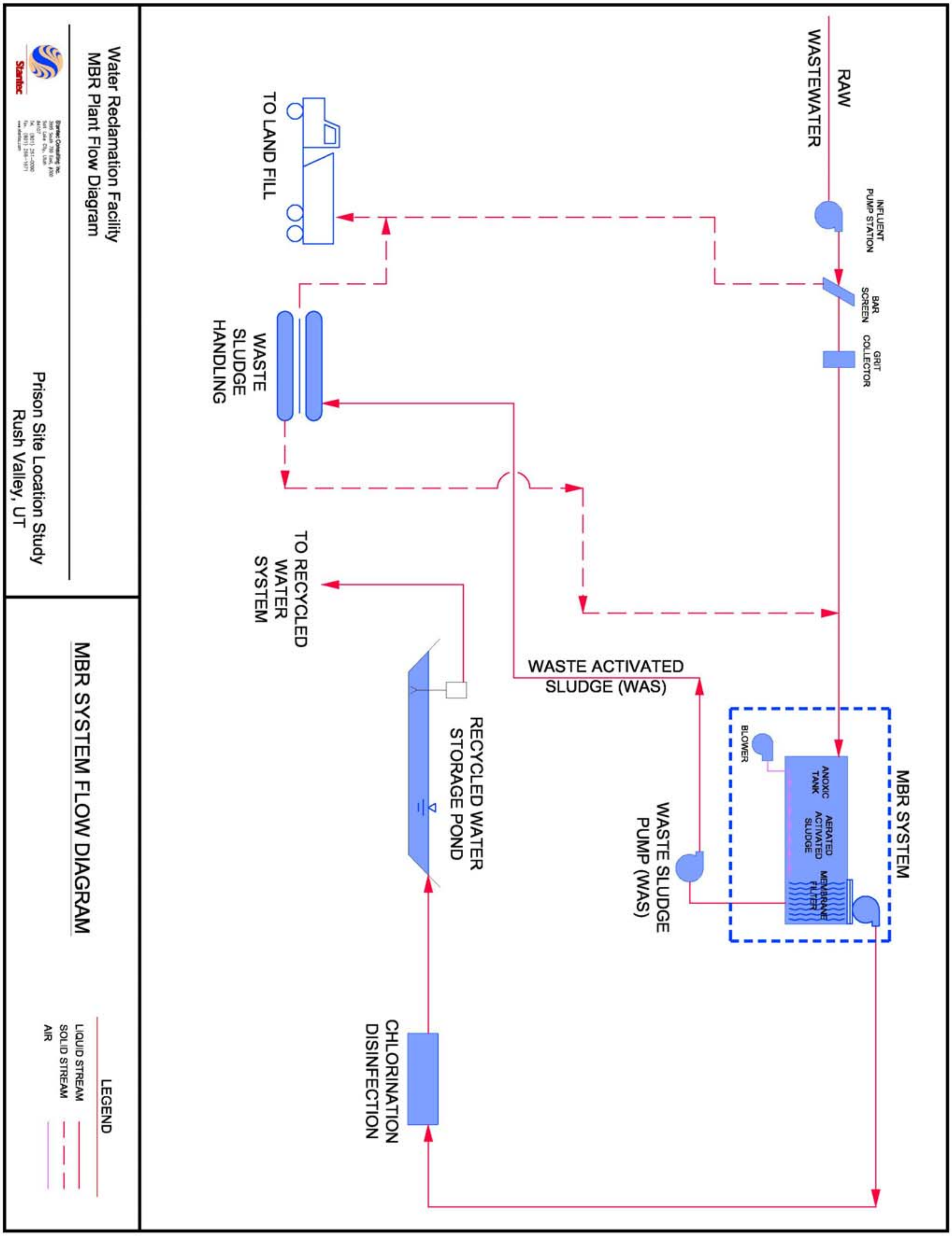


Figure 3.5 *MBR Process Flow Diagram*

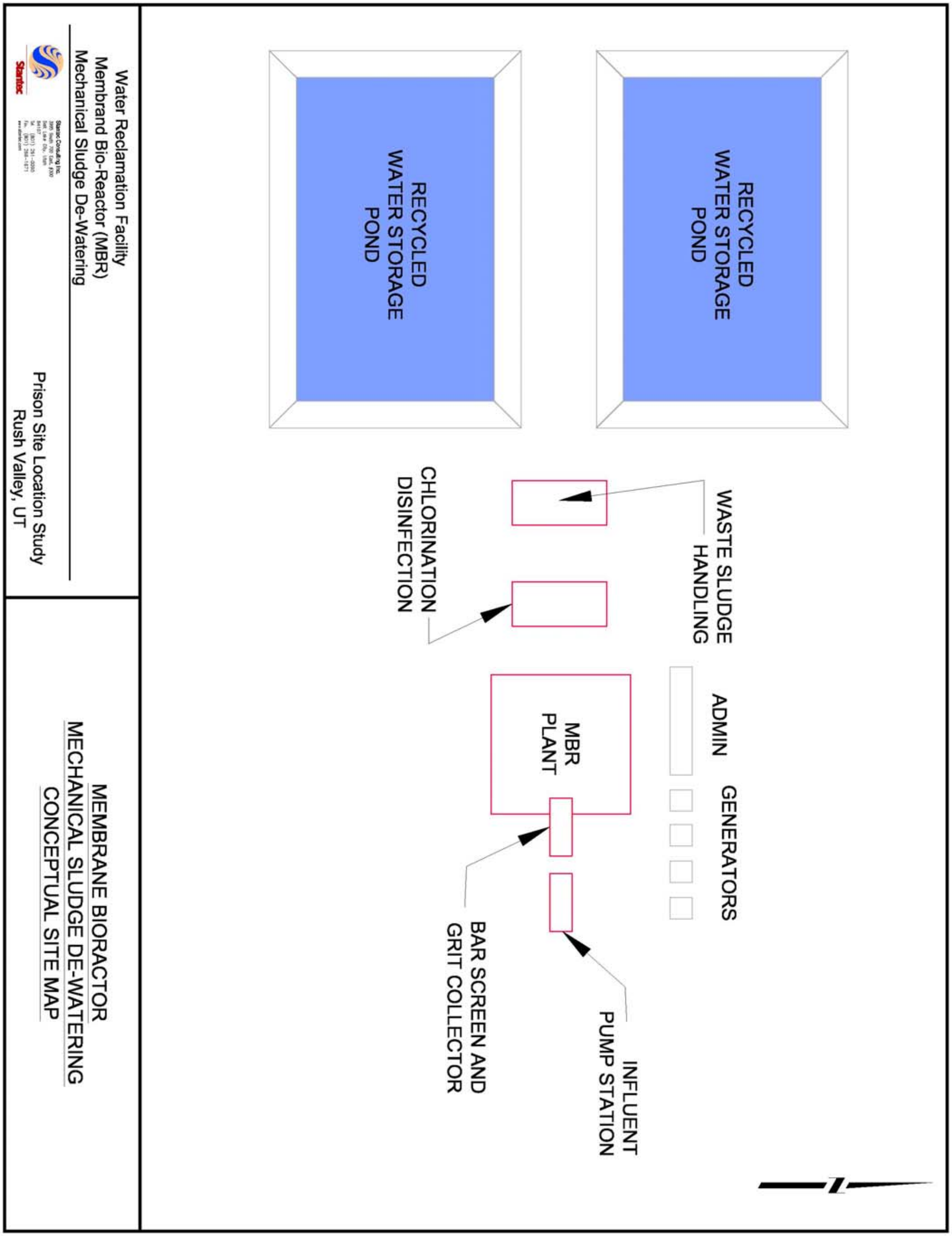


Figure 3.6 *MBR Site Plan*

- Sludge Dewatering System.
- Recycled Water Storage Pond.
- Recycled Water Pump Station.

The influent lift station and plant headworks are similar to the MBR system.

The aerated activated sludge basin (oxidation ditch) is typically larger than a MBR aeration basin. Oxidation ditches are usually circular trenches with brush-shaped aerators. RAS is recycled back into the oxidation ditch. Oxidation ditch MLSS concentrations are usually less than 4,000 mg/L. Due to the lower MLSS concentrations, a much larger footprint is required than a typical MBR plant.

The anoxic zone is similar to the MBR process and also serves as a method for de-nitrification.

Conventional clarifiers operate differently than an MBR process. Conventional clarifiers use settling instead of filtration to separate the solids. Clarifiers are typically circular in shape. Mixed Liquor (MLSS) from the oxidation ditch is sent to the clarifier bottom and effluent is allowed to flow over a weir into the effluent launder. A sludge recycling pump is located at the bottom of the clarifier that pumps the recycled sludge back to the oxidation ditch. These recycle pumps are typically centrifugal pumps.

The Oxidation Ditch system will produce Type II water at the end of the clarifier stage. Type II water has not undergone as much treatment as Type I water and cannot be used for food crops unless the water does not contact the food. In other words, sprinklers cannot be used. If Type II water is acceptable for a use other than crop irrigation, then further treatment at the tertiary filter will not be required. The tertiary filter will be employed if the desired use for the water requires Type I, Recycled Water. The probable capital cost for the 6,000 bed facility Oxidation Ditch Plant will be approximately $6.2 million. The probable capital cost for the 10,000 bed facility Oxidation Ditch Plant will be approximately $10.3 million. These values may be considered average values for all proposed processes. Details on the estimates can be seen in Tables 3.2 and 3.3.

LEED Certification

There is a Leading Energy and Environmental Design (LEED) credit for wastewater technologies design. The intent of the credit is to reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge. There are two options available for obtaining the credit; the second one is applicable to this project. Option 2 requires that 50% of the wastewater be treated on-site to tertiary standards and the treated water be used on-site. Both of the proposed treatment processes will be capable of treating 50% of the wastewater on-site. The credit will also be fulfilled if the treated water is used for crop irrigation.

Recycled Water Analysis

The wastewater system at the proposed prison site will require a wastewater disposal system. Such disposal could consist of a rapid infiltration system or a slow percolation system. A rapid infiltration system will provide wastewater disposal into unlined disposal ponds. This option would provide rapid wastewater disposal but would not provide irrigation benefits. This system may be desirable in situations where excess wastewater is produced or irrigated land is not available. A slow percolation system provides wastewater disposal through an irrigation system. This provides a secondary benefit as irrigation water. Disposed water can be used to irrigate crops or landscaping.

Due to the availability of area for irrigation on the property, the prison site would be amenable to a slow percolation system. Slow percolation would allow for the production of crops such as alfalfa that would assist in the disposal of water and nutrients through consumption. Re-use water may be used to produce crops for food purposes and irrigate landscaped areas. Water treatment requirements differ depending on the purpose of the reuse water.

The definition of Type II water and its irrigation uses is shown below in Utah State Regulation R-317-3-11:

11.5 Use of Treated Domestic Wastewater Effluent Where Human Exposure is Unlikely (Type II)

A. Uses Allowed

1. *Irrigation of sod farms, silviculture, limited access highway rights of way, and other areas where human access is restricted or unlikely to occur.*
2. *Irrigation of food crops where the applied treated effluent is not likely to have direct contact with the edible part, whether the food will be processed or not (spray irrigation not allowed).*

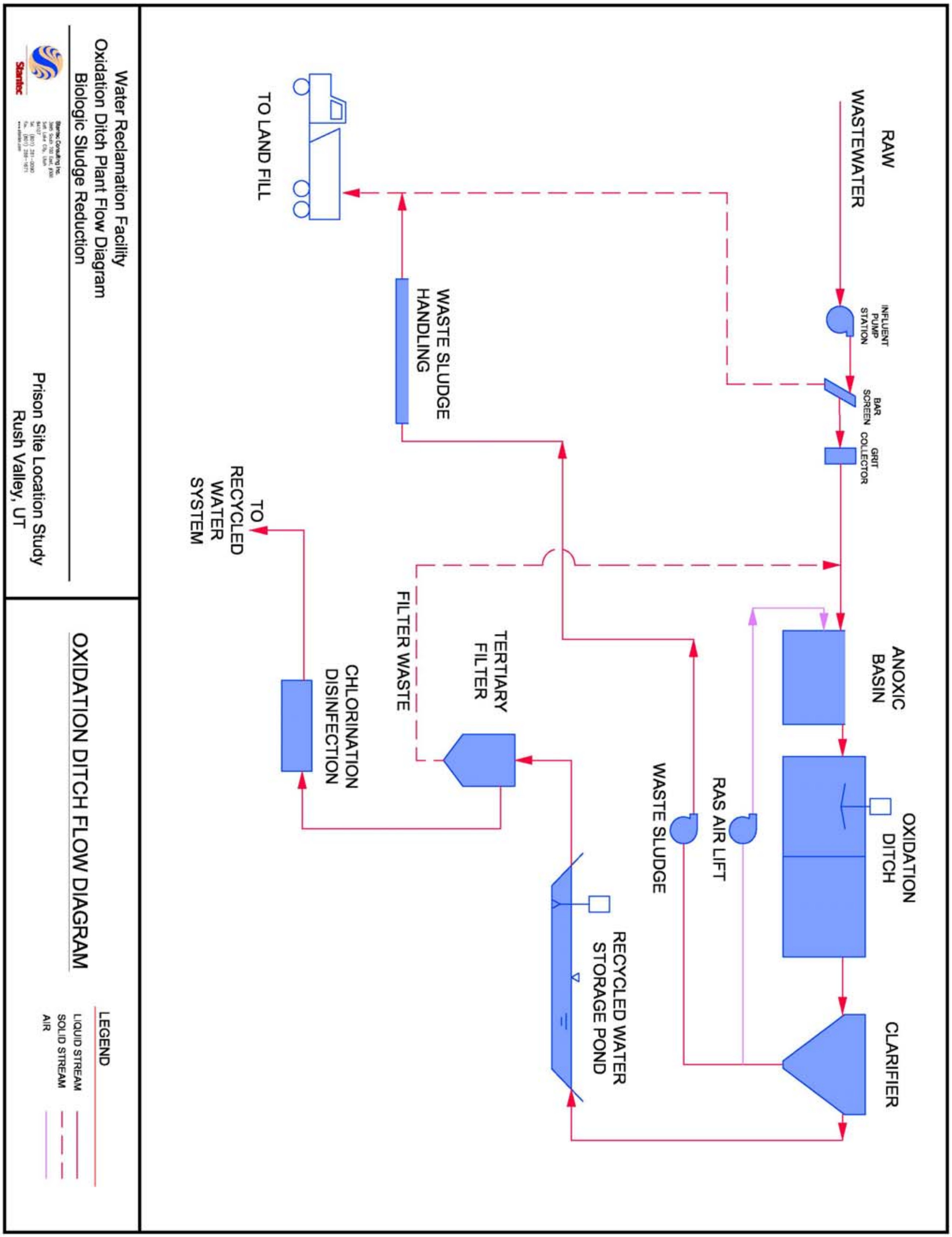


Figure 3.7 *Oxidation Ditch Process Flow Diagram*

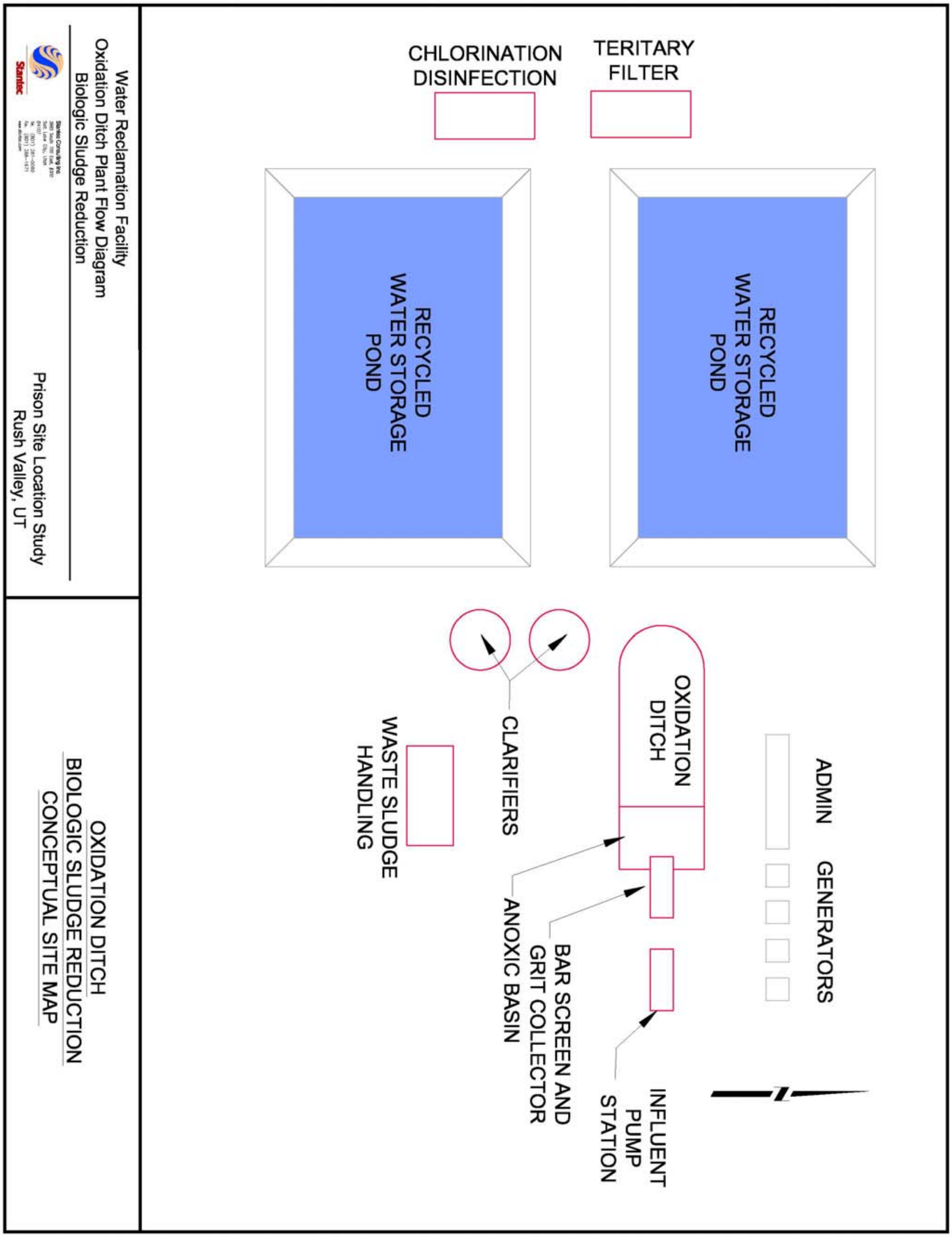


Figure 3.8 *Oxidation Ditch Site Plan*

Table 3.2 ***Opinion of Probable Construction Cost Summary***
(Mechanical Sludge Dewatering System)
(6,000 Bed Facility, 0.7 MGD Flowrate)

LINE NO.	Direct Construction Costs		Item Totals	Project Totals
00	General Plant Site Work		$249,000	
01	Influent Submersible Pump Station		$76,800	
02	Headworks		$353,400	
03	Oxidation Ditch		$587,400	
04	Clarifiers		$396,000	
05	RAS Pump System		$75,000	
07	Effluent Pump Station		$94,800	
08	Sludge Dewatering and Processing		$1,057,200	
09	Disposal Pump Station		$54,000	
10	Storage Lagoon		$1,655,400	
11	Gas Chlorination Disinfection System		$18,000	
12				
13		**Direct Construction Cost Subtotal**	**$4,617,000**	$4,617,000
14				
15	**In-Direct Construction Costs**			
16	Miscellaneous = 5%		$231,000	
17		**Sub Total**	**$231,000**	
18	Engineering = 12%		$581,760	
19		**Sub Total**	**$812,760**	
20	MOB / DE-MOB = 5%		$231,000	
21	Contingency = 5%		$271,000	
22	Admin & Legal = 5%		$231,000	
23	**In-Direct Construction Cost Subtotal**		**$1,546,000**	$1,546,000
24			**Total Project Construction Cost:**	**$6,163,000**

Table 3.3 *Opinion of Probable Construction Cost Summary*
(Mechanical Sludge Dewatering System)
(10,000 Bed Facility, 1.15 MGD Flowrate)

LINE NO.	Direct Construction Costs		Item Totals	Project Totals
00	General Plant Site Work		$415,000	
01	Influent Submersible Pump Station		$128,000	
02	Headworks		$589,000	
03	Oxidation Ditch		$979,000	
04	Clarifiers		$660,000	
05	RAS Pump System		$125,000	
07	Effluent Pump Station		$158,000	
08	Sludge Dewatering and Processing		$1,762,000	
09	Disposal Pump Station		$90,000	
10	Storage Lagoon		$2,759,000	
11	Gas Chlorination Disinfection System		$30,000	
12				
13		**Direct Construction Cost Subtotal**	**$7,695,000**	$7,695,000
14				
15	**In-Direct Construction Costs**			
16	Miscellaneous = 5%		$385,000	
17		**Sub Total**	**$385,000**	
18	Engineering = 12%		$969,600	
19		**Sub Total**	**$1,354,600**	
20	MOB / DE-MOB = 5%		$385,000	
21	Contingency = 5%		$452,000	
22	Admin & Legal = 5%		$385,000	
23	**In-Direct Construction Cost Subtotal**		**$2,577,000**	$2,577,000
24			**Total Project Construction Cost:**	**$10,272,000**

3. Irrigation of animal feed crops other than pasture used for milking animals.

4. Impoundments of wastewater where direct human contact is not allowed or is unlikely to occur.

5. Cooling water. Use for cooling towers which produce aerosols in populated areas may have special restrictions imposed.

6. Soil compaction or dust control in construction areas.

B. Required Treatment Processes

1. Treatment processes that are expected to produce effluent in which both the BOD and total suspended solids concentrations do not exceed secondary quality effluent limits as defined in R317-1-3.2.

2. Disinfection to destroy, inactivate, or remove pathogenic microorganisms by chemical, physical, or biological means. Disinfection may be accomplished by chlorination, ozonation, or other chemical disinfectants, UV radiation, or other approved processes.

The definition of Type I water and its irrigation uses is shown below in Utah State Regulation R-317-3-11:

11.4 Use of Treated Domestic Wastewater Effluent Where Human Exposure is Likely (Type I)

A. Uses Allowed

1. Residential irrigation, including landscape irrigation at individual houses.

2. Urban uses, which includes non-residential landscape irrigation, golf course irrigation, toilet flushing, fire protection, and other uses with similar potential for human exposure. Internal building uses of treated effluent will not be allowed in individual, wholly-owned residences; and are only permitted in situations where maintenance access to the building's utilities is strictly controlled and limited only to the services of a professional plumbing entity. Projects involving effluent reuse within a building must be approved by the local building code official.

3. Irrigation of food crops where the applied reuse water is likely to have direct contact with the edible part. Type I water is required for all spray irrigation of food crops.

4. Irrigation of pasture for milking animals.

5. Impoundments of wastewater where direct human contact is likely to occur.

6. All Type II uses listed in 11.5.A below.

B. Required Treatment Processes

1. Treatment processes that are expected to produce effluent in which both the BOD and total suspended solids concentrations do not exceed secondary quality effluent limits as defined in R317-1-3.2.

2. Filtration, which includes passing the wastewater through filter media such as sand and/or anthracite, approved membrane processes or other approved filtration processes.

3. Disinfection to destroy, inactivate, or remove pathogenic microorganisms by chemical, physical, or biological means. Disinfection may be accomplished by chlorination, ozonation, or other chemical disinfectants, UV radiation, or other approved processes.

Type II water can be used to irrigate non-contact food crops and animal feed crops such as alfalfa. Type II water is defined as water that meets effluent BOD and TSS standards and has undergone a disinfection step. This water has not undergone a final tertiary filtration step.

Type I water can be used for irrigation of food crops, parks, golf courses, and landscaped areas. Table 3.4 shows the crop consumptive use on a monthly basis. For the purposes of this study, preliminary crop water consumption and re-use water storage pond requirements have been calculated. Crop water consumption was estimated by using the following data:

- Evaporation data.
- Crop consumption data
- Mean monthly temperature
- % of Daytime Hours with consumption
- Deep Percolation

The K value shown in Table 3.4 is an indicator of the amount of water that the crops will require during the respective month. A higher K value indicates that more water will be consumed by the crop. The percent of daytime hours is the percent of time during the day that irrigation is required. The mean monthly temperature was also utilized in calculating the crop consumptive use. Table 3.4, Table 3.5, Table 3.6, and Figure 3.9 illustrate the storage pond and irrigation calculations.

Recycled water storage will also be a major consideration. A treated wastewater pond is proposed to the northwest of the proposed treatment plant. This pond will have a maximum surface area of 25 acres and depth of 15 feet. This size will allow an area of approximately 350 acres to produce crops with irrigation. The pond will be constructed at an elevation of 5240 feet. This will allow for a 12" irrigation line to run on gravity to the proposed irrigation area with a maximum elevation of 5140 feet. The irrigation system could potentially be served by gravity flow and the site would have a minimum elevation of 5,060 feet. (See Figure 3.1)

Future Plant Expansion

The prison site wastewater infrastructure has been estimated for a 6,000 bed facility with the potential for expansion to a 10,000 bed facility in mind. This expansion will affect the way that the initial treatment plant will be designed. The main process infrastructure, influent headworks, and pump stations will need to be designed for the 10,000 bed flow rate.
The storage pond system can be easily phased to accommodate prison expansion. The easiest way to do this is through a multiple pond system. Pond storage size can be scaled in proportion to the wastewater flow rate. Initial pond storage will require 15 acres of pond area and future expansion will require 25 acres. Multiple 5-acre ponds could be constructed in phases to accommodate these storage requirements.

Table 3.5 Wastewater Storage Pond Calculations

Site name:	**STATE PRISON**
Location:	**RUSH VALLEY, UTAH**
System average daily flow: (MG/D)	**1.15**
Yearly evaporation rate: (in/year):	73.76
Total lake and free water surface area:	25.00
Lagoon Depth (ft.)	15.0
Landscape acreage:	350.00
Summer crop:	**Alfalfa**
Winter crop:	**Alfalfa**
Estimated Storage required (gal./mo.):	95,461,600
Water balance total/year:	(1,265,148)

A positive value indicates insufficient water usage, a negative value is indicated by (parentheses).

Table 3.4. *Crop Consumptive Use*

Month	K Value	% Daytime Hours	Mean Monthly Temperature (°F)
January	0.00	7.10	26.7
February	0.00	6.91	29.9
March	0.48	8.35	37.1
April	0.58	8.80	46.4
May	0.64	9.71	55.9
June	0.75	9.71	64.6
July	0.80	9.88	74.5
August	0.80	9.34	72.8
September	0.80	8.35	62.9
October	0.64	7.90	50.5
November	0.48	7.02	36.5
December	0.00	6.93	29.9

Source: Blaney, H.F., and Criddle, W.D., 1962, Determining Consumptive Use Irrigation Water Requirements. USDA Technical Bulletin Number 1275, 59 pages.

Table 3.6 *Water Balance Spreadsheet*

	Monthly effluent available: gallons:	Rainfall inches per month:	Rainfall gallons per month:	Total evaporation: gallons per month:	System leakage and percolation if allowable: gallons per month:	Consumptive use of grasses: inches per acre:	Consumptive use of grasses: gallons per month:	Consumptive use of trees: gallons per month:	Total landscape water demand: gallons per month:	Total water available: gallons per month:	Net water balance gallons per month:
January	35,650,000	0.95	9,673,043	0	28,470,750	0.00	0	0	0	16,852,293	16,852,293
February	32,200,000	0.94	9,571,221	0	28,470,750	0.00	0	0	0	13,300,471	13,300,471
March	35,650,000	1.45	14,764,118	2,484,445	28,470,750	1.49	14,131,162	0	14,131,162	19,458,923	5,327,760
April	34,500,000	1.58	16,087,797	4,208,622	9,490,250	2.35	22,327,041	0	22,327,041	36,888,925	14,561,884
May	35,650,000	1.63	16,596,905	6,238,264	9,490,250	3.47	32,983,645	0	32,983,645	36,518,391	3,534,746
June	34,500,000	1.00	10,182,150	8,064,263	9,490,250	4.68	44,475,261	0	44,475,261	27,127,637	(17,347,624)
July	35,650,000	0.85	8,654,828	9,774,864	9,490,250	5.89	55,960,228	0	55,960,228	25,039,714	(30,920,514)
August	35,650,000	0.72	7,331,148	8,600,523	9,490,250	5.44	51,659,016	0	51,659,016	24,890,375	(26,768,641)
September	34,500,000	0.49	4,989,254	5,824,190	9,490,250	4.20	39,930,374	0	39,930,374	24,174,814	(15,755,560)
October	35,650,000	1.18	12,014,937	3,299,017	9,490,250	2.55	24,240,664	0	24,240,664	34,875,670	10,635,007
November	34,500,000	1.34	13,644,081	1,574,839	28,470,750	1.23	11,672,185	0	11,672,185	18,098,492	6,426,307
December	35,650,000	1.15	11,709,473	0	28,470,750	0.00	0	0	0	18,888,723	18,888,723
SUMS:	419,750,000	13.28	135,218,952	50,069,026	208,785,500	31.29	297,379,575	0	297,379,575	296,114,426	(1,265,148)

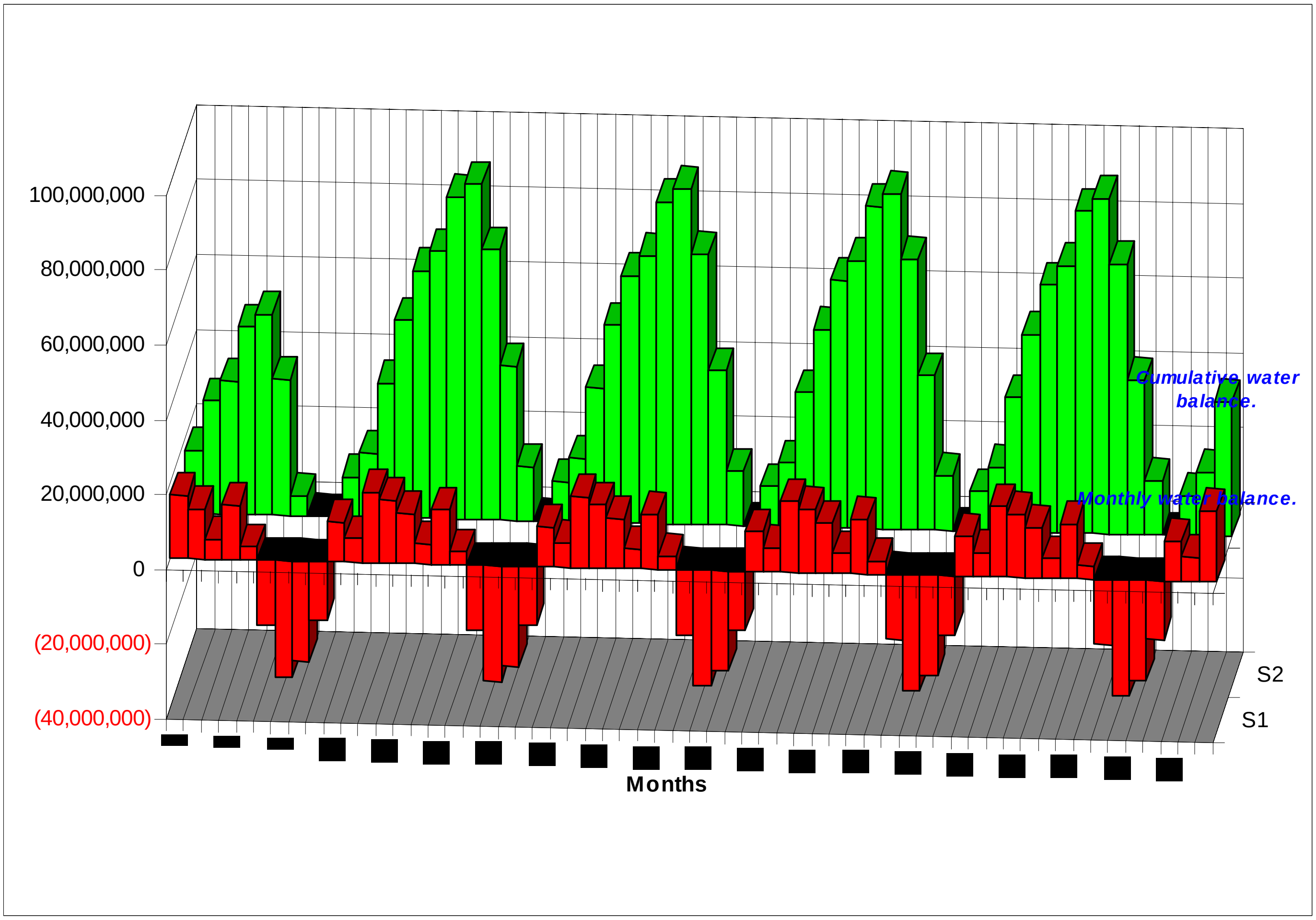


Figure 3.9 *Monthly Water Balance (Red) and Cumulative Water Balance (Green), the Y-axis is in gallons.*

NATURAL GAS ANALYSIS

There are currently multiple 8" high pressure natural gas lines that cross through the proposed prison site on Highway 73. The prison site would require an 8" supply line with a minimum of 50 psi. According to the Questar Gas Company (Questar), the existing gas supply lines under Highway 73 would provide adequate supply to the proposed site. Adequate gas supply was determined by Questar in their supply model. This assumption was based on a 10,000 bed prison facility.

Cost estimates have been provided by Questar to construct a new gas connection and any required piping. Questar supplied gas construction would include tapping the existing high pressure main in Highway 73, and providing an 8" supply line to the site. This estimate does not include the onsite gas line distribution and sub-metering. See the site figure at the end of the document for gas line location information. The cost estimate provided by Questar for a new gas connection at the proposed prison site was: $31,000.

STORM DRAINAGE ANALYSIS

The storm drainage analysis looked at two different types of storm drainage systems—a detention pond system and a retention pond system. A detention pond system reduces peak stormwater flow rates in order to reduce the potential for downstream flooding and erosion. A retention pond system eliminates all stormwater discharges to surface water. Stormwater is infiltrated instead.

The analysis included a study of pre-development versus post-development runoff volumes and peak flow rates, major storm drainage line requirements, and detention or retention storage requirements. Consideration has also been given to meeting requirements for storm drainage credits to apply for Leadership in Energy and Environmental Design (LEED) certification. No re-use of stormwater for irrigation purposes was considered. This is due to the much greater volume of recycled wastewater and State regulations that prohibit the mixing of stormwater with recycled wastewater.

Runoff Calculations

Runoff volumes and peak flow rates were calculated based on the preliminary site layout. The area of roofs, parking lots, and landscaping were estimated and input into the rational runoff equation. This equation uses different runoff coefficients for each type of area, producing different runoff amounts for landscape area and roof area (see Table 3.7).

Table 3.7. *Roof, Pavement, and Landscape Area*

Description	Area (ft^2)
Roof	2,571,000
Pavement	452,000
Landscape	100,000
Total	**3,123,000 (72 acres)**

Rainfall data used in the runoff calculations is shown in Table S8. These data were used to estimate the intensity of rainfall and probability of rainfall events. Generally stormdrainage systems are designed to handle 10-year storm events. A ten year return interval indicates a 10 percent annual chance of occurrence.

Table 3.8. *Rainfall Data for 24-hour Rainfall Events*

Return Interval	Total Rainfall
1-year	1.11 in
2-year	1.55 in
10-year	2.23 in

Table 3.9 shows the peak runoff flow rates that were calculated for the site under pre-developed conditions and post-developed conditions. Stormwater detention ponds and retention ponds were preliminarily sized to reduce peak discharge rates to pre-development conditions.

Table 3.9. Pre-Development versus Post-Development Runoff

	Pre-Development	Post-Development
10-yr Peak Flow Rate	26 cfs	109 cfs
2-yr Peak Flow Rate	16 cfs	68 cfs

LEED Certification

The intent of LEED certification for stormwater is to limit the disruption of natural hydrology be reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants. There are two LEED stormwater credits: Stormwater Design: Quantity Control, and Stormwater Design: Quality Control.

Stormwater Design: Quantity Control

The LEED Stormwater Design: Quality Control Requirements are shown below.

CASE 1 – Existing Imperviousness is less than or equal to 50%

> *Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two- year 24-hour design storms.*
>
> *OR*
>
> *Implement a stormwater management plant that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies. "LEED for New Construction & Major Renovations", U.S. Green Building Council.*

The preliminary storm drainage study for the prison site location has determined detention pond or retention pond requirements to meet the first half of this standard. Storm drainage detention ponds have been sized to retain stormwater to the predevelopment peak flow rate for one and two-year 24 hour design storms. These ponds will provide more retention storage than traditional design. This extra pond volume decreases peak flow rates and reduces the potential for erosion at the stormdrain discharge point. Additional retention storage improves discharge water quality due to additional solids settling.

Consideration was also given to a stormwater retention system. A system such as this would provide water quality treatment as well as infiltration and groundwater recharge. It would require larger ponds to allow adequate time for infiltration, but would provide more treatment than a detention system. It would also mimic a natural drainage system because it allows stormwater to infiltrate back into the groundwater like a natural drainage system.

Stormwater Design: Quality Control

The LEED Stormwater Design: Quality Control Requirements are shown below:

> *Implement a stormwater management plant that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall using acceptable best management practices (BMPs). BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.*
> *"LEED for New Construction & Major Renovations", U.S. Green Building Council.*

The LEED requirements encourage the use of alternative surfaces such as vegetated roofs and pervious pavement and nonstructural techniques such as vegetated swales, and disconnected imperviousness. They also promote stormwater quality design strategies such as constructed wetlands, settling ponds, and vegetated filters and open channels.

Stantec recommends that the prison site consider the use of stormwater quality measures. These include drainage structures such as stormwater swales, wet settling ponds, and filter fabrics that provide increased detention time, additional solids removal, and increased residence time to treat contaminants. Many of these structures can be included with landscape features and water features. Such structures have additional maintenance requirements but have major environmental quality benefits.

Detention Ponds

Stormwater detention ponds were sized to reduce peak runoff potential to pre-development levels during a 10-year event. These pond sizes are:

- A 1.9 acre-foot pond (5 ft deep, 140ft x 140 ft) on the Men's side.
- A 0.2 acre-foot pond (5 ft deep, 20ft x 20 ft) on the Women's side.

These ponds would reduce peak runoff flow rates to pre-development levels. Ponds would discharge to existing swales. See the following sizing calculations for more detail.

Retention Ponds

Stormwater retention ponds would require more available volume than the detention ponds. Retention ponds have been sized to retain 2-yr 24-hour storm events. Two stormwater retention ponds have been sized for the site, they include:

- A 5.0 acre-foot pond (5 ft deep 270 ft x 135 ft) on the Men's side.
- A 0.5 acre-foot pond (5 ft deep 70 ft x 35 ft) on the Women's side.

These retention ponds would allow one-year and two-year storm events to infiltrate into groundwater and not discharge into surface water. See the following sizing calculations for more detail.

Storm Drain Collection System

A storm drain collection system will be required to convey stormwater to the ponds. The major storm drain lines will need to be designed for a 10-year flow rate of 109 cfs. This will require a 36" diameter main trunk line with a minimum slope of 2.7%. Smaller stormdrain lines would be located on the uphill side of the site and the larger lines on the downhill side. The storm drain inlets would be located in the prison yard, near building runoff collection systems and parking lots. Security would be required for the lines within the fenced perimeter.

The stormdrain collection system would utilize vegetated swales where possible and infiltration trenches along storm drain pipe routes. Existing drainage pathways would be routed around the uphill side of the prison site and be separate from the storm drain system. These measures will potentially reduce the runoff load on the storm drain collection system.

LEED -Detention/Retention Storage **Credit 6.1 (LEED Ver. 2.2)**
Site Under 50% Impervious

Project: Prison Site Location Study
Proj. No.: **By:** Ken Engstrom
Date: 10/7/2008 **Revised:** 10/29/2008
2 Year Return Storm Event
V:\52863\active\186302095\design\analysis\storm\[LEED-6.1-rate-volume-calcs-prison-predesign-rev 20081029.XLS]under 50% impervious

LEED Certification
A. Peak post-developed discharge rate to not exceed pre-development rate.

Pre-development Discharge Rate: Q_{predev} = CiA = **16.06 cfs** Q_{predev} = CiA = 67.74
C = 0.2 C = 0.84
i_{15min} = 1.12 in/hr i_{15min} = 1.12 in/hr
A = 71.69 acres (Total Site Area) A = 71.69 acres

Post Development Discharge Rate:
Post Development Runoff Coefficient:

Desc.	Area (A)*	Coeff. (C)	CA		
Roof	2,571,000	0.85	2,185,350		
Pavement	452,000	0.95	429,400		
Landscape	100,000	0.2	20,000		
Sum =	3,123,000		2,634,750	**"C" =**	**0.84**
=	71.69 Acres, total site.				

Calculate Detention Storage Volume
Allowable Discharge Rate: 16.06 cfs. (Pre-development Rate)
Add infiltration rate for pond sizing: Percolation rate= 10000 minutes/inch= 1.389E-07 cfs/sf
(if approprate) (1min/in=.001389 cfs/sf)
Percolation Area: 6 ft. x 1890 ft. x = 11340 sf.
Percolation Rate: 11340 sf. X 0.00000 = 0.00 cfs.

Total Discharge Rate for detention sizing: 16.06 + 0.00 = **16.06 cfs.**

Elapsed (min.)	Total (in.)	(cu.ft.)	Discharge (cu.ft.)	Req'd (cu.ft.)
15	0.28	61478	14455	47023
30	0.39	85629	28910	56719
60	0.49	107586	57820	49766
360	1.02	223954	346919	-122966
720	1.28	281040	693839	-412799
1440	1.55	340322	1387677	-1047355

Discharge = Time x Qall
Storage = Runoff - Discharge

Required Detention Storage =
56,719 cu.ft.

Orifice Size:
Max. Orifice Head (H, ft.) = **2.5** ft. Qall = CA (2gH)^0.5 Solving for "A"
Orifice Coefficient (C) = **0.6** **A =** 2.1094 s.f. = **303.76** sq. in.
Orifice Diameter (in.) = **19.67**

Orifice sized for head when pond is full.

Figure 3.10

LEEDS -Detention/Retention Storage Credit 6.1 (LEED Ver. 2.2)

Site Under 50% Impervious

Project: Prison Site Location Study
Proj. No.: **By:** Ken Engstrom
Date: 10/7/2008 **Revised:** 10/29/2008
2 Year Return Storm Event
V:\52863\active\186302095\design\analysis\storm\[LEED-6.1-rate-volume-calcs-prison-predesign-rev 20081029.XLS]under 50% impervious

B. Post-developed discharge quantity is not to exceed the pre-developed discharge quantity.

2 year - 24 hour Storm total runoff = 1.55 in. = 0.13 ft
C_{predev} = 0.20 $C_{postdev}$ = 0.84
A = 3,123,000 sf = 71.69 Acres, total site.

Predev V_{tot} = C_{predev} * total runoff * A = 80,678 ft^3

Postdev V_{tot} = $C_{postdev}$ * total runoff * A = 340,322 ft^3

Retention Volume Required: V_{retain} = Postdev V_{tot} - Predev V_{tot} = **259,644 ft^3**

C. Storage Volumes Provided:

Detention Pond Volume Estimate:

		width (ft)		length (ft)
Area (top) =	25088 ft^2	112	x	224
Area (bot) =	20808 ft^2	102	x	204
Depth =	2.5 ft			

Detention Pond Vol. = $(d/3)*A_T+A_B+(AT*AB)^{1/2}$ = **57,287** ft^3
This is greater than 56,719 ft^3 required.

Retention Pond Volume Estimate:

		width (ft)		length (ft)
Area (top) =	55278.125 ft^2	166	x	332.5
Area (bot) =	48828.125 ft^2	156	x	312.5
Depth =	5 ft			

Retention Pond Vol. = $(d/3)*A_T+A_B+(AT*AB)^{1/2}$ = **260,099** ft^3
This is greater than 259,644 ft^3 required.

Notes:
1. The above figures are for a 10,000 bed facility.
2. 2 - year return period is used.
3. This detention storage provides the post development runoff to match the pre-developed runoff rate.

Figure 3.11

Detention/Retention Storage

Project: Prison Expansion
Proj. No.: 186302095 **By:** Dave Barrett
Date: 10/6/2008 **Revised:** 10/29/2008
10 Year Return Storm Event
V:\52863\active\186302095\design\analysis\storm\[detention-volume-calcs-pre-design-rev 20081029.XLS]Sheet 1

Runoff Coefficient:

Desc.	Area (A)*	Coeff. (C)	CA
Roof	2,571,000	0.85	2,185,350
Pavement	452,000	0.95	429,400
Landscape	100,000	0.2	20,000
Sum =	3,123,000		2,634,750
=	71.69 Acres, total site.		

"C" = **0.84**

Allowable Discharge Rate:
A = 71.69 acres
i = 1.8 in/hr (assumes 15 min. time of concentration)
C = 0.20 (Pre-developed runoff rate assuming all landscaping)

Q = CiA = 25.81 cfs

Post Development Discharge Ra
A = 71.69 acres
i = 1.8 in/hr
C = 0.84

Q = CiA = 108.87 cfs

Calculate Detention Storage Volume
Allowable Discharge Rate: 25.81 cfs. (Pre-development Rate)
Add infiltration rate for pond sizing: Percolation rate= 1000000 minutes/inch= 1.39E-09 cfs/sf
(if approprate) (1min/in=.001389 cfs/sf)
Percolation Area: 6 ft. x 1890 ft. x = 11340 sf.
Percolation Rate: 11340 sf. X 0.00000 = 0.00 cfs.

Total Discharge Rate for detention sizing: 25.81 + 0.00 = **25.81 cfs.**

Elapsed (min.)	Total (in.)	(cu.ft.)	Discharge (cu.ft.)	Req'd (cu.ft.)
15	0.45	98803	23229	75574
30	0.62	136129	46458	89671
60	0.79	173454	92916	80539
360	1.51	331539	557495	-225955
720	1.86	408386	1114989	-706603
1440	2.23	489624	2229978	-1740354

Discharge = Time x Qall
Storage = Runoff - Discharge

Required Detention Storage =
89,671 cu.ft.

Orifice Size:
Max. Orifice Head (H, ft.) = **5** ft.
Orifice Coefficient (C) = **0.6**
Orifice Diameter (in.) = **20.96**

Qall = CA (2gH)^0.5 Solving for "A"
A = 2.3972 s.f. = **345.20** sq. in.

Orifice sized for head when pond is full.

CStorage Volumes Provided:

Detention Pond Volume Estimate:

Area (top) = 33489 ft^2 (183' x 183') 183
Area (bot) = 27225 ft^2 (165' x 165') 165
Depth = 3 ft
Detention Pond Vol. = $(d/3)*A_T+A_B+(AT*AB)^{1/2}$ = **90,909** ft^3
This is greater than 89,671 ft^3 required.

Notes:
1. The above figures are for a 10,000 bed facility.
2. 10 - year return period is used.
3. No storm water retention is included.
4. This detention storage provides the post development runoff to match the pre-developed runoff rate.

Figure 3.12

GEOLOGIC AND SOILS CONDITIONS

Geologic data availability for the Rush Valley area is limited, however a general geologic and soils investigation of available published literature was conducted. General geologic and soil conditions at the site were determined from the Natural Resource Conservation Service (NRCS) soil mapping data, Utah Automated Geographic Reference Center (AGRC) Geologic Hazards Layer and 1:100,000 scale US Geologic Survey (USGS) Geologic maps. See Figure 3.13 and Figure 3.14 for the geologic map and soils map.

The Utah AGRC geologic hazards map provides information on geologic hazards such as: Liquefaction, Surface Fault Rupture, Landslides, Rock Fall, Alluvial-Fan Flooding, and Problem Soils. No specific geologic hazards were identified at this site. The USGS Geologic maps describe the local deposits as unconsolidated Quaternary colluvium and alluvium (Qag) and conglomeratic deposits of uncertain age with low to high permeability (QTu). Deposits consist of a sand gravel conglomerate that includes a veneer of windblown sand.

The NRCS soils report identifies two types of soils on the site these consist of: Hiko Peak gravelly loam, 2 to 15 percent slopes (Map Unit 21) and Taylorsflat loam, 1 to 5 percent slopes (Map Unit 64). The majority of the soil on the site is Hiko Peak gravelly loam. This soil is formed from alluvial deposits and is classified as well drained. The soil has a low shrink swell potential and has no zone of water saturation within a depth of 72 inches. The soil is classified as "very limited" because it is not suitable for construction of small commercial buildings when slopes are steep. This is not an issue, however, on the proposed prison site, which has an average slope of only 3%. The soil map unit has slopes that vary from 2% to 15%. The building impairment is likely to occur at slopes greater than 8%.

The organic matter content in the surface of Hiko Peak soils is approximately 2 percent and the calcium carbonate equivalent within 40 inches of the surface typically does not exceed 35 percent. The soil has a moderately sodic horizon within 30 inches of the soil surface. The natural ecological site is classified as a Semidesert Gravelly Loam (Wyoming Big Sagebrush). The natural desert plant community consists of: Bluebunch wheatgrass, Wyoming Big Sagebrush, Indian Ricegrass, Shadscale, Bottlebrush Squirreltail, and Low Rabbitbrush.

Hiko Peak soil is classified as very limited for lawns and landscaping due to: sodium content, gravel content, slope, and large stones content. For irrigation yields, Hiko Peak soils are classified as type 4e, soils that have severe limitations that restrict the choice of plants or that require very careful management due to erosion potential. It is likely that erosion controls will have to be employed at the prison site.

The Taylorsflat loam soil, which is also at the site has similar engineering and agricultural characteristics but consists of mixed alluvial and lacustrine deposits.

These soil descriptions are general classifications using generalized maps. A detailed geotechnical investigation of the site including test pits, samples, and soil classification will be required.

SITE UTILITY LAYOUT AND DISTRIBUTION

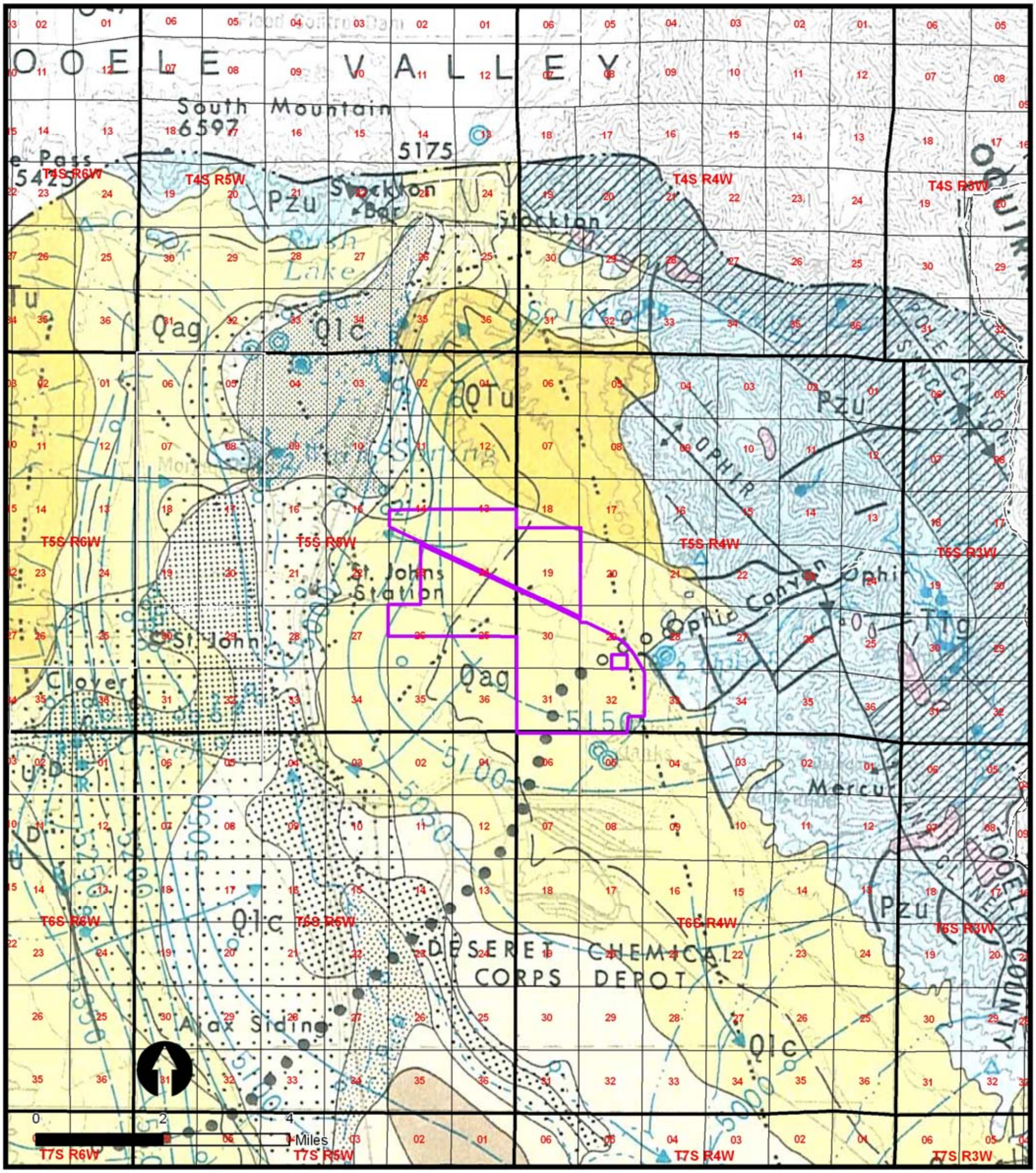
The following description was used in cost estimating and coordination of different proposed improvements.

Culinary Water

In order to bring potable water to the site, two wells are proposed east of the facility which would supply two storage tanks. These tanks will then deliver water to the site through a 12 inch main line water/ fire line. Once the line reaches the facility it would split and run toward the women's and men's portions of the prison. A 12 inch water/ fire loop will extend around the outer perimeter of both the women's and men's facilities. Water valves will be installed at approximately a 300 foot interval. Fire hydrants will be placed around the site. A 6 inch fire lateral and a 4 inch culinary lateral will extend from the loop to each building. Metering will be done at the well and tank location. Sizes are estimates only and may change as the design proceeds.

Sanitary Sewer

Estimated 6 inch sewer laterals are expected to sewer each building. These will run through individual sewage grinders before entering a sewer main line which will run to the north-west. Grease traps will also be installed on each building. The sewer for both the women's and men's portion of the prison will combine



Geologic Site Map

Prison Site Location Study - Rush Valley, Utah

Stantec Consulting Inc.
3995 S 700 E, Ste. 300
Salt Lake City, UT
84107-2540
Tel. 801.261.0090
Fax. 801.266.1671
www.stantec.com

QTu - Deposits and surfaces of uncertain age
QAg - Colluvium and alluvium
Pzu - Sedimentary Rocks
Qlc - Lakebed sediments

Notes:
USGS Geologic Map 1:100,000 scale

Figure 3.13 *Geologic Map*

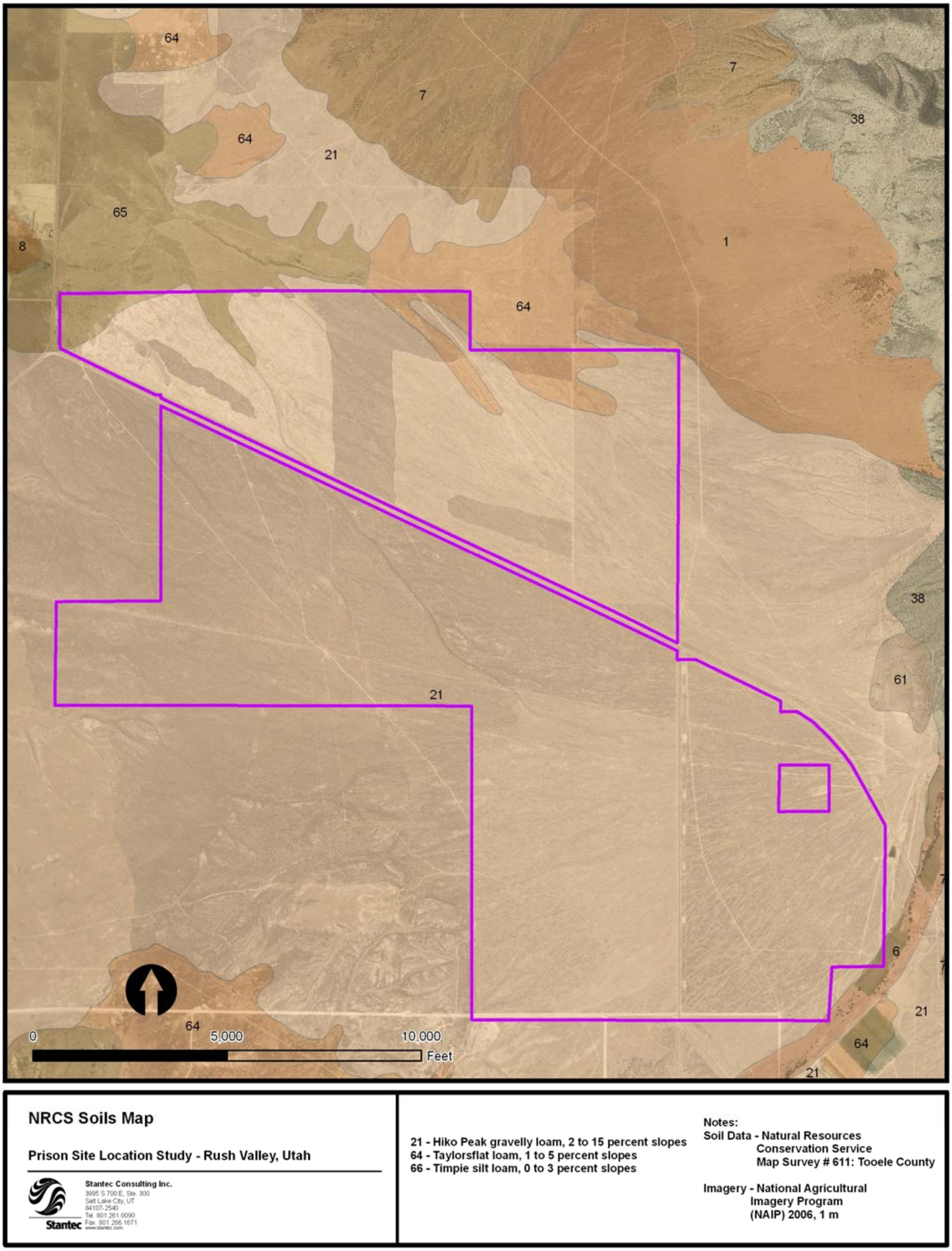


Figure 3.14 *NRCS Soils Map*

approximately 1200 feet to the west and enter a new sewer treatment facility. This facility will consist of a treatment plant and a wastewater pond.

Storm Drain

Storm drain lines have been conceptually sized to handle a 10-year storm. Storm drain inlets will be placed around the site in order to direct surface runoff into the storm drain system in order to avoid ponding and surface erosion. 15 inch to 36 inch diameter pipes will carry storm water to the northwest and terminate in ponds west of the women's and men's portions of the prison. A 1.0 acre-foot detention pond will serve the women's facilities and a 4.0 acre foot detention pond will serve the men's facilities. The ponds will then be discharged in a manner so as not to cause erosion of the existing natural area to the north-west. This storm water will need to be kept separate from the treated waste water according to state regulations.

Natural Gas

An existing gas transmission line runs along the roadway corridor splitting the women's and men's facilities. A new 8 inch diameter main will connect to this transmission line and run to a new gas meter near the main entrance. After the meter this main will then be split and continue with 6 inch lines and run toward the women's and men's portions of the prison. The men's facilities will have a 6 inch loop which will extend around the perimeter with laterals to each building. Isolation valves will be installed every 300 feet.

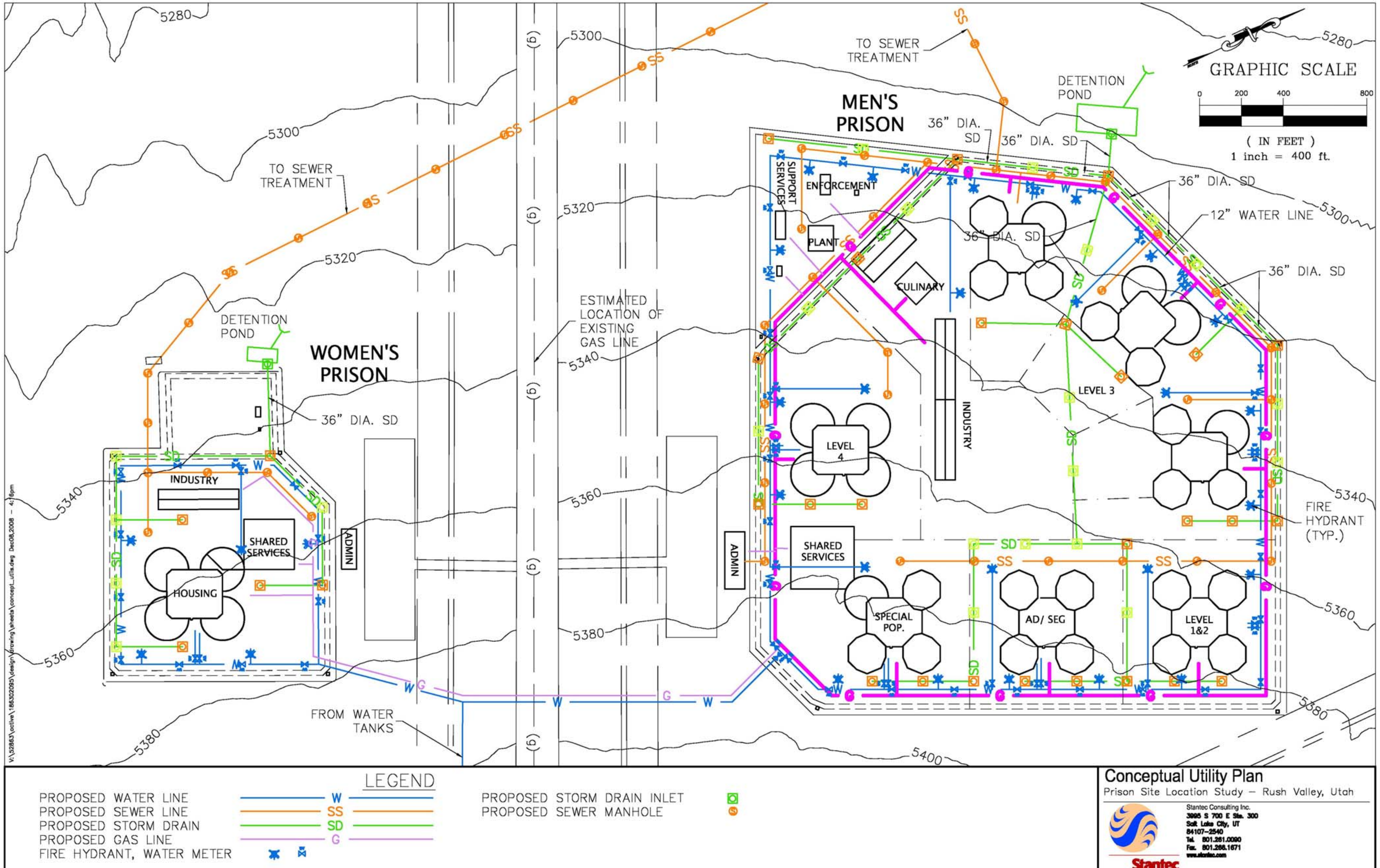


Figure 3.15 ***Conceptual Utility Plan***

SECTION IV: PRISON ELECTRICAL LOAD

NEW PRISON CAMPUS ELECTRICAL LOAD OVERVIEW

The current maximum demand load reported by Rocky Mountain Power at the Draper Prison site is in the 3.7 to 5 Mega Watt range (4,700-5,000 kW). Given the overall maximum expansion capacity of the new proposed prison site, we should anticipate from preliminary load analysis that the demand load for the new facility would be in the 10 to 15 Mega Watt range. There is a tremendous amount of variance potential in this estimate, given the current load status of the existing prison, how much energy is contributed geothermally, and what energy usage demands could change over the next 20 to 50 years. So, for the purpose of this study, a nominal demand load of 12 Mega Watts will be used in our comparative analysis.

EXISTING PRIMARY POWER AVAILABILITY

Spectrum Engineers conducted several interviews with representatives of PacifiCorp's Rocky Mountain Power regarding potential distribution service to a new prison facility located at the intersections of Utah State Routes 36 and 73 in Rush Valley, Utah.

Our first inquiry related to available transmission delivery voltages that existed in the area (either 46kV or 138kV). Rocky Mountain Power stated that at this time there is not a 138kV source anywhere close to this area. To determine what utility work would need to be implemented to provide 138kV service, the facility would require a feasibility study on the part of Rocky Mountain Power. Since the available voltage on the Primary Hi-Line really only affects line losses to the utility and the input primary voltage of the prison's substation transformers, it did not pose a major stumbling stone regarding a preliminary recommendation for substation design. If and when the project actually comes to fruition, a hi-line feasibility study on the part of Rocky Mountain Power would prove prudent.

As of today it appears that there is capacity on the existing 46kV system fed from the Tooele substation that would handle the initial on-line load of 3 to 5 Mega Watts. However, when the prison expands to its full capacity of 10,000 inmates, the Tooele substation and associated radial distribution system would require major upgrades. Rocky Mountain Power stated that a load of this magnitude would require upgrades to the overhead distribution lines as the line serving the intersections of Utah State Routes 36 and 73 is currently subject to significant voltage loss due to the distance from the Tooele substation. Rocky Mountain Power confirmed the distribution lines at the sub station would require some mitigation. A potential solution would be to install a load tap changer on the substation transformer or some type of voltage regulation at the prison's substation secondary taps.

For transmission delivery, and to receive the best utility rate possible, Rocky Mountain Power primary customers are required to build, own, maintain and operate their own substation. In addition, the customers are responsible for ALL the costs to bring the transmission line to their substation from its current available tap point. The proposed project site at the intersections of Utah State Routes 36 and 73 in Rush Valley, Utah is about 20 miles from Tooele. According to Rocky Mountain Power, the cost per mile of line for transmission line distribution construction is approximately $1.3 million per mile (a very rough estimate), and this does not included the expenses to secure rights-of-way. In urban areas, right-of-way easements could easily double the costs of line construction. Also, these numbers provided by Rocky Mountain Power are based on current 2008 construction costs and the Utility conceded these numbers could increase significantly in the next 10 years.

To provide distribution delivery at 12,470 volts, Rocky Mountain Power's nearest source is at Rush Valley, which is currently a very small substation. The Rush Valley substation is already very close to maximum capacity and a project of this magnitude would require its total reconstruction. The approximate distance from the Rush Valley substation to the proposed facility site is less than 3 miles, but no current three-phase line exists to the site. A totally new overhead line would need to be constructed to the proposed prison site at the intersections of Utah State Routes 36 and 73. The cost per mile for distribution line construction at 12,470 volts is approximately $350,000 per mile based on 2008 dollars and does not include costs to secure rights-of-way. An advantage to this scenario is that when power is delivered to the customer at the distribution service level (12,460 Volts), the Rocky Mountain Power Company would fund the line extension and upgrades up to a pre- negotiated allowed maximum with the Department of Corrections which is determined by taking 16 months of the monthly revenue the customer is expected to generate.

Rocky Mountain Power is currently in the process of determining site routing for new transmission lines at 138kV from Mona through Tooele County to provide an interconnect and supplemental with Rocky Mountain Power's Oquirrh substation located in West Jordan. Depending on the exact final site location and orientation, these new transmission level lines could foreseeably have a positive impact on the Department of Corrections long term plans for this proposed prison site. Rocky Mountain Power stated during an oral interview that this utility construction project is still pending the environmental impact study by the Bureau of Land Management (BLM) and a preferred route has yet to be determined.

Rocky Mountain Power also stated the utility has several plans for other significant system improvements over the next few years that may have a positive affect for the proposed project site. However, the utility would not discuss details of these plans stating their master plans are internal to the company and, until funded, could not be made public.

Utility Primary Power Redundancy

Of major concern is the fact that once we achieve transmission level service to the proposed site, it will ONLY be a single three-phase radial feeder from one transmission line fed from a single substation. So the potential of a twin feed substation design with dual redundant utility primary feeders is not even on the table for consideration. Based on that assumption, which is founded in firm fact directly from Rocky Mountain Power, this preliminary study would recommend a single utility input feed to the substation with the prison's own integral co-generation station. The details and advantages of co-generation are addressed later in this study, but for the purpose of conceptualizing a substation design for estimating purposes, we will assume a single utility input with a synchronized co-generation power plant located near the campus physical plant and in close proximity to the prison's substation

A very rough estimate for the cost of a substation of this size is around $2 million.

Campus Secondary Site Distribution

The recommended secondary site distribution from the substation throughout the prison campus should distribute at 15kV (12,460 volts) three-phase four wire. The secondary distribution should consist of a dual redundant loop, with each set of twin loop feeders sized to carry the maximum demand load of the entire facility. This token ring dual feeder concept would allow the maintenance staff to switch load connections between alternate feeders for repairs, and still leave the entire campus under full power capability feed from either direction on the loop. By providing a token ring dual redundant campus loop, any individual section of secondary distribution could be completely isolated for maintenance and servicing reasons with no loss of power.

The overall concept for the looped dual redundant secondary 15kV distribution system would be to feed the loops from the campus substation with twin duct banks, looped around the male site and interconnected across State Route 73 to the female campus, looping the female site. The twin duct banks would encircle each campus. Twin manholes would be placed at no more than 400-foot centers to facilitate conductor-pulling needs, and to accommodate any major changes in direction. The concept of the dual duct banks and manholes has huge merit because either redundant loop could be taken off line, with absolutely no interruption in power, and the off line conductors could be serviced in the manholes with no energized conductors in the manhole, a huge safety consideration.

At each major facility within both campuses, or loop tap point, this study would recommend installation of 15kV underground distribution switchgear. This style of low profile equipment would prove very beneficial to the overall security concept of the campus, as there would be a minimum profile for an escapee to hide behind.

The industry leader in this type of underground distribution switchgear is the S&C Corporation. Rocky Mountain Power utilizes S&C medium voltage distribution equipment exclusively because of its reliability, serviceability, and proven long-term industry track record of high performance.

The low profile, pad mounted style, of this of switchgear is illustrated in figure 4.1.

S&C also manufactures a zero profile vault mounted style of 15kV switchgear that would be even more beneficial to the prison from a security standpoint because none of the equipment is above grade, leaving nowhere for an escapee to hide, see figure 4.2.

Figure 4.3 from S&C illustrates the at-grade servicing of a typical vault mounted underground distribution 15kV switchgear, with all the equipment underground.

Figure 4.2: *Typical S&C 15kV Vault Mounted Distribution Switchgear*

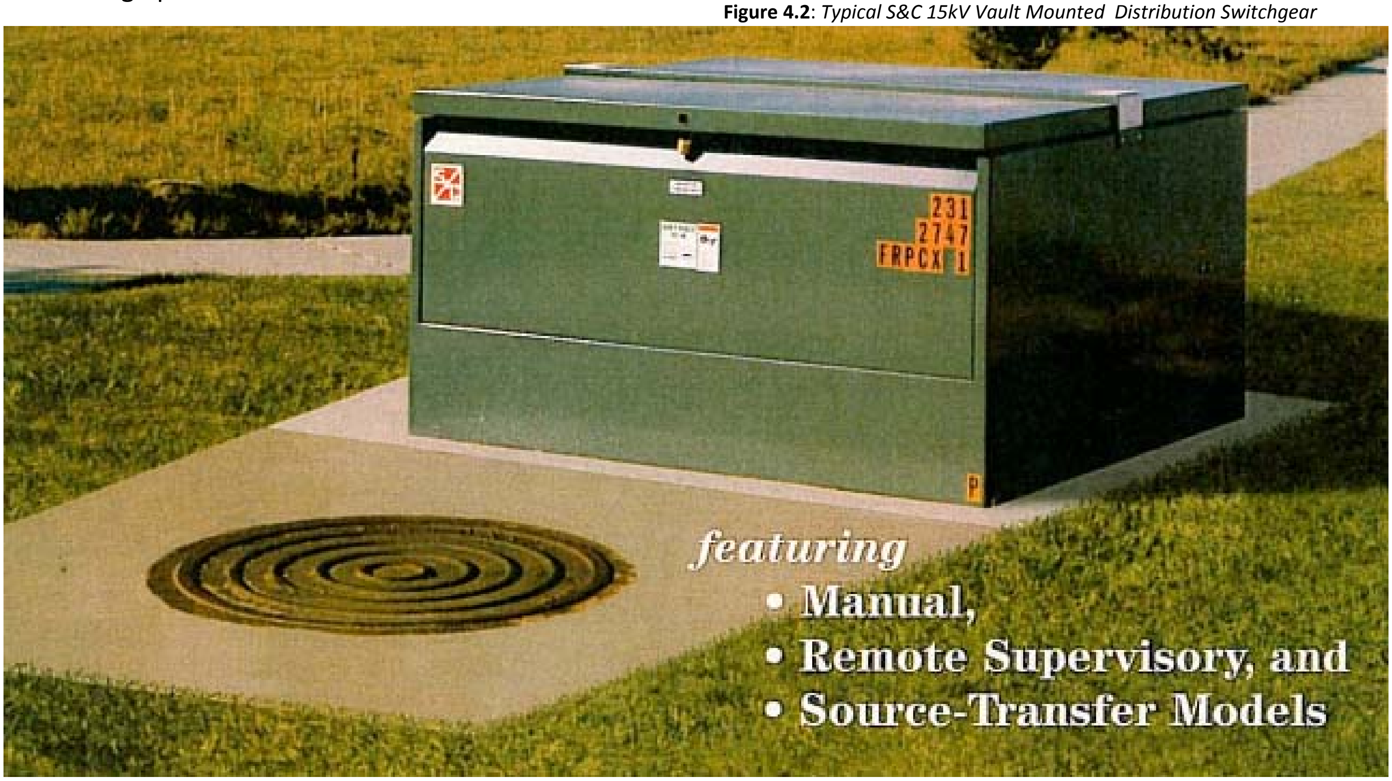


Figure 4.1: *Typical S&C Low Profile Pad Mounted 15kV Distribution Switchgear.*

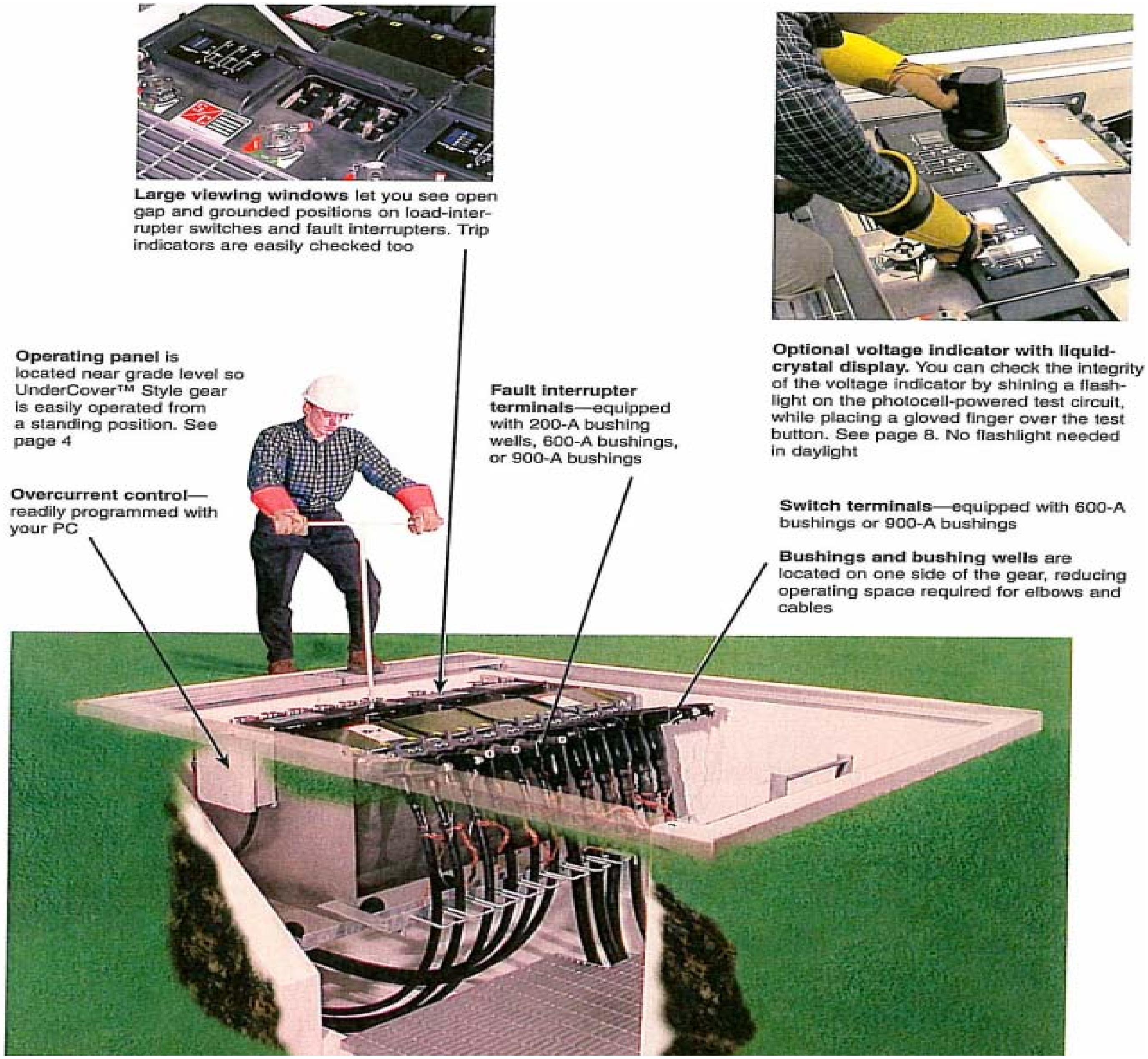


Figure 4.3: *Typical Cross Section View of S&C Low Profile Pad Mounted 15kV Distribution Switchgear.*

Load interrupter switches in the vaults would provide three-pole simultaneous switching of the connected loads with no measurable loss of power downstream. The individual switches would have three positions (Open, Closed, and Grounded) and would provide a clearly visible “Gap” when opened to ensure safe serviceability.

Arc-spinning technology from S&C would be recommended for fault interruption to reduce the above grade profile of the vault mounted equipment by over 12” if the pad mounted units were chosen over the vault mounted units.

At each facility, the 15kv Distribution Switchgear would be load tapped with a radial facility feeder distributing 15kV power to the individual building transformer. Again the individual building transformers could be vault mounted to provide a clear view of the site, or the individual building electrical rooms could be designed with small unit substations inside the facilities to accommodate the interior installation of the transformers.

The 15kV secondary side distribution voltage would then be transformed at each building to 277/480 Volt building distribution voltages within the interior of each building.

A generator room would house an emergency standby generator within each facility to provide standby emergency power to each individual facility. The generator distribution and transferring scheme in each individual facility could be designed to allow and accommodate the generators synchronizing with the campus loop, and when operating in a power outage situation, actually back feeding the entire campus loop in harmony, much like the current configuration at Draper.

PERIMETER LIGHTING AND ILLUMINATION FOR ROADS AND FENCING

The ultimate goal in the design of lighting the perimeter fence and yard at any Correctional Facility is straightforward and simple: prevent escapes. Over the years, most Correctional Facilities have learned that inmates can be quite creative when plotting and carrying out a prison break.

The fences are the last obstacles prisoners would generally encounter during an escape attempt. Any lighting design should consider the alternatives required to provide the guards in the sites guard towers with as much light as possible without creating glare. The design should also want to help them distinguish colors so they could determine which inmates were involved in a potential escape.

State of the art prison site exterior site illumination techniques should employ 100-ft high-mast lighting systems installed along the perimeter fencing and also in the inmate-occupied yards. The fenced site at the proposed Rush Valley Institution is split into two large fenced areas, one for a eventual male population of approximately 8,500 inmates, and one for a separately fenced female population of 1,500 inmates. The combined sites cover an area of over 100 acres, with about 25% of that space currently programmed and devoted to yard. Inmates will have access to the yard area for recreation and exercise, with parts of the yard used as a sports field. Computer Aided Lighting Analysis (CALA) software should be employed during the actual design phase of the project to determine exact pole placement and how high the luminaires should be mounted and how they should be aimed. Current programming concepts would employ sixteen to twenty high-mast poles mounted throughout the yard areas with each pole utilizing ten to twelve 400-W metal halide luminaires mounted on each pole, depending on location and orientation. Yard poles would be spaced 350 to 370 ft apart, with light levels at 3-5 foot candles minimum maintained.

Yard areas should always be a concern from a security standpoint because the perimeter fence is located so far from the buildings. Any designed lighting system should have an ultimate goal of supplying enough light so guards can detect any movement in the yard, yet attempt to use as few poles as possible to avoid obstructing the guards' views. Each guard’s limit of vision should be confined to looking across no more than 900 ft of space from the tower locations.

Perimeter fence illumination should be achieved with an appropriate number of high-mast poles mounted along the fence line with each pole utilizing 10 to 12 400-W metal halide luminaires mounted on each pole, depending on location and orientation. Ideally, these fence line poles would be located 6 to 10 feet outside the fence line and nominally be spaced 300 to 350 ft apart, with light levels in the 2-3 foot candle range minimum maintained.

Chase road illumination should be achieved with an appropriate number of high-mast poles mounted along the chase roads with each pole utilizing ten to twelve 400-W metal halide luminaires mounted on each pole, depending on location and orientation. Ideally, these chase road poles would be located 10 to 20 feet off the paved area and alternating on each side of the road. The chase road fixtures should nominally be spaced 300 to 400 ft apart, with light levels in the 2-3 foot candle range minimum maintained.

Figure 4.4: *Typical nighttime fence line illumination level of 2-3 foot candles.*

Whether in the yard or along the fence line or chase roads, luminaires should be aimed to achieve considerable overlap to eliminate dark spots in case a lamp or two burns out. The installed units should utilize differing beam patterns so the light is directed exactly where it is needed, throughout the yard and across portions of the roof where inmates may potentially gain access. Precise exterior site light control also prevents unwanted site illumination from infiltrating building interiors. All site luminaires should be controlled by a photocell and should be illuminated from dusk to dawn.

To facilitate ease of maintenance, each high-mast pole should be designed to include an internal winch and drive motor that lowers the luminaires to within 3 ft of the ground for ease of servicing and routine maintenance.

Utilization of a self-centering guiding tram will allow the lowering of units in winds up to 30 miles per hour. All moving latching components should be designed so they are mounted on the lowering ring so they may be serviced on the ground.

Figure 4.5: *Typical high mast fixture lowering device*

Maintenance protocols should mandate for the high-mast system site illumination fixtures to be group re-lamped to avoid burned out lamps and ensure maximum performance and illumination reliability.

GENERATOR SYSTEM OPTIONS FOR A COGENERATION PLANT

The next section of the study will address various options for power generation available for consideration in a proposed Main Campus Co-Generation Power Plant. This analysis will first analyze generation system options and potential fuel sources.

Gas-Fired Reciprocating Engines

We begin our generator option discussions by considering the emergency power generation systems that the Department of Corrections currently utilizes at other facilities to generate emergency power in its existing prisons.

Direct hydrocarbon gas-fired (#2 diesel fuel) reciprocating engines utilized as the prime movers to drive generator sets are most commonly used for on-site electric generation in smaller commercial applications. These types of engines are more commonly known as internal combustion engines. They convert the energy contained in fossil fuels into mechanical energy, which rotates a piston driving a prime mover to generate electricity. Diesel-fired reciprocating engines typically generate from less than 5 kW, up to 7 megawatts (MW), meaning they can be used as a small-scale residential backup generator, or to a base load generator in industrial settings. Diesel-fired reciprocating engines offer efficiencies from 25 to 45 percent, and can also be used in a Combined Heat and Power (CHP) system to increase energy efficiency. Combined Heat and Power (CHP) applications will be detailed later in this study.

Research indicates the most efficient generation process using Gas-Fired Reciprocating Engines would be to utilize natural gas in a Combined Heat and Power (CHP) application, where the heat generated from the combustion process is captured and redirected for other uses. There are a large number of generator and fuel options available for consideration. Some of the commercially tested systems are by General Electric and Jenbacher. Product information on these units is provided for illustration in the Appendices of this report.

Figure 4.6: *Typical 3 to 5 megawatt range gas-fired Jenbacher reciprocating engine generator set.*

Steam Generation Units

Natural gas can be used to generate electricity in a variety of ways. The most basic natural gas-fired electric generation consists of a steam generation unit, where fossil fuels are burned in a boiler to heat water and produce steam, which then turns a turbine to generate electricity. Natural gas may be used for this process, although these basic steam units are more typically a major utility utilizing large coal or nuclear generation facilities. These basic steam generation units have fairly low (poor) energy efficiency. Typically, only 33 to 35 percent of the thermal energy used to generate the steam is converted into electrical energy in these types of units. The feasibility of using a steam generation system in this case is doubtful; however, if steam generated at the prison's main physical plant were used to drive a prime mover, this option may be within the realm of possibility.

Centralized Gas Turbines

Direct-fired industrial gas turbines or traditional internal combustion engines are also used as prime movers to generate electricity. In these types of applications, instead of heating steam to turn a turbine, hot gases from burning fossil fuels (particularly natural gas) are used to turn the turbine and subsequently generate electricity. Gas turbine and internal combustion engine plants are traditionally used primarily for handling peak-load demands. A major benefit of direct-fired units is the ability to quickly and easily turn them on. These types of plants have increased in popularity due to advances in technology and the availability of natural gas. However, they are still traditionally slightly less efficient than large steam-driven power plants.

Combined Cycle Units

Many of the new natural gas-fired power plants are what are known as "Combined-Cycle" units. In these types of generating facilities, there is both a gas turbine and a steam unit, all in one. The gas turbine operates in much the same way as a normal gas turbine, using the hot gases released from burning natural gas to turn a turbine and generate electricity. In combined-cycle plants, the waste heat from the gas-turbine process is directed towards generating steam, which is then used to generate electricity much like a steam unit. Because of this efficient use of the heat energy released from the natural gas, combined-cycle plants are much more efficient than steam units or gas turbines alone. In fact, combined-plants can achieve thermal efficiencies of up to 50 to 60 percent.

Distributed Generation

With distributed generation, turbines are located in close proximity to where the electricity will be consumed. Industrial turbines—producing electricity through the use of high temperature, high-pressure gas to turn a turbine (prime mover) that generates a current—are compact, lightweight, easily started, and relatively simple to operate. Distributed generation is commonly used by medium- and large- sized commercial establishments, such as universities, hospitals, large commercial buildings, and industrial plants. These systems are typically 21 to 40 percent efficient.

However, with distributed generation, the heat that would normally be lost as waste energy can easily be harnessed to perform other functions, such as powering a boiler or space heating. This is known as Combined Heat and Power (CHP) Systems. This option for a Central Campus Generation Plant seems to provide a viable and energy conscious alternative. Below is a discussion of the advantages of Combined Heat and Power (CHP) Systems followed by a discussion of the options of both direct-fire gas turbines and traditional combustion engines as the prime movers to turn our generators.

Combined Heat and Power (CHP) Systems

Using energy efficiently has become a national goal across industries in the past decade. Driven by rising energy prices, an increasingly competitive marketplace, and environmental regulation of harmful pollutant emissions, commercial and industrial energy users are searching for the most efficient and cleanest energy sources. One innovation finding rapid and abundant commercial and industrial application is what is known as Combined Heat and Power (CHP) Systems. Essentially, this type of system recovers the waste heat from the burning of fossil fuels to generate electricity and applies it to power another process. For example, a basic Combined Heat and Power System might generate electricity through a large gas-fired turbine. The generation of this electricity would produce a great amount of waste heat. A Combined Heat and Power System might apply that waste heat to fire an industrial boiler instead of allowing this heat to escape into the atmosphere. In this way, more of the energy contained in the natural gas is used than with a simple gas turbine. This increases energy efficiency, which implies that less energy is needed to begin with (costing the user less), and fewer emissions are generated because a smaller amount of natural gas is used. Typically, a Combined Heat and Power System produces a given amount of electricity and usable heat with 10 to 30 percent less fuel than would be needed if the two functions were separate. A typical electric generation facility may achieve up to 45 percent efficiency in the generation process, but with the addition of a waste heat recovery unit, can achieve energy efficiencies in excess of 80 percent.

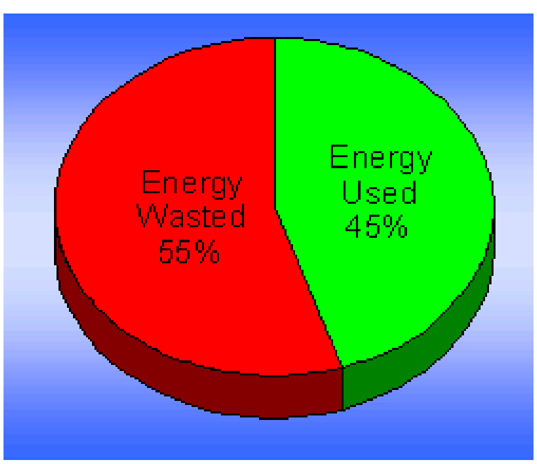


Figure 4.7: *Energy Efficiency in a Regular Electric Generation Facility*

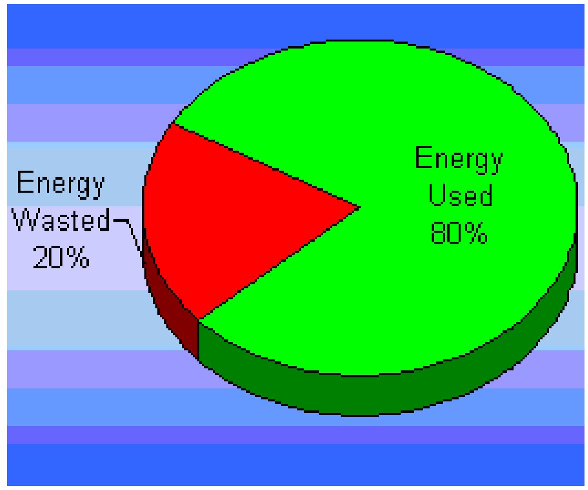


Figure 4.8: *Energy Efficiency in a Combined Heat and Power Generation*

Combined Heat and Power Systems (CHP) can be implemented to produce as much as 300 megawatts (MW) of electricity, to as little as 20 kilowatts (kW) of electricity, depending on the electrical and usable heat needs of the facility. It is not uncommon for larger cogeneration units to be installed in a facility that has very high space and water heating requirements, but lower electricity requirements. Under this scenario, the excess electricity is easily sold back to the local electric utility.

Types of Combined Heat and Power Systems

A typical (CHP) consists of an electric generator, which is driven by a gas turbine, steam turbine, or traditional combustion engine. In addition to this electric generator, a waste heat exchanger is installed with the generation package, which recovers the excess heat or waste exhaust gas from the electric generator to in turn generate steam or hot water.

There are two basic types of Combined Heat and Power Systems. The first is known as a “Topping Cycle System,” where the system generates electricity first, and the waste heat or exhaust is used in an alternate process, and the second is known as a “Bottoming Cycle System,” usually seen in industrial process plants and described below.

Four types of Topping Cycle Systems exist. The first, known as a “Combined-Cycle Topping System,” burns fossil fuel in a gas turbine or combustion engine to generate electricity. The exhaust from this turbine or engine can either provide usable heat, or go to a heat recovery system to generate steam, which then may drive a secondary steam turbine.

The second type of Topping Cycle System is known as a "Steam-Turbine Topping System." This system direct burns fuel to generate steam, which then generates power through a steam turbine. The exhaust (left over steam) can be used as low-pressure process steam, to heat water for example.

The third type of Topping Cycle System, "Absorption Recovery Topping System," consists of an electric generator in which the engine jacket cooling water (the water that absorbs the excess emitted heat from an internal combustion engine) is run through a heat recovery system to generate steam or hot water for space heating.

The fourth, and last type of Topping Cycle System, is known as a "Gas Turbine Topping System." This system consists of a natural gas-fired turbine, which as the prime mover drives a generator that produces electricity. The exhaust gas flows through a heat recovery boiler, which can convert the exhaust energy into steam, or usable heat.

While Topping Cycle Systems are the most commonly used Combined Heat and Power Systems (CHP), there is another type of Combined Heat and Power System (CHP) known as "Bottoming Cycle Systems." This type of system is the reverse of the above systems in that excess heat from a manufacturing process is used to generate steam, which then produces electricity.

These types of systems are common in industries that use very high temperature furnaces, such as the glass or metals industries. Excess energy from the industrial application is generated first, and then used to power an electric generator. If the capability to utilize excess or waste steam from the campus Physical Plant is an option, a "Bottoming Cycle System" may be worthy of additional evaluation.

In addition to these two types of systems, fuel cells may also be used in a Combined Heat and Power System (CHP). Fuel cells can produce electricity using natural gas, without combustion or burning of the gas. However, fuel cells also produce heat along with electricity. Although fuel cell Combined Heat and Power Systems (CHP) are still in their infancy, it is expected that these applications will increase as the technology develops. Natural Gas Fuel Cells will be additionally briefed in the following section.

Figure 4.9: *A Test Fuel Model Cell Cogeneration Plant at Miramar Naval Air Station*

Natural Gas Fuel Cells

Fuel cells powered by natural gas are an exciting and promising new technology for the clean and efficient generation of electricity. Fuel cells are still in development and are fast approaching commercial viability. Depending on when a new prison is built, they may well be the preferred solution for providing power to the prison. Fuel cells have the ability to generate electricity using electrochemical reactions as opposed to combustion of fossil fuels to generate electricity. Essentially, a fuel cell works by passing streams of fuel (usually hydrogen) and oxidants over electrodes that are separated by an electrolyte. This produces a chemical reaction that generates electricity without requiring the combustion of fuel, or the addition of heat as is common in the traditional generation of electricity. When pure hydrogen is used as fuel, and pure oxygen is used as the oxidant, the reaction that takes place within a fuel cell produces only water, heat, and electricity. In practice, fuel cells result in very low emission of harmful pollutants, and the generation of high-quality, reliable electricity. The use of natural gas-powered fuel cells has a number of benefits, including:

- ***Clean Electricity*** - Fuel cells provide the cleanest method of producing electricity from fossil fuels. While a pure hydrogen, pure oxygen fuel cell produces only water, electricity, and heat, fuel cells in practice emit only trace amounts of sulfur compounds, and very low levels of carbon dioxide. However, the carbon dioxide produced by fuel cell use is concentrated and can be readily recaptured, as opposed to being emitted into the atmosphere.

- ***Distributed Generation*** - Fuel cells can come in extremely compact sizes, allowing for their placement wherever electricity is needed. This includes residential, commercial, industrial, and even transportation settings.

- ***Dependability*** - Fuel cells are completely enclosed units, with no moving parts or complicated machinery. This translates into a dependable source of electricity, capable of operating for thousands of hours. In addition, they are very quiet and safe sources of electricity. Fuel cells also do not have electricity surges, meaning they can be used where a constant, dependable source of electricity is needed.

- ***Efficiency*** - Fuel cells convert the energy stored within fossil fuels into electricity much more efficiently than traditional generation of electricity using combustion. This means that less fuel is required to produce the same amount of electricity. The National Energy Technology Laboratory estimates that, used in combination with natural gas turbines, fuel cell generation facilities can be produced that will operate in the 1 to 20 Megawatt range at 70 percent efficiency, which is much higher than the efficiencies that can be reached by traditional generation methods within that output range.

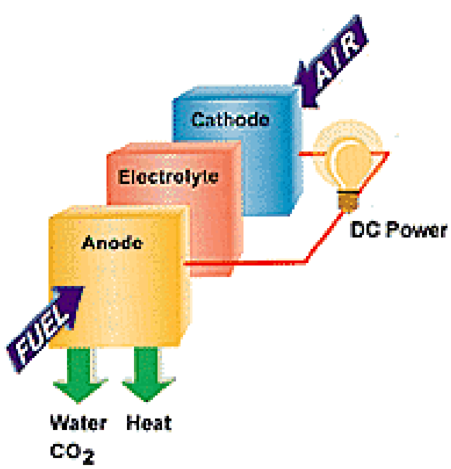


Figure 4.10: *How a Fuel Cell Works*
Source: DOE - Office of Fossil Energy

The generation of electricity has traditionally been a very polluting, inefficient process. However, with new fuel cell technology, the future of electricity generation is expected to change dramatically in the next ten to twenty years. Research and development into fuel cell technology is ongoing, to ensure that the technology is refined to a level where it is cost effective for all varieties of electric generation requirements.

While the concept of fuel cells has been around for more than 100 years, the first practical fuel cells were developed for the U.S. space program in the 1960s. The space program required an efficient, reliable, and compact energy source for the Gemini and Apollo spacecraft, and the fuel cell was a good fit. Today, NASA continues its reliance on fuel cells to power space shuttle vehicles. Because of technology improvements in recent years and significant investment by auto companies, utilities, NASA, and the military, fuel cells are now expected to have applications for distributed power generation within the next decade.

Figure 4.11: *A Typical 20kW Commercial Application Fuel Cell*
Photo Source: National Energy Technology Laboratory, Department of Energy

There are four primary fuel cell technologies. These include Phosphoric Acid Fuel Cells (PAFC), Molten Carbonate Fuel Cells (MCFC), Solid Oxide Fuel Cells (SOFC), and Proton Exchange Membrane Fuel Cells (PEMFC). The technologies are at varying states of development or commercialization. Fuel cell stacks utilize hydrogen and oxygen as the primary reactants. However, depending on the type of fuel processor and reformer used, fuel cells can use a number of fuel sources including gasoline, diesel, LNG, methane, methanol, and natural gas.

Natural gas (methane) is considered to be the most readily available and cleanest fuel (next to hydrogen) for distributed generation applications, so most research for stationary power systems is focused on converting natural gas into pure hydrogen fuel. This is particularly true for low-temperature fuel cells (PEMFC and PAFC). Here, fuel reformers use a catalytic reaction process to break the methane molecule and then separate hydrogen from carbon-based gases.

A fuel cell is similar to a battery in that an electrochemical reaction is used to create electric current. The charge carriers can be released through an external circuit via wire connections to anode and cathode plates of the battery or the fuel cell. The major difference between fuel cells and batteries is that batteries carry a limited supply of fuel internally as an electrolytic solution and solid materials (such as the lead acid battery that contains sulfuric acid and lead plates) or as solid dry reactants such as zinc carbon powders found in a flashlight battery. Fuel cells have similar reactions; however, the reactants are gases (hydrogen and oxygen) that are combined in a catalytic process. Since the gas reactants can be fed into the fuel cell and constantly replenished, the unit will never run down like a battery.

Fuel cells are named based on the type of electrolyte and materials used. The fuel cell electrolyte is sandwiched between a positive and a negative electrode. Because individual fuel cells produce low voltages, fuel cells are stacked together to generate the desired output for specified applications. The fuel cell stack is integrated into a fuel cell system with other components, including a fuel reformer, power electronics, and controls. Fuel cell systems convert chemical energy from fossil fuels directly into electricity. The image below shows the basic components of a generic fuel cell.

The fuel (hydrogen) enters the fuel cell, and this fuel is mixed with air, which causes the fuel to be oxidized. As the hydrogen enters the fuel cell, it is broken down into protons and electrons. In the case of PEMFC and PAFC fuel cells, positively charged ions move through the electrolyte across a voltage to produce electric power. The protons and electrons are then recombined with oxygen to make water, and as this water is removed, more protons are pulled through the electrolyte to continue driving the reaction and resulting in further power production. In the case of SOFC, it is not

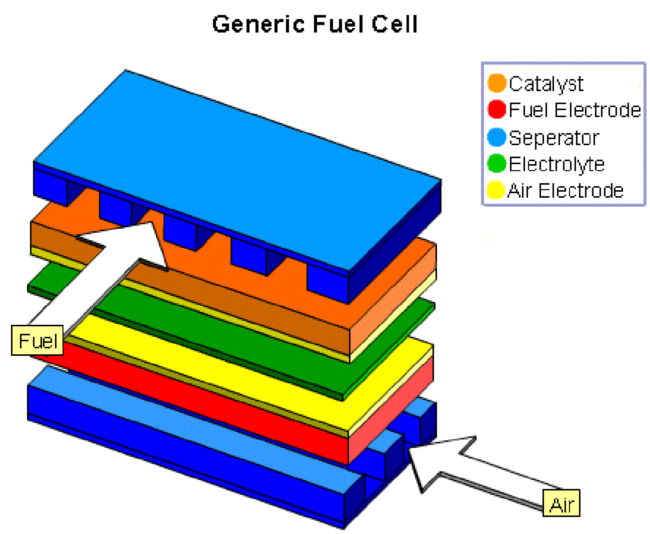


Figure 4.12: *A Typical Generic Fuel Cell*

Table 4.1: Fuel Cells Overview

	PAFC	SOFC	MCFC	PEMFC
Commercially Available	Yes	No	Yes	Yes
Size Range	100-200 kW	1 kW - 10 MW	250 kW - 10 MW	3-250 kW
Fuel	Natural gas, landfill gas, digester gas, propane	Natural gas, hydrogen, landfill gas, fuel oil	Natural gas, hydrogen	Natural gas, hydrogen, propane, diesel
Efficiency	36-42%	45-60%	45-55%	25-40%
Environmental	Nearly zero emissions	Nearly zero emissions	Nearly zero emissions	Nearly zero emissions
Other Features	Co-Gen (hot water)	Co-Gen (hot water, LP or HP steam)	Co-Gen (hot water, LP or HP steam)	Co-Gen (80°C water)
Commercial Status	Some commercially available	Likely commercialization 2010	Some commercially available	Some commercially available

protons that move through the electrolyte, but oxygen radicals. In MCFC, carbon dioxide is required to combine with the oxygen and electrons to form carbonate ions, which are transmitted through the electrolyte.

Given that the commercial applicability of fuel cell technology is still in development, it does not appear to be a currently viable solution for the Department of Corrections needs. If, however, construction on the prison is delayed for 5 to 10 years, this technology may be fully developed and ready for utilization.

Combined Heat and Power Applications

Combined Heat and Power Systems (CHP) have applications both in large centralized power plants and in distributed generation settings. Cogeneration Systems have applications in centralized power plants, large industrial settings, large and medium sized commercial settings, and even smaller residential or commercial sites. The key determinant of whether or not combined heat and power technology would be of use is the nearby need or purpose for the captured waste heat. While electricity may be transferred reasonably efficiently across great distances, steam and hot water are not as transportable. Heat that is generated from cogeneration plants has many uses, the most common of which include industrial processes and space and water heating. Those facilities that require both electricity and high temperature steam are best suited for Combined Heat and Power Systems (CHP), as the system can operate at peak efficiency. There are many industries that require both electricity and steam, for example, the pulp and paper industry is a major user of Combined Heat and Power Systems (CHP). Electricity is required for lighting and operating machines, while the steam is useful in the manufacturing of paper.

Many commercial establishments also benefit from Combined Heat and Power Systems (CHP). Universities, hospitals, condominiums, and office buildings all require electricity for lighting and electronic devices. These facilities also have high space and water heating requirements, making cogeneration a logical choice. For example, the University of Florida has an on-campus 42 MW gas turbine cogeneration facility that produces electricity and space and water heating for the campus.

Gas Turbine Engine Electrical Generation (Over 500 kW)

Conventional Combustion Turbine (CT) generators are a very mature technology. They typically range in size from about 500 kW up to 25 MW for Industrial and Commercial applications, and up to approximately 250 MW for central power generation. They are fueled by natural gas, oil, or a combination of fuels ("dual fuel"). Modern single-cycle combustion turbine units typically have efficiencies in the range of 20 to 45% at full load. Efficiency is somewhat lower at less than full load.

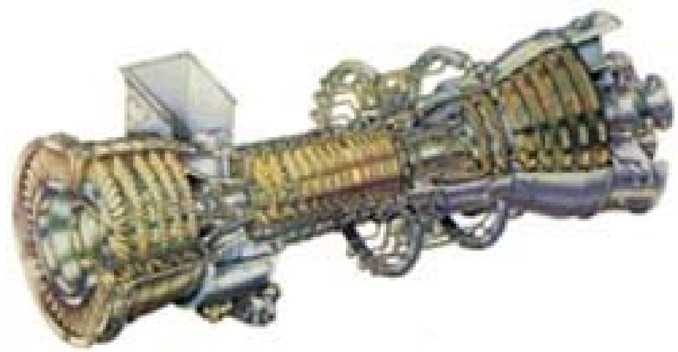


Figure 4.13*: A Typical Conventional Combustion Turbine Generator*
Photo Source: University of Florida

Table 4.2: Combustion Turbine Overview

Commercially Available	Yes
Size Range	500 kW - 25 MW
Fuel	Natural gas, liquid fuels
Efficiency	20-45% (primarily size dependent)
Environmental	Very low when controls are used
Other Features	Co-generation (gas or steam)
Commercial Status	Widely Available

There are three main components in a combustion turbine generator:

1. Compressor - incoming air is compressed to a high pressure.
2. Combustor - fuel is burned, producing high-pressure, high-velocity gas.
3. Turbine - energy is extracted from the high-pressure, high-velocity gas flowing from the combustion chamber.

Gas turbine systems operate in a manner similar to steam turbine systems except that combustion gases are used to turn the turbine blades instead of steam.

In addition to the electric generator, the prime mover turbine also drives a rotating compressor to pressurize the air, which is then mixed with either gas or liquid fuel in a combustion chamber. Increasing the compression raises the temperature, thereby achieving greater efficiency in a gas turbine. Exhaust gases are emitted into the atmosphere from the turbine or recovered for re-use in a Combined Heat and Power (CHP) System. Unlike a steam turbine system, gas turbine systems do not have boilers or a steam supply, condensers, or a waste heat disposal system. Therefore, capital costs are much lower for a gas turbine system than for a steam system. In electrical power applications, gas turbines are typically used for peaking duty, where rapid startup and short runs are needed. Most installed simple gas turbines with no controls have only a 20- to 30-percent efficiency, with the addition of Combined Heat and Power (CHP) Systems, efficiencies can increase in excess of 80% percent.

In addition, on-site natural gas turbines can be used in a combined cycle unit, as discussed above. Due to the advantages of these types of generation units, a great deal of research is being put into developing more efficient, advanced gas turbines for distributed generation.

Rolls Royce and General Electric are the leading manufactures of jet engines for aircraft. These two companies have also gone the furthest in the commercial development of turbine engines used as prime movers in electrical generation sets. This study will provide an analysis of the combined product research of these two recognized names in the development of the gas turbine generation. Product information from both manufacturers will be included in the Appendices of this report.

Gas Turbine Engine Noise

According to product data information available from General Electric, gas turbine generation systems can be extremely noisy. These turbines are comparable in noise level to aircraft jet engines, which are very noisy, even at idle speed. Stringent acoustical design rules must be followed wherever such systems are installed.

The noise level at any location within a power plant is the combined effect of noise radiated by all sources. Therefore, the noise from each individual source must be less than the overall plant requirement. In addition, the containment of the sound energy within a building results in a reverberant buildup of noise. The noise reflected from the interior building walls and other surfaces causes an increase in the noise level. General information and Acoustic terms regarding Turbine Generation is detailed in the Appendices Tab 12 document by GE entitled *"Acoustic Terms, Definitions and General Information."*

As an example cited in the GE *"Near-Field Noise Consideration Document,"* (reference Appendices) in order for the entire power plant to satisfy a required noise guarantee of no more than 85 dBA, it is necessary that each piece of equipment (including all turbine generator scope of supply equipment as well as the equipment supplied by others) that may be influenced by one or more of these factors, must radiate less than 85 dBA. If, for illustration, an adjacent system vacuum pump and the combustion turbine are located 2 meters apart, and if the vacuum pump radiates 80 dBA at 1 meter and the combustion turbine radiates 80 dBA at 1 meter, the resulting sound level from the two pieces of equipment is 83 dBA at a location 1 meter from both pieces of equipment. In addition, there will be noise from other equipment within the area. A 1-dBA allowance is included to account for the contribution from this other equipment. To account for the reverberant buildup effect of noise within a building with interior walls that are properly treated for acoustics, an additional 1-dBA allowance is also included. Therefore, these two pieces of equipment must be designed to a level of 80 dBA or less for the measured sound levels to meet the client's requirement of 85 dBA.

Beyond the worker exposure noise level requirements, consideration of noise pollution outside the facility is a major concern. If chosen as the preferred design solution, a Gas Turbine Generation Systems Facility will have to have stringent design considerations for both internal noise protections for workers, along with exceptional noise abatement and critical muffler systems to avoid noise pollution onto the campus outside the facility.

Gas Turbine Engine Emission Controls

The next issue to consider regarding selection of a Gas Turbine Generation Systems Facility is emissions controls. Reference Appendix X, which is GE's document entitled *"Gas Turbine Emissions and Control."* That document explains in great detail the design and operational considerations that must be in place when considering the Gas Turbine Generation System. These controls will affect both operation and maintenance costs.

Typical exhaust emissions from a stationary gas turbine are defined in two distinct categories. The major species Carbon Dioxide (CO2), Nitrogen (N2), Water Vapor (H2O), and Oxygen (O2) are present in significant percent concentrations. The minor species (or pollutants) such as Carbon Monoxide (CO), Unburned Hydrocarbons (UHC), Nitrous Oxide (NO), Nitrous Dioxide (NO2), Sulfur Dioxide (SO2), Sulfur Trioxide (SO3), and particulate matter smoke are present in parts per million concentrations. In general, given the specific fuel composition and machine operating conditions, the major species compositions can be calculated. The minor species, with the exception of total sulfur oxides, cannot. Characterization of the potential pollutants requires careful measurement and semi-theoretical analysis. The pollutants shown in "*Table 1"*of Appendices covering the *"GE Gas Turbine Emissions and Control*" document are a function of gas turbine operating conditions and fuel composition.

Plant layout is another significant concern in consideration of a Gas Turbine Generation Systems Facility. Major items that must be considered are as follows: (Please Reference Appendix X: *"Power Plant Layout and Planning*")

Corrosive Emission Sources

What Corrosive chemicals, such as the following, are known or may be present?

- Coastal, within 12 miles of surf
- Heavy industrial
- Light industrial
- Agricultural with spray irrigation, frequent harvesting, soil preparation
- Dry salt lake nearby
- Desert
- Inland, rural
- Other

Local Emission Sources

List nearby (< 2 miles) potential sources of particulates:

- Coal piles
- Major highways
- Reclamation centers
- Mining operations
- Foundries
- Sawmills
- Wallboard manufacturing
- Agricultural activities
- Other

List nearby (< 2 miles) potential sources of liquid aerosols:

- Cooling water towers
- Spray irrigation systems
- Petrochemical processing
- Other

Weather

What are the monthly minimum, average, and maximum values for the following?

- Wind speed
- Wind direction (wind rose if available)
- Relative humidity
- Temperature
- Rainfall
- Snowfall
- Fogging conditions, number of days
- Icing conditions, number of days

Additional Emission Sources

List any additional emission sources not included above.

The above list identifies many issues that would need to be dealt with on the preferred site.

Gas Turbine Engine Maintenance and Training

Maintenance costs and availability are two of the most important concerns to a heavy-duty gas turbine equipment owner. Therefore, a well thought-out maintenance program that optimizes the owner's costs and maximizes equipment availability should be instituted. For this maintenance program to be effective, owners should develop a general understanding of the relationship between the operating plans and priorities for the plant, the skill level of operating and maintenance personnel, and all equipment manufacturer's recommendations regarding the number and types of inspections, spare parts planning, and other major factors affecting component life and proper operation of the equipment.

Ongoing operating and maintenance practices for GE heavy-duty gas turbines are extensively reviewed in Appendix X: *"Heavy-Duty Gas Turbine Operating and Maintenance Considerations*", with emphasis placed on types of inspections plus operating factors that influence maintenance schedules. Regardless of the equipment selected, a well-planned maintenance program will result in maximum equipment availability and optimization of maintenance costs.

Given that gas turbine technology would be a new concept to the Department of Corrections maintenance personnel, a considerable amount of specialized training will have to occur to provide operation and maintenance teams with the necessary prerequisite skills to operate and maintain this technology. All of the manufacturers researched had extensive training programs available either on-site, or at the factories, and any gas fires turbine equipment specification written for procurement should absolutely include the requirements for extensive and adequate Corrections personnel training.

MICRO-GAS TURBINE ENGINE ELECTRICAL GENERATION (25 TO 500 KW)

Micro-turbines are scaled down versions of larger industrial gas turbines. As their name suggests, these generating units are very small, and typically have a relatively small electric output. These types of distributed generation systems have the capacity to produce from 25 to 500 kilowatts (kW) of electricity, and are best suited for residential or small-scale commercial development.

Figure 4.14: ***Gas Fired Micro-Turbine***
Source: Oak Ridge National Laboratory

Advantages to micro-turbines include a very compact size (about the same size as a refrigerator), a small number of moving parts, lightweight, low cost, and increased efficiency. Using new waste heat recovery techniques, micro-turbines can achieve energy efficiencies of up to 80 percent.

Micro-turbines were derived from turbocharger technologies found in large trucks or the turbines in aircraft auxiliary power units (APUs). Most micro-turbines are single-stage; radial flow devices with high rotating speeds of 90,000 to 120,000 revolutions per minute. However, a few manufacturers have developed alternative systems with multiple stages and/or lower rotation speeds.

At the end of 2006, micro-turbines were nearing commercial status availability. For example, a company called Capstone has delivered over 2,400 micro-turbines to customers (since 2003). However, many of the micro-turbine installations are still undergoing extensive field tests or for a large part, commercial large

Table 4.3: Micro-turbine Overview

Commercially Available	Yes (Limited)
Size Range	25 – 500 kW
Fuel	Natural gas, hydrogen, propane, diesel
Efficiency	20 – 30% (Recuperated)
Environmental	Low (< 9 – 50 ppm) NOx
Other Features	Cogeneration (50 – 80°C water)
Commercial Status	Small volume production, commercial prototypes now.

Figure 4.15: *Multiple 500 kW micro-turbines connected in a staged parallel arrangement*

scale test demonstrations. Our limited research into this developing technology of micro-turbines leaves it suspect to being a current viable alternative for the Department of Corrections.

Micro-turbine generators can be divided in two general classes:

- Recuperated micro-turbines, which recover the heat from the exhaust gas to boost the temperature of combustion and increase the efficiency, and
- Un-recuperated (or simple cycle) micro-turbines, which have lower efficiencies, but also lower capital costs.

While some early product introductions have featured un-recuperated designs, the bulk of developers' efforts are focused on recuperated systems. The recuperator recovers heat from the exhaust gas in order to boost the temperature of the air stream supplied to the combustor. Further exhaust heat recovery can be used in a cogeneration configuration. The figure below illustrates a recuperated micro-turbine system.

Generator Equipment and Fuel Comparisons

There are many advantages and disadvantages to different types of generation systems as illustrated previously in this report. Also, the fuel options available for use to fire an emergency generator vary in many operational aspects. Nearly all generators utilize gasoline, diesel, natural gas or propane for their operational needs. The generator system operation and fuel comparison chart illustrated on the following pages will identify operational and design concerns regarding application of different types of equipment and varying fuel sources. Some general features of the generator operation and maintenance itself influence final generator equipment and fuel option decisions. Where possible this comparison indicated specific generator hardware and environmental differences in generator set types and their operation along with a comparison to their fuel option choices.

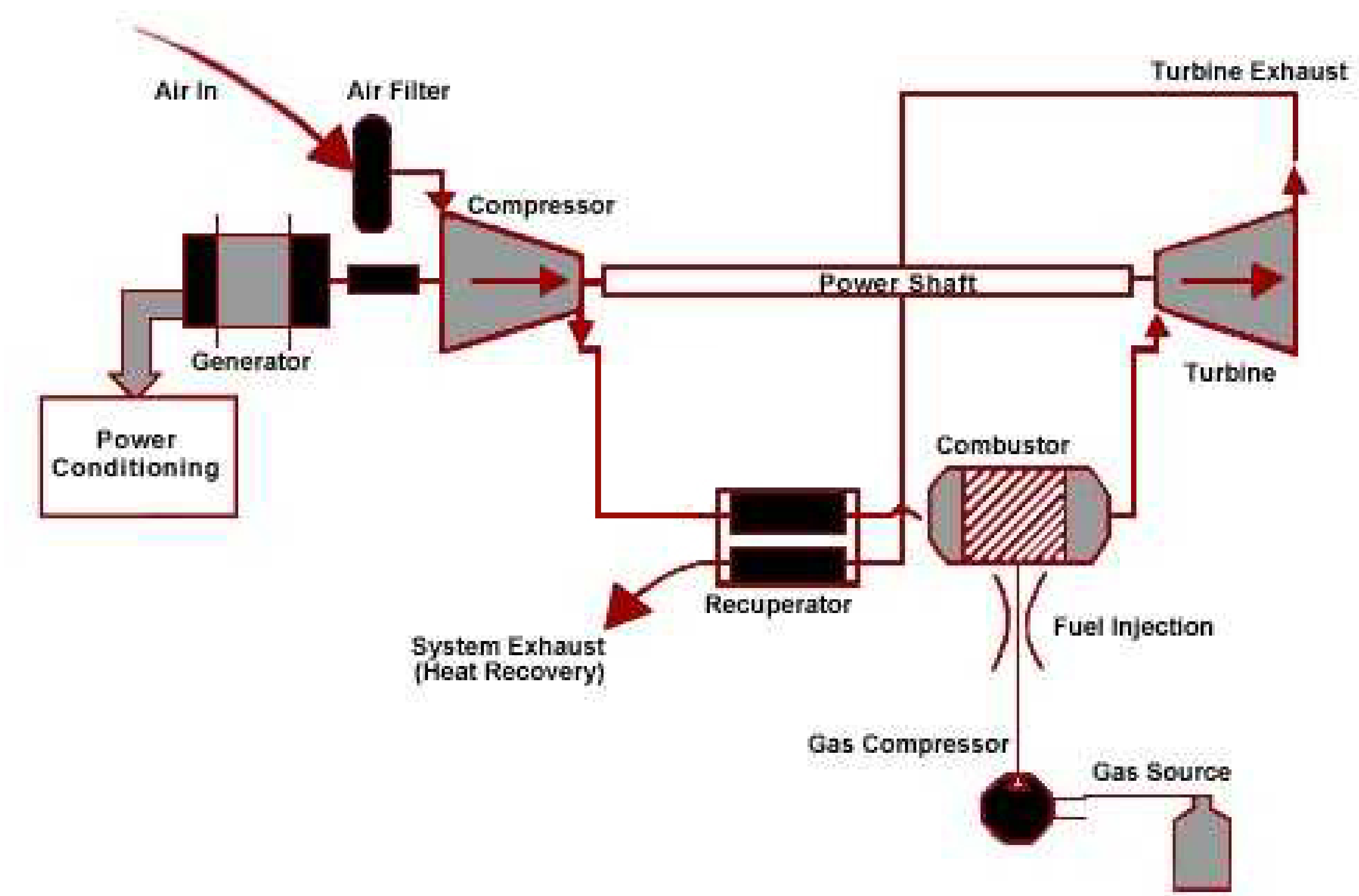


Figure 4.17: *Block Diagram of a recuperated micro-turbine system arrangement*

Table 4.4: Campus-wide Cogeneration Power System Equipment and Fuel Utilization Option Comparison Chart

This chart compares various types of systems that can be utilized for emergency power generation. This study shall compare the advantages of each type of system and compare advantages and disadvantages.

	Advantages	Disadvantages
Gasoline Fired Reciprocating Engines: Manufacturers Considered: Caterpillar Generac General Electric Kohler Onan/Cummins Detroit Diesel	Utilize readily available fuel sources - easily obtained. Proven Technology. Reliable. Clean burning fuel.	Highly flammable fuel sources. Short shelf life of fuel (12 months or less). Storing large quantities of fuel is hazardous. Refueling may be difficult during power outages. Somewhat expensive fuel. Inefficient. Low operating efficiencies in the 25 to 30% range.
Diesel Fired Reciprocating Engines: Manufacturers Considered: Caterpillar Generac General Electric Kohler Onan/Cummins Detroit Diesel	Least flammable fuel source. Fuel easily obtained *(fuel is easier to obtain during a disaster because it is a necessary fuel for the military, trucking industry, and farming operations).* On site fuel delivery available. Engine life for liquid-cooled 1800 RPM engines can approach 20,000 hours if properly serviced depending on the application and environment. High speed 3600 RPM diesel engines normally have a 10,000 to 15,000 hour life expectancy with proper maintenance and service under most conditions Less expensive to operate than gas engines. *The general rule of thumb for fuel consumption is 7% of the rated generator output (Example: 20 kW x 7% = 1.4 gallon per hour at full load).* Engines designed to work under a load for long periods of time and perform better when worked hard rather than operated under light loads. Can operate in sub-arctic conditions with fuel additive. Equipment is competitively priced for comparative sized water-cooled gaseous models with the same features. In high use situations overall long term cost of operation is much lower than gaseous GenSets. Fast start for stand-by generation options *(10 seconds or less).*	Fuel Source only has 18-24 month shelf life, without additives. Requirements for large storage tank systems increases cost of system. Delivery of fuel may not be available during long extended power outages. Total amount of diesel fuel storage must be considered relative to required run time in your geographical area. Engine noise much higher on a diesel GenSets compared to a gaseous engine. Use of a properly designed enclosure and sound attenuation system is more critical on a diesel engine system. Subject to "wet stacking" or over fueling if run for long periods of time with ultra light loads (less than 40% of the rated output). *"Wet Stacking" causes the engine to smoke and run rough because the injectors become carbonized. Running a heavy load will usually clean up the over-fuel condition and allow the engine to perform normally. Diesel engines operate better and are more fuel efficient when loaded (70-80% is optimum).* In sensitive emission areas in some states diesel engines are prohibited from operating over a prescribed number of hours per year to help reduce pollution levels. Requires clean moisture free fuel and a bit more maintenance than a comparable gaseous unit. Some cities and counties require the generator on-board fuel tanks to be double-wall containment type, which can increase the cost of the generator system. Equipment is typically heavier and requires more planning to load and unload than a lightweight gaseous GenSet. Operating efficiencies in the 20 to 45% range.

Table 4.4 continued: Campus-wide Cogeneration Power System Equipment and Fuel Utilization Option Comparison Chart

	Advantages	Disadvantages
Natural Gas Fired Turbine Generation: (w/LP Gas Backup) Manufacturers Considered: Caterpillar Generac General Electric Rolls Royce Onan/Cummins Detroit Diesel	Least flammable fuel source. Engines designed to work under a full load for long periods of time and perform better when worked hard rather than operated under light loads. Can operate in sub-arctic conditions with no fuel additive. In high use situations overall long term cost of operation is much lower than gaseous Reciprocating Engine GenSets. Proven mature technology with widely available equipment options. Unlimited fuel source - refueling not necessary. More convenient fuel source. Gas Turbines do not have a problem with "wet stacking" like diesels. *Natural gas is a mixture of hydrocarbons (mainly methane (CH4)) and is produced either from gas wells or in conjunction with crude oil production. Because of the gaseous nature of this fuel, it must be stored onboard a vehicle in either a compressed gaseous state (CNG) or more commonly as liquefied state (LNG).*	Large LP storage tanks required. Engine noise is much higher on a turbine compared to a gaseous engine. *(in excess of 120 dB when unattenuated). Use of a properly designed enclosure and worker protection along with extensive sound attenuation system is more critical on a turbine generation system.* Emission controls are an expensive consideration. Make-up and combustion air design considerations are complicated. Maintenance concerns are a new technology to the DOC and will require extensive training. Designed for continuous duty, not intended for short term standby considerations. Long start cycle *(much more than the 10 seconds required for stand by emergency generators in hospital applications).* New technology concept for the DOC. Natural Gas can become very dangerous if lines are broken. May be unavailable during natural disasters (earthquakes, etc) Lower power output (30% less BTU's per unit than gasoline). Fuel system plumbing results in higher installation cost. Natural Gas not available in many areas. Natural gas (NG) begins to de-rate at +20 degrees above zero. Initial generator cost is higher *(15 to 20% especially in sizes larger than 30 kW).* More expensive to operate by as much as 3-times the fuel consumption compared to diesels. Earthquakes can disrupt the flow of natural gas lines with up-rooted trees.
Micro Gas Fired Turbine Generation: Manufacturers Considered: Capstone	Compact Size (25-500kW) Small number of Moving Parts. Lightweight. Lower Costs in comparable size. Higher efficiencies, up to 45%. Low pollutant emissions.	Emerging Technology. Multiple units difficult to synchronize. Slow to start. *(In excess of 10 seconds).* In prototypical development. Limited Commercial availability. Requires extensive training for operation.
Natural Gas Fuel Cells: Manufacturers Considered: Fuel Cell Technologies	Easy to synchronize. Negligible Environmental Concerns. Up to 70% efficient. Completely Enclosed. No Moving Parts. Extremely Quiet. Does not generate surges.	Emerging Technology. In prototypical development. Limited Commercial availability. Requires generation of pure hydrogen as fuel. Currently very high costs commercially.

Table 4.4 continued: Campus-wide Cogeneration Power System Equipment and Fuel Utilization Option Comparison Chart

	Advantages	Disadvantages
Natural Gas with LP/ Propane backup LP/Propane *(as an alternate backup fuel Option)*:* **See propane notes below.*	Long shelf life Clean burning Easily stored in large grade or underground tanks. Fuel Source easily obtainable during extended power outages. Quieter engine noise level. More emission compliant. Gaseous engines do not have a problem with "wet stacking" like diesels. Engine life for liquid-cooled 1800 RPM engines can approach 15,000 to 18,000 hours on industrial quality gaseous GenSets. Backup fuel source would be Available in large storage capacities at the proposed Physical Plant. Higher efficiency rate, 44% for natural gas versus 36% for comparable sized diesel. Cost of fuel less per million BTUH generated.	Pressurized cylinder of flammable gas. Fuel system is more complicated. Larger tanks are not aesthetically pleasing (unsightly). Fuel system plumbing results in higher installation cost. LP backup gas slightly more expensive fuel than natural gas, but still cheaper than diesel. Propane can become very dangerous if lines are broken. Propane begins to de-rate around -20 degrees below zero Fahrenheit. Initial cost of generator is extremely high compared to diesel. 25 to 50% in sizes under 100 kW. Equipment price doubles in sizes over 1 MW. Transient response time is slower than diesel. Longer start-time than diesel engines by comparison in size (10 plus seconds).
CHP – Combined Heat and Power Systems:	Works with any fuel source. Increases generation efficiency to in excess of 80%. Captures wasted heat normally expelled to atmosphere. Helps reduce engine noise levels. Helps emission compliance.	Increases first time Costs. Requires generation plant location in proximity to applicable use of reclaimed heat. Operational mechanical and plumbing systems for heat recovery results in higher installation cost. Initial cost of generator is somewhat higher, 10 to 20% to accommodate heat recovery needs.

Table 4.5: Summary of Fuel Factors

FACTOR	GASOLINE	DIESEL & MIXES	NATURAL GAS*	VAPOR PROPANE*	LIQUID PROPANE*
ENGINE COST	EXCELLENT (many low-cost GenSets on market)	VARIES (higher cost in small sizes)	VARIES (low cost in small sizes)	VARIES (low cost in small sizes)	VARIES (low cost in small sizes)
FUEL SYSTEM INSTALLATION & STORAGE COST	VARIES (low cost in small sizes)	VARIES (low cost in small sizes)	EXCELLENT (if gas service already available at site)	MEDIUM (if adequately sized tank already at site)	MEDIUM (if adequately sized tank already at site)
FIRE & PERSONNEL SAFETY	POOR (highly flammable, vapors poisonous)	EXCELLENT (high flash point)	MEDIUM (rare leak risk)	MEDIUM (rare leak or tank explosion risk)	MEDIUM (rare leak or tank explosion risk)
ENVIRONMENTAL IMPACTS	POOR (spill risk, exhaust not clean)	POOR (spill risk, exhaust not clean)	EXCELLENT (clean burning)	EXCELLENT (clean burning)	EXCELLENT (clean burning)
FUEL AVAILABILITY	MEDIUM (easy to purchase)	MEDIUM (must be delivered & stored)	EXCELLENT (storage not required, supply rarely lost)	MEDIUM (must be delivered & stored	MEDIUM (must be delivered & stored
COLD STARTING & OPERATION	POOR (forms gum deposits)	MEDIUM (hard starting at cold temperatures)	EXCELLENT	MEDIUM (tank must be large and full for vaporization)	EXCELLENT (no tank vaporization issue)
ENGINE LIFE/WEAR	POOR/ MEDIUM (depends on engine type)	EXCELLENT	MEDIUM	MEDIUM	MEDIUM

**See propane notes below.*

Table: 4.6: Fuel Preference by Geography and General Use

Place	Use	Preference	Avoid or Reasons
Pacific Time Zone	Residential	Propane, Diesel	Avoid Natural Gas due to earthquakes
	Ranch	Diesel, Propane	
	Industrial	Diesel, Propane, NG	
Mountain Time Zone	Residential	Propane, Diesel	Propane preferred in mountain areas. Diesel preferred on ranches and farms for duel use.
	Ranch	Diesel, Propane	
	Industrial	Diesel, NG, Propane	
Central Time Zone	Residential	NG, Propane, Diesel	Natural Gas very dependable in these time zones
	Ranch	Diesel, Propane	
	Industrial	Diesel, NG, Propane	
Eastern Time Zone	Residential	NG, Propane, Diesel	
	Ranch	Diesel, Propane	
	Industrial	Diesel, NG, Propane	

Gaseous fuels such as natural gas, vapor propane and liquid propane are the most common choice for small automatic standby generators. Propane engines are economical to build and these fuels provide good starting reliability and are in common use. These fuels are available everywhere.

*A **vapor propane system** draws the fuel from the **top** of the tank usually through a pressure regulator at the tank. The liquid in the lower part of the tank must be able to absorb sufficient heat from the tank surroundings for vaporization to take place. Therefore, it is important that the tank has enough exposed surface area for this heat transfer. There can be a problem of insufficient fuel flow in very cold weather or if the tank is less than half full or is too small. In practice this only is an issue in the far northern areas of the USA.

*A **liquid propane system** draws the liquid from the **bottom** of the tank and small high-pressure tubing is used to carry it to the GenSet. The GenSet is then equipped with a special device to vaporize the fuel before combustion. This eliminates the low temperature vaporization concerns at the tank in cold climates. However it may complicate using propane for other appliances since it is being supplied in liquid form to the point of use.

Table 4.7: Six Classes of Fuel Oil

Name	Alias	Alias	Type	Chain Length
No. 1 fuel oil	No. 1 distillate	No. 1 diesel fuel	Distillate	9-16
No. 2 fuel oil	No. 2 distillate	**No. 2 diesel fuel or heating oil**	Distillate	10-20
No. 3 fuel oil	No. 3 distillate	No. 3 diesel fuel	Distillate	
No. 4 fuel oil	No. 4 distillate	No. 4 residual fuel oil	Distillate/Residual	12-70
No. 5 fuel oil	No. 5 residual fuel oil	Heavy fuel oil	Residual	12-70
No. 6 fuel oil	No. 6 residual fuel oil	Heavy fuel oil	Residual	20-70
Marine Classification for Fuel Oils				
MGO (Marine gas oil)	Roughly equivalent to No. 2 fuel oil, made from distillate only.			
MDO (Marine diesel oil)	A blend of gas oil and heavy fuel oil.			
LFO (Light fuel oil)	A blend of gas oil and heavy fuel oil with very little gas oil than marine diesel oil.			
IFO (Intermediate fuel oil)	A blend of gas oil and heavy fuel oil, with less gas oil than marine diesel oil.			
MFO (Medium fuel oil)	A blend of gas oil and heavy fuel oil, with less gas oil than intermediate fuel oil.			
HFO (Heavy fuel oil)	Pure or nearly pure residual oil, roughly equivalent to No. 6 fuel oil.			

Review of the above campus-wide Power System Co-Generation Equipment and fuel utilization option comparison chart condenses all pertinent evaluation factors regarding campus-wide generator selection into one concise tabular format for evaluation.

It is relatively easy to dismiss the Micro-Turbine and Fuel Cell technologies as viable options because of their high first time costs, limited availabilities, and the fact that they are still in developmental stages.

Gasoline Fired Reciprocating Engines, although a viable operational option, should be eliminated because of the fuel use, transport and handling issues, and because of the low operating efficiencies.

Natural Gas Fired Turbine Generation, with all its benefits should be strongly considered, if proper training and operational maintenance issues are adequately addressed.

By the process of elimination, this study's final recommendation option for generator selection is Diesel or LP/Natural Gas Fired Reciprocating Engines. The choice of Diesel Fired Reciprocating Engines should be a front line contender for selection for a large number of reasons. First, and most importantly, the technology is familiar to the Department of Corrections, as all its existing emergency power generation needs are of this type. Therefore, there would be no learning curve involved in adoption of this technology. In addition, Diesel Fired Reciprocating Engines are "fast start"—requiring less than 10 seconds to deliver emergency or cogeneration power. Going beyond these significant considerations, the choice of Diesel Fired Reciprocating Engines has a multitude of additional positive features. Diesel fuel used to fire the engine is one of the least flammable fuel sources, is simple to transport, and is easily obtainable, even in a long term emergency crisis (earthquake, for example) since the military, along with the trucking and agriculture industries depend on this fuel source. Generator life in a standby mode can be in excess of 15,000 operating hours when properly maintained, meaning a properly maintained generator can last up to 50 years. Being such a proven technology, most manufacturers will provide maintenance, parts and service on this type of equipment for many years into the future.

There are some disadvantages to this generation method. Diesel Fuel only has an 18 month shelf life. Also, a unit in the 5,000 kW range, at full load will consume in excess of 200 gallons of fuel per hour, requiring huge storage tanks, especially if the unit is intended for peak shaving. Beyond those negative considerations is high engine noise, potential for "Wet Stacking" and related emission considerations.

These negative diesel fuel-related issues make the consideration of an LP/Natural Gas Fired Generator a very worthy option. Natural gas burns much cleaner than diesel, and has minimal environmental impacts. LP/natural gas units tend to be slightly more efficient (44% for Natural Gas versus 36% for Diesel) with lower fuel consumption costs, and longer engine life of up to 18,000 standby hours of operation before a major overhaul (Life expectancy of over 50 years). The only major drawback to Natural Gas Generators in the 3 to 5 MW range is the much higher first-time cost than a diesel unit (as much as two to three times the equipment cost for a comparable size diesel unit). The final decision on fuel sources is the discretion of the Department of Corrections, however, considering all the options discussed, from an engineering and operational standpoint, this study would recommend strong consideration of a duel fuel Gas Fired Reciprocating Engine Generator Set utilizing natural gas as the primary fuel source with the capability of burning LP gas or #2 Diesel as the reserve alternate fuel source.

Site Location for Campus Generation Plant

First, a 5 to 15 MW Campus Generation Plant will be extremely noisy (in excess of 85 dBA), even with proper sound attenuation and critical silencers. The plant should not be placed in the heart of the central campus for that reason. Location of fuel storage is another major concern. This study recommends the use of natural gas as the primary fuel source with LP gas or #2 Diesel as backup to fuel the new generator plant. Since LP Gas appears to be available in abundance at the chosen site, a back-up fuel storage facility near the Physical Plant, and in close proximity to the sub-station, is a viable option. This arrangement is also attractive and ideally situated for the co-generation plant location since we intend to recover the waste heat in a Combined Heat and Power Application from the generation process in the form of 15-Pound steam that will need to be piped back into the Physical Plant. Lastly, from an electrical standpoint, the most straightforward electrical connection to the campus loop would lie in proximity to the new sub-station, where we could utilize in-place infrastructure to intercept the proposed connection to the campus 15 kV primary electrical distribution system.

If diesel engines are chosen as the design solution for capital cost savings, the substation location for the new generation plant is still the only logical choice for the reasons previously listed. Additionally, there is insufficient room in the heart of the central campus to install the underground diesel fuel tank.

Cost and Equipment Options for the New Campus Cogeneration Facility

Table 4.8 illustrates approximate incremental costs associated with the installation of a Campus-Wide Co-Generation System. This listing could be used as a "Kit-of-Parts" budgetary shopping list to commit to a particular design configuration or solution that falls within available funding and/or budgetary considerations or can be utilized for modeling future construction funding appropriations.

Table 4.8: Incremental Campus Cogeneration System Construction/Procurement Costs

Equipment or Work Item	Median Cost	$/kW
Caterpillar 2.5MW Diesel Generator Set	$680,000	$272
Caterpillar 3.0MW Diesel Generator Set	$850,000	$283
Caterpillar 5.0MW Diesel Generator Set	$2,000,000	$400
Caterpillar 2.0MW NG Generator Set	$1,200,000	$600
Caterpillar 3.0MW NG Generator Set	$2,200,000	$733
Caterpillar 5.0MW NG Generator Set	$6,000,000	$1200
GE 2.5MW Diesel Generator Set	$750,000	$300
GE 3.0MW Diesel Generator Set	$900,000	$300
GE 5.0MW Diesel Generator Set	$1,800,000	$360
GE 2.5MW NG Generator Set	$1,300,000	$650
GE 3.0MW NG Generator Set	$1,750,000	$583
GE 5.0MW NG Generator Set	$4,500,000	$900
Cost of 4000 SQFT Generator Metal Building	$800,000	
Brick Façade for Generator Building	$300,000	
Heat Recovery Equipment (Per Unit)	$250,000	
Steam Tunnel and Lines to Physical Plant	$600,000	
Natural Gas Lines	$200,000	
Electrical Connections to Physical Plant	$350,000	
Synchronizing Switchgear	$500,000	
Cost for a 30,000 Gal Diesel UG Storage Tank	$400,000	

Cogeneration Conclusions

The results of this study clearly indicate the application of a campus-wide Co-Generation System will provide operational benefits to the Department of Corrections in operational efficiencies and system reliability and redundancy, especially since Rocky Mountain Power can only currently support one main substation feeder to the entire site. Most importantly, adding a second level of redundant power to the entire campus radial 15 kV distribution loop would help mitigate the potential of an overall campus outage in the event on a power outage.

Furthermore, the application of this campus-wide Co-Generation System could also provide the added benefit of peak shaving of high utility demand charges in the summer months. It also holds the potential for cogeneration applications in the future, or even potentially making the site self sufficient in the event of a catastrophe.

Turbine technology is the most costly system proposed, and has a number of complications (slow start, high noise, emissions, maintenance, and training on a new technology). However, is a worthy candidate for consideration.

Fuel cell technology looks extremely promising; however, it is still an emerging technology and, as such is risky and expensive. This development of this technology should be followed closely because it may become commercially viable in the near future.

Micro turbine technology looked extremely promising, but given the loads of our system needs, it would require synchronization of well over 20 units that would be next to impossible to synchronize and coordinate with available commercial synchronization technology.

Generation of electricity using a Combined Heat and Power (CHP) System that generates campus-wide electricity through a large diesel or natural gas-fired generator set would produce a great amount of waste heat. A CHP System could be designed to apply that waste heat into firing an industrial boiler instead of allowing this heat to escape into the atmosphere. In this way, more of the energy contained in the diesel fuel or natural gas is used than with a simple internal combustion engine. This greatly increases energy efficiency, which implies that less energy is needed to begin with (costing the Department of Corrections less in long term operational costs), and fewer emissions are generated because a smaller amount of diesel fuel or natural gas is used. Research indicates a typical Electric Generation Facility may achieve up to 45 percent efficiency in the generation process, but with the addition of a waste heat recovery unit, can achieve energy efficiencies in excess of 80 percent.

The technology, operation and system reliability of traditional direct diesel or gas-fired reciprocating engines utilized as the prime movers to drive generator sets are currently utilized for electric generation at other DOC Complexes. Because of this, and the fact that these engines' operation costs and maintenance needs are not a variable from the Corrections perspective, recommendation of this comfort level of operation and accepted technology needs no further discussion. This Study's recommendation is to proceed with known technology and pursue a Campus Wide Co-Generation Distribution System utilizing gas-fired internal combustion engines. The final decision of whether to fire these engines with diesel fuel or natural gas will be determined by the ability to fund the first-time capital equipment costs.

Co-Generation Plant Design Recommendations

The maximum peak demand load the Draper Campus has ever experienced based on the information provided by the local utility and the Department of Corrections has been in the 5 megawatt range. The most operationally effective design of the Campus Emergency Distribution Generation System would utilize LP/natural gas internal combustion engines driving up to three emergency generators, providing a staged power input capacity operating in a Combined Heat and Power System designed to recover heat generated during the combustion process of the generator. Exact generator sizing, and final specific generation plant locations are decisions that should be made during the actual schematic design process of the generation plant, but this study would recommend consideration of a base plant design that would locate a new Co-Generation Distribution System Building in the general vicinity of the Campus substation. This proximity to the substation and the campus physical plant would make the electrical interconnection to the campus 15 kV distribution system relatively straightforward. In addition, the close proximity would keep construction costs to a reasonable level for a few reasons. First, the lines carrying steam generated in the combustion process back to the physical plant for re-use would be shorter. Second, natural gas lines at the physical plant could be tapped to service the boilers. Third, the LP or diesel storage facility could be used as the back-up fuel source.

However, with a differential in base system equipment costs of up to 300%, between diesel and natural gas engines, many of the operational efficiencies of natural gas over diesel may be overridden by the huge first-time capital equipment cost savings realized by diesel generator engines.

Available equipment sizing varies from manufacturer to manufacturer, but in general, the initial base plant should be designed to accommodate up to three generators in the 5 to 10 megawatt range to handle the initial demand load, have expansion capabilities for the future, and, most importantly, allow two generators to handle the baseline (and future) campus load while a third generator is off line for maintenance. The plant should then be designed to accommodate expansion for the future addition of at least two more generation units of equal capacity for future growth and facility expansion.

Cost of the base generator system equipment itself represents the largest incremental capital expenditure and would range in the $270 to $400 range per kilowatt generated for diesel equipment (between 1.3 and 4.0 million dollars per generator, depending on selected generator manufacturer, equipment sizes and installation configurations), and in the $600 to $1200 range for natural gas equipment (between 3.0 and 8.0 million dollars per generator, depending on selected generator manufacturer, equipment sizes and installation configurations). The facility required to house the generator plant and supporting building infrastructure would cost in the $750,000 to $1,000,000 range, and the mechanical infrastructure and equipment to capture the waste heat and return that 15 Pound Steam to the physical plant would be in the $1,000,000 to $1,500,000 range. If the natural gas option is chosen, cost to get the adequate supply of LP/natural gas to the generators is contingent on the exact final location of the generation plant, and the closest available high-pressure natural gas line and proximity to the onsite LP/diesel storage tanks. Details of specific generator equipment design and package specification are all issues that should be further studied and developed once final decisions are made regarding equipment type, fuel firing methods, waste heat reutilization needs, final site location, and currently available or future funding.

Phone – Data and Communications (To the Site)

Telecommunications circuits required by the combined men's and women's facilities has been estimated at approximately 4000 Mb/s (ten each T-5 circuits) as per the "Prison Site Location Study" RFP dated October 24, 2007. Traditionally, T-carrier circuits have been delivered using multi-pair copper UTP cabling (Unshielded Twisted Pair). However, T-carrier technologies using copper UTP cabling have given way to the use of optical cable trunks as evidenced by the fact that fiber has already been laid along Highway 73 and the access road to the Chemical Depot providing close access from the prison site to a telecommunication services provider. Cost of delivery to the site would entail a prison-provided ductbank connection from the prison site's demarcation facility (most likely the Administration Building) to the utility provider's nearest manhole.

With the utility services already in place in the form of optical fiber, this particular prison site is already in line to have provided to it a veritable future proof resource of communication services. A single OC-48 network line (2 fiber strands), the mostly commonly deployed, has transmission speeds up to 2488 Megabits/sec (2.4 Gigabit/sec) or more than twice than half the capacity of the ten T-5 carriers. A single 48 strand single-mode cable is approximately 0.5 inches in diameter and carries more than seven times the same transfer rate as the ten T-5 carriers. As the demand for wide area telecommunication circuits are driven by the wireless technologies moving from 3G to NextG for Internet, data, and media services, the recent installation of optical carriers adjacent to the site has the prison facilities already covered.

As suggested in the RFP, microwave communications may also be an alternative to delivering high transfer rates of telecommunications. This is certainly available in the greater Salt Lake area, but the technology lends itself to more remote applications where cross country trenching is so much more cost prohibitive because of distance. Since optical carriers have already been installed in close proximity to the site, exploring the alternative of microwave services is unnecessary. Even in an equal cost comparison, a direct hard line connection will always be preferred over a wireless connection.

Currently, OC carriers are considered a SONET technology (Synchronous Optical Network) that is used worldwide for delivering primarily voice and data communications. The horizon however sees 100 Gigabit Ethernet as an emerging delivery method. Ethernet is an asynchronous technology with direct protocol comparisons to the IP (Internet Protocol) world we live in. Several methods of data delivery have come and gone over the past 35 years – including Token ring, Ethernet, ATM, Frame Relay, X.25, SONET, ISDN, etc. But as the ways of packaging data have evolved, Ethernet has maintained its position and has proved to be the most solid and adaptable of delivery methods. That being said, whether the next five to ten years move towards higher Ethernet transfer rates or stays with synchronous transfer rates, like the current OC carriers, the media of choice will be fiber.

Phone – Data and Communications (At the Site)

Delivery of phone and data communications, as well as other low voltage systems' communications, to all sectors of the prison site is best done using "rings" or circulating duct banks that encircle the facility. The intent of the "ring" theory is that the duct bank pathways are continuous with no dead-ends. This provides a natural means of redundancy and reliability by employing "self healing" technologies, with backbone cabling going in both directions, such that it precludes any full scale shutdown of any of the low voltage communications and services. A breach at any point on the "ring" calls into action the need for the electronics to send information over the other remaining circuit paths.

Communication needs for the duct bank include any and all systems that utilize any kind of network communication between panels and/or servers, whether it is standard Ethernet or not. An ever expanding list includes the following: Telephone circuits, facility intercom and mass notification circuits, computer/data circuits (LAN), Fire Alarm communications, BMS (Building Management Systems) communications, Security systems including video surveillance, gate controls, fence protection, and radio connections. In addition to these services other needs for TV, media, entertainment, and educational content to be delivered on site should also be included. Each of these systems will employ potentially different cable types and requirements for "repeating" signals over large distances. A singular type of media for all systems, such as fiber, makes sense but may not be possible depending on the availability of equipment that can "translate" from one signal or communication type to a common mode of delivery allowing all system circuits to be transported over fiber. Taking advantage of the increased distance afforded by fiber between "repeats" however, makes for a cleaner and more manageable systems' effort by having less connection locations to keep track of.

It is preferred that this communications duct bank be installed outside the perimeter fence and that it encircles the entire facility. A minimum of 12 each 4 inch conduits, encased in concrete, should be considered for the men's facility and a minimum of 8 each 4 inch conduits, also encased in concrete, for the women's facility. This duct bank will be interrupted periodically with underground vaults for pulling and branch exit requirements. The RFP suggested a 300 foot separation between these vaults. As has been learned in the past, these vaults do not always remain dry and are subject to filling with water. For this purpose, each vault will have an above ground enclosure provided for any and all splicing, terminations, etc. that might be needed at the vault location. Depending on the location of the vault, such as at the far sides of the site perimeter where no terminations or splicing may be required due to the use of longer distance media types, the vaults may be spaced at greater distances than 300 feet and may also not require the above ground enclosures.

The proposed site layout for the men's prison site is approximately 10,000 feet of perimeter assuming the duct banks will be 20 to 30 feet out away from the perimeter fence. This computes to roughly 30 vaults to be installed as part of the communications duct bank. The main communications connect "facility" should either be located inside the Administration building or located in a separate smaller building adjacent to the Administration building. The duct bank will directly intersect with this main connect facility, limiting the number of bends in the conduit pathway. The proposed site layout for the women's prison site is approximately 5,000 feet and translates into roughly 16 vaults with enclosures. Again, the main connect facility will intersect this duct bank. A separate duct bank of a minimum of 6 each 4 inch conduits for communications and systems' requirements only will need to be installed between the two main connect facilities at the men's and women's prison sites.

Security Systems Perimeter Fence

The perimeter fence construction should follow established standards found in UDC Construction documents, which takes the form of two lines of fence, inside and outside, each topped with razor ribbon, and separated by 25 to 30 feet of open rock filled space. Concrete foundations under the fence lines secure the fabric to the ground.

There are presently several types of fence protection systems being used in other states and being further developed. Most of the different fence protection products can be categorized into three main groups. The "shake and rattle" group uses sensor cable of either copper or fiber optics to detect when the sensor cable is physically moved. For this purpose, the sensor cable is generally affixed directly to the fence fabric. Variations include the use of fiber optic cables that usually require more installation and maintenance time as they are most often installed as a "mesh" to cover more of the fence fabric. Fiber terminations and connections also require special tools and skills. Other fence protection methods in this group include taut wire installations. These usually become a third fence line as the wire is stretched between isolators held off of the actual fence or are placed on their own row of fence posts. The second group or category uses motion to set off detectors. Pairs of microwave transmitters and receivers are located such that any disturbance between the two microwave heads is registered as an alarm. This includes most anything that gets in the way, such as weeds, paper, animals, etc. The third group uses “volume” to detect an intrusion into the space. Examples of this group include electromagnetic fields, electrostatic fields, and magnetic anomaly detection fields. The magnetic anomaly detection product is essentially a metal detector looking for any kind of conductive metal. This works well keeping weeds, paper, and animals from causing an alarm, but could also be compromised by a person with no metal as well. The electrostatic field is generated by above ground wires, much like the taut wire product, on their own fence posts or insulators. The electromagnetic field probably works the best in this group as it is a buried set of cables that are looking for any kind of conductive material or mass moving through its field, not just metal. It gives no pre-warning of its presence by not being seen, but can become unreliable due to ground temperature and moisture changes and inaccurate depth installation problems. Non lethal electric fences need the same kind of installation – separate fence rows- as the taut wire and electrostatic field sensors.

The current combination used by the UDC has functioned well and has been consistently maintained to where the technical crews are now considered “experts” on these two systems. Both the sensor wire fence protection system and the microwave motion detection system are used in tandem as the state’s perimeter fence protection. The inherent weaknesses of both systems are mitigated by new DSP filtering and comparisons in the new electronics to get higher detection capabilities with lower nuisance alarms. Once the systems have been installed correctly and any problems created by bad fence construction (loose fabric, insufficient post support, etc) are fixed, the continued maintenance is fairly simple – keeping the trash and weeds cleaned up and sensor cable affixed to the fence fabric.

Staying with the current fence protection system standards established by the UDC will maintain a high level of security. None of the other fence protection products would provide higher detection levels. Furthermore, the other products would be more costly to install and would have higher maintenance requirements.

Security Systems Perimeter Cameras

Placement of perimeter and site cameras should be defined in terms of being a supplement to actual visual line of site by officers. Perimeter cameras should be deployed as both fixed and pan/tilt/zoom (PTZ) types. Fixed cameras should be used at locations where a fairly constant view is needed and is usually aimed at specific objects such as gates, docks, and entrances. PTZ cameras should be placed to cover a lot of ground, not just specific objects. All camera images should be recorded digitally 24/7 or programmed for motion detection recording. Individual digital video recorders (DVR’s) with TCP/IP (Ethernet) capability for both remote control and/or viewing shall be required. New technologies that record camera images directly to network hard drives should also be considered. Video surveillance for the site perimeter, facilities, and gates should be partitioned from other interior site camera locations to limit the number of cameras the officers in the towers are directly concerned with. With too much to watch, nothing gets seen.

For the proposed men’s prison site, it is estimated that there should be a minimum of 4 PTZ and 4 fixed cameras on the perimeter fence and an additional 3 PTZ cameras covering the interior grounds, with 3 fixed cameras for the exercise yards. For the proposed women’s prison site, it is estimated that there should be a minimum of 3 PTZ cameras and 2 fixed cameras on the perimeter fence. Interior grounds should be able to be seen by the perimeter PTZ cameras.

Perimeter Gate Controls and Towers

Guard towers should be located at every other change in fence direction. A tower officer should have a clear visual view of two perimeter fence rows, one to his left and one to his right. Any extended distances should be supplemented with fixed cameras. There should be two towers with view of the site perimeter entrance gates. This provides a redundancy of both visual and electronic control of the gates, with both towers having potential control of the gates. Thus complete control of the gates cannot be overtaken by the surrender of a single tower. The towers should be fashioned after those used at CUCF.

In addition to the two towers with gate control, there should be another failsafe location with minimal controls consisting mainly for the lockdown of all gate controls and/or override of tower control. Typically a location in the Enforcement Building situated outside the perimeter that also has a visual view of the gates is a good location.

All gates in the vehicle sally port should be interlocked including both vehicle and man gates, meaning only one gate at a time can be open. For instances when two gates need to be open at the same time, a separate manually operated "interlock override" switch is activated. While activated, this switch beeps to remind the officer that override is on. There should be no controls inside the sally port for any of the gates.

For the proposed men's prison site, five towers should be provided. For the proposed women's prison site, three towers should be provided.

FOOTNOTES SECTION 4

Information Included in Appendix D

Caterpillar *"Solar"* Gas Turbine Generator Sets

GE-Jenbacher Type 6 Turbo Generator Specifications

GE Model GE-10-1 Gas Turbine Specifications

Rolls Royce 501 Gas Turbine Specifications

Gas Turbine Maintenance Considerations

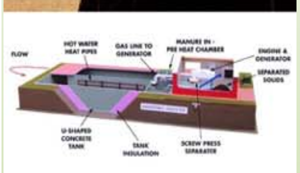
Acoustic Terms and Definitions

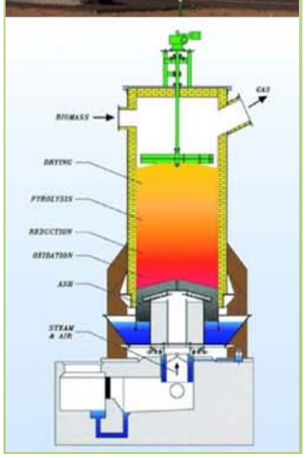
Near Field Power Plant Noise Considerations

Power Plant Layout Planning Considerations

Gas Turbine Emissions and Control

S&C 15kV Distribution Switchgear





SECTION V: RENEWABLE ENERGY

INTRODUCTION

The present review seeks to identify probable renewable energy opportunities and technologies for a proposed Utah State Prison on a site in Rush Valley, Utah. There is no assumption that renewable energy can replace or displace fossil fuel energy from the utility grids, but rather the assumption that economics and environmental motivations will soon propel both government and the private sector to transition aggressively toward integration of renewable energy in many forms into facility energy supplies. We seek also to make the case for rigorous energy demand reductions—'efficiency'—as an essential first step toward 'high performance prison' planning, design and construction. Singular, 'silver bullet' solutions to energy needs are rare, if not illusory. To be sure, it is possible for a single renewable energy resource to supply a facility with all the energy it needs, and more, given sufficient, focused investment. The Draper Correctional Facility has taken advantage of geothermal resources for an important part of its energy needs. Our glimpse into the crystal ball reveals a materializing vision of landowners, especially those among government agencies, doing all they can with given pieces of property to develop renewable energy resources in concert, to create economic vitality, clean jobs, and a landscape as economically productive as possible through exploration of clean energy as economic development driver. As a consequence, this study seeks to inventory not only the individual energy resources and the various technologies that may effectively capture and convert to usable energy, but also combinations of resources and technologies for sustainable, synergistic benefits, all built on a foundation of energy efficiency through sustainable, integrative facility design and construction.

Energy and resource efficiency has emerged as a complex, critical issue in the creation of government facilities of all types. Correctional facility planners have responded in recent years with more energy efficient, environmentally sustainable facilities. Several states, particularly on the West Coast, have built advanced, 'certified-sustainable' correctional institutions, using US Green Building Council 'LEED' certification (Leadership in Energy and Environmental Design) for 3rd-party verification of efficiency and sustainability measures attained.

Although the Utah Department of Corrections has not identified LEED certification as an objective, the Utah State High Performance Building Rating System encompasses a portion of LEED values and methods, primarily emphasizing verification by commissioning of energy efficiency of each building created by DFCM. Other prisons, notably in the western United States, have constructed renewable and efficient energy systems integral with strategies of energy reliability and budget independence from price fluctuations.

Regardless which, if any, approach is formally designated to energy efficiency, renewable energy generation and sustainable building, a comprehensive analysis of the adaptation of a facility concept/program to a specific site must screen technologies and technology combinations for congruence with Owner's objectives and needs, as well as comparative economic feasibility. This study extends review of energy technologies to the larger context of sustainability, here defined to include selective aspects of LEED certification in an 'integrative' manner: energy, water and other resource efficiencies, primarily as a discipline to assure consideration of all relevant opportunities and concerns; and the additional opportunities for operational and maintenance accountability afforded by complementary LEED disciplines.

A central feature of this review focuses on the Owner's need for energy reliability and redundancy, and the comparative capacity of various renewable energy resources to meet this energy reliability need economically. Short of discovering another 'silver bullet' energy resource at the proposed site, we must consider some combination of renewable energy applications as the most likely scenario for sustainable energy supply for the facility, integrated with an energy efficient facility plan and design.

FACILITY OWNER'S OBJECTIVES AND NEEDS

Security

The paramount concern of the Department of Corrections is security, as a matter of clear public purpose, in support of public safety. To the extent that energy reliability and energy costs make up important aspects of the Department's institutional strategy, these factors must be considered as part of the security mission of the proposed facility.

Energy Reliability and Backup

Energy reliability is essential to the core purpose of correctional facility security. No latitude for error exists in this essential relationship among energy reliability, systems function, and backup redundancy. Brownouts and blackouts experienced in other parts of the country cannot be allowed in the State Correctional System facilities. This complex but critically important value, that of the highest level of reliability, may alter otherwise conventional evaluations of energy systems.

Cost and Future Price Stability

Energy costs respond to market forces, including distant trends and events beyond control of state governments or agencies. In a facility as large and intensive as a state prison, energy consumption levels are equivalent to moderately large towns or industrial operations. Although a large proportion of total energy demand in a prison is non-essential, the magnitude of essential energy needs must be met with redundancy, and much of it with multiple redundancies. As has been demonstrated in events such as the California 'energy crisis' and in budget struggles essentially everywhere for public funds for essential services, energy costs are integral to cost projections.

Electricity, natural gas, diesel fuel, gasoline and other fossil fuels fluctuate in price according to markets, which also respond to extremely rapid population and economic growth in the developing world, as well as within our own nation. As with water prices, future energy costs are seen to be capable of at least an order of magnitude of variability. Budget certainty becomes nearly impossible, except through strategies strongly dependent on demand reduction through efficiency coupled with availability of renewable energy.

Peak Demand Avoidance and Energy Reduction

Variation patterns in energy demand may result in 'peaks,' incurring extremely high demand rates from the electrical utility, not only for the increment in excess of agreed demand levels, but carried over to portions of conventional energy consumption. These peak demand charges may accumulate, significantly elevating average electrical costs. Thus, an additional value of alternative energy systems can be the avoidance or minimization of demand charges through leveling strategies, or through the creation of relative grid-independence for portions of demand that are episodic in nature.

Expandability

Estimated Utah State Prison electrical demand for the existing Draper prison is in the range of 3.7 to 5.0 megawatts, as reported elsewhere in this document. Geothermal energy provides a large amount of heat for culinary hot water and space heating, not quantified thus far in electrical equivalency units (estimated to be on the order of several thousands of megawatt-hours electrical equivalent/annum). Projected Prison expansion will, of necessity, increase electricity demand proportionally, minus efficiencies and alternative, renewable energy resources that may be integrated into facility energy supply. Demand for non-electrical energy forms, such as culinary hot water, space heating, and cooling (which may or may not be fueled by electricity) will increase with facility capacity, but may do so according to a strategy or design.

SUSTAINABILITY

Environmental and social sustainability is commonly understood as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, WCED, 1983). Other, less simplistic and more place-specific concepts of sustainability can be made more useful by recognition of factors and realities that characterize a place, and even the needs of specific communities, cultures and ecosystems. A clear idea of sustainability should, as a consequence, be the product of constituent process, seeking to develop "sustain – ability": the ability to sustain an activity or facility, relative to scarce resources, occupant and employee health and welfare, vulnerable communities, and critical ecosystems and wildlife.

Due to realizations strengthened in decades since the Brundtland Commission's WCED process, energy is increasingly seen as the single most critical environmental issue among many, at the causal heart of global climate change, regional and local fossil fuel-generated contamination, regional haze, acid deposition, dependence on hostile regimes for oil, and physical damage to the land inflicted by coal extraction. The integration of factors considered here—need for reliability, cost restraint, price stability, peak avoidance, and expandability—may strongly inform energy strategy and facility design.

Expectations are increasing, moreover, to include environmental sustainability in this catalog of most important planning and design considerations. By applying a recognized discipline of environmental accountability such as LEED, a planning/design team may best assure that a responsible effort is made toward Project sustainability in both narrow and broad contexts.

PRISON ENERGY USE/APPLICATIONS – HEAT, ELECTRICITY AND FUELS

The Draper Correctional Facility reportedly uses between 3.5 and 5.0 megawatts of electrical energy, and an undefined quantity of heat. The heating energy is partially derived from use of the geothermal resource on the site, resulting in annual energy savings of about $300,000. A 'best guess' at natural gas rates for industrial/large scale users, and at the conversion factors to arrive at 'decatherms' and equivalent cubic feet of natural gas, places the quantity of natural gas replaced by geothermal heat in a range between 130,000 decatherms/year and 200,000 decatherms/year; and the volume of natural gas somewhere between 140,000,000 cubic feet and 180,000,000 cubic feet.

Liquid fuels such as gasoline and diesel, and possibly compressed natural gas, are used in vehicles, emergency generators and possibly other backup systems. Quantities cannot be estimated for liquid fuels. Regardless of the quantities, the services this electrical energy and heat energy must perform at the prison include at least the following:

- Direct space heating
- Culinary hot water
- Showers, personal hygiene, cleaning and wash-down
- Ventilation and air conditioning
- Food production, greenhouses, cooking
- Laundry
- Lighting
- Security systems and communications
- Emergency power
- Transportation

These functional needs must be met for the entire prison population and staff by whatever menu of energy forms that can be made available to best advantage, logistically, economically and environmentally.

Renewable Energy in the Great Basin Region

The American West's Great Basin physiographic province is rich in renewable energy potential.

Wind resources

Wind resources are concentrated at moderately consistent types of sites, the consequence of air mass movement generally from west to east, and due to canyon winds at certain locations. Wind energy occurs primarily along mountain range ridge lines; in many of the region's valley mouths, where mountain-canyon winds discharge according to diurnal cycles of valleyplateau thermal exchange; and of the passage of weather disturbances. As a result, economically feasible wind geography is erratic, but worthy of consideration and site-specific assessment.

Geothermal Energy

Geothermal energy usually corresponding to the fractured geological structure and history of the region, is widespread, though often at significant depth for high-temperature resources. Much of Utah's 'West Desert' region, to the northwest of the Rush Valley site, is thought to possess good high-temperature and intermediate-temperature geothermal resource. This prospectively superior geothermal resource appears not to extend, however, into the Rush Valley area.

Some areas to the south and west also are known to be populated with hot springs and excellent geothermal resources, as at the Blundell Geothermal Power Plant at Roosevelt Hot Springs, near Milford-Beaver, Utah. Intermediate-temperature hot springs or wells are used for aquaculture, greenhouses and recreation. Lower temperature geothermal energy exists at many locations as a localized phenomenon, while thermal inertia inherent in earth's relatively constant temperatures is available for heat exchange near-surface, essentially everywhere.

Solar Energy

Solar energy potential is pervasive, except on north-facing slopes and in forests. As demonstrated by solar energy projects in the northern tier of states, many forms of solar energy are worthy of evaluation for a wide variety of applications. Although intermittent, solar energy matches approximately the daily cycles of human and economic activity, making solar energy a valuable 'peak' form of energy.

Biomass Energy

Biomass energy is variably available for energy conversion in the region. Forests are biomass rich, while valleys are generally deserts, poor in biological productivity except where irrigated for crops on where water tables are near the surface. The two major forms of plant material that may offer opportunities for direct energy recovery or conversion to fuels, electricity or heat energy are urban and agricultural:

- Urban: municipal waste, sewage sludge and urban forest and 'green waste'; and
- Agricultural: animal, crop and rural forest waste materials, possibly including forest thinning residues from wildfire prevention, beetle-kill control and sustainable forestry activities.

The conversion of energy and nutrients from organic waste has been characterized as one of the most neglected, underutilized resource recovery opportunities of our time (*source: Gardner, Recycling Organic Waste, Worldwatch Paper 138, 1996).* Much of the waste stream that we treat as quintessentially problematic is an untested opportunity, especially in light of the catalog of mature technologies to accomplish conversions to energy, nutrients, value-added chemicals and countless valuable materials.

Site Energy Geography and Attributes

The Rush Valley site has received little attention for its renewable energy development potential. No site-specific renewable energy resource assessments are in the public record, probably indicating that they have not been done.

Geographic and Climatic Setting

The Rush Valley site is situated among the easternmost valleys of the Basin and Range physiographic province, on a westward-sloping alluvial fan from the southern end of the Oquirrh Mountains. Climate is one of seasonal variability, from cold winters to hot summers typical of Great Basin semi-desert valleys. Extremes can bring winter low temperatures well below zero degrees F, and above 100 degrees F. Humidity is typically low. Annual precipitation averages approximately ten to twelve inches, uncertain for the proposed site due to variability and difference of circumstance from nearest weather stations.

In relatively moist years in such foothill environments, most precipitation tends to occur in the fall-winter-spring season; but dry years see precipitation spread more or less evenly through the year. Weather patterns are dominated by the swings among arctic Canadian, Pacific and southern continental air masses. Intermittent valley temperature inversions are common in winter, as well as in stagnant summer conditions. Cloud cover is relatively rare, allowing approximately

300 days per year of significant solar radiation to reach the ground surface. Wind is intermittent, a function of storm passage, valley-mountain winds, and the general movement of air from west to east across the region. Specific information about exact weather conditions for the area is anecdotal and subject to question, however, given the absence of scientific weather monitoring within the valley environment of the Rush Valley site. The nearest authoritative weather stations are located in Tooele, Provo, and southern Salt Lake County. Before design proceeds, establishment of a temporary weather monitoring station could fill in a great many data gaps, given observations from at least a full year, preferably more.

Wind Energy Potential

Insufficient information exists to judge wind energy resource potential. No site-specific wind resource assessment has been found, though statewide surveys provide some indications that a modest wind resource may exist, possibly seasonally limited. In general, it is not advisable to guess at wind resources in Great Basin mountain-valley terrain, nor wise to rely on anecdotal characterizations. Generalized information is included in the National Renewable Energy Lab summaries prepared for the Western Governors' Association 'Western Renewable Energy Zone Assessment' (WREZ), though data are derived from earlier Pacific Northwest Laboratory information (PNL, 1987, from WREZ 2008). Approximations of wind velocities presented in a summary from 20+ years ago ('West and Southwest Wind Atlas,' DeHarpporte, 1984), show the mountainous area immediately northeast of the Rush Valley site to vary seasonally from class 2 to class 5 wind resource potential.

This estimate was based on the international standard assessment tower height of 33 feet above ground. Wind speed typically increases with height, and both daily and seasonal variations may be dramatic with height. Given that utility-scale wind resources are measured typically installed at a minimum of 30 m (100 feet) or higher (50 m = 164 feet is common for very large turbines), it follows that a site wind resource assessment is imperative to facilitate an accurate evaluation of resource potential.

There are indications of spots of fair quality wind resources nearby, represented as very small, isolated areas on the Utah wind resource map of the National Renewable Energy Laboratory (NREL). At present level of site information, knowledge is insufficient to justify investment beyond a robust site assessment, with the possibility of using wind to meet specific, high-priority purposes. As a matter of procedure, all sites must be subjected to specific data-gathering at statistically meaningful height above ground level for at least a 12-month cycle before assumptions can be made about the magnitude and consistency of any given wind resource. This site, too, warrants resource verification. Camp Williams, Spanish Fork Canyon and Milford are each somewhat unique in geographic position relative to diurnal air movement patterns, not sharing apparent attributes with the Rush Valley site. It is worth noting that the Milford 'wind corridor' appears only slightly more significant than Rush Valley on the same NREL map.

An obvious recommendation is that anemometer data logging equipment with a suitable height, temporary tower (50 or 60 meters) with calibrated anemometer and data logging equipment should be installed to further develop data for renewable energy strategies formulation.

Geothermal Energy Potential

Virtually the entire West Desert of Utah, along with the south portion of the Salt Lake Valley, are underlain by moderate geothermal resources at widely varying depths, temperatures and flow or heat exchange potential. None of the water wells recorded for the immediate vicinity of the site shows thermal characteristics of a mid-temperature geothermal resource. High temperature geothermal resources are somewhat rare in Utah, and are not to be anticipated at this location. Common, earth-temperature conditions occur everywhere, however, and moderate temperature geothermal resources *may* be found at some unknown depth if one drills until those temperatures are encountered. Even then, warm water flow rates may not be sufficient to utilize. The likelihood of locating a geothermal resource of the magnitude of the Draper Prison site is not high.

Conversely, the potential utility is excellent of 'ground-coupled' or 'water-coupled' heat pump technology, drawing on the inertia of earth temperature as a heat source or heat sink for individual buildings and for a 'district' scale heating and cooling system.

Solar Energy Potential

The Rush Valley site is in an area that receives an annual average of 5.0 to 5.5 kWh/m^2/day (NREL, Western Governors' Assn. 'Western Renewable Energy Zone Solar Resources, PV Flat Plate Tilted at Latitude,' Sept. 18, 2008). Seasonal variation ranges from a low of approximately 1,825 kWh/m2/annum to a high of approximately 2,007.5 kWh/m2/annum (NREL, solar data for Salt Lake City). While not approaching the highest insolation values seen in the desert Southwest, from southern Utah southward through Arizona, New Mexico, Texas and California, this solar resource is substantial, consistent and dependable, both for capture of solar energy as an electrical and a thermal resource. Aspect (orientation of slope) is east to west, which while not ideal is subject to satisfactory engineering responses, depending on technology.

Biomass Energy Potential

Rush Valley's desert environment offers little existing biomass resource. Subject to infrastructure and logistical limitations, however, proximity to urban areas presents underutilized waste streams of various sorts, including municipal solid waste, landscaping 'green' waste, and sewage sludge. Virtually every municipality and county is struggling with the challenge of exporting all forms of waste, some great distances at significant expense. Internal, facility-generated organic wastes and municipal waste equivalents may contribute to various opportunities for conversion to fuels or to thermal or electrical energy. In addition, opportunities exist to combine adequate irrigation water with abundant land to grow crops dedicated to energy production, possibly including cellulose or oil crops for conversion to various fuels or to heat or electrical energy.

Hydropower

Little or no 'run of stream' hydropower potential exists at the Rush Valley site. Slope is relatively gentle from east to west. For an 'engineered,' small-scale hydropower scheme, perhaps to complement other renewables, topographic gradient is 414 vertical feet in approximately 3.5 miles.

Site climate attributes and cycles for facility design

As discussed in this report, site-specific knowledge of microclimatic variability is essential to building energy optimization. This level of 'bioclimatic' or microclimatic data is not available for consideration in the present study. Prevailing valley-mountain breezes, for example, may cycle to offer opportunity for natural, low-energy ventilation. It is advised that site observation be carried out at intervals over the course of at least one cycle of seasons, to allow accumulation of design team knowledge of natural patterns of the portion of the site chosen for facility location.

Prisons and Energy

Imperatives for security of prison facilities raise concerns of energy reliability on a par with or beyond the highest-priority energy demand centers, such as critical defense facilities and government and corporate data centers. In addition, the reconciliation of budgets with energy price instability has emerged as an important recent concern. States are responding by creating energy-efficient and sometimes comprehensively sustainable prisons. Federal and state prisons in Pennsylvania, California, Arizona, Nevada and Washington state have been built or designed to high standards of energy efficiency and renewable energy dependence, with the express intention of reducing 'grid dependence.' Recent projects include the following:

- Federal Correctional Institution, Phoenix AZ: Parabolic trough collector solar-thermal system heats 40,000 gal/day of water for culinary, shower and laundry use for 1,250 inmates, offsetting approx. 1,000 mWh of electricity; financed through 'Energy Savings Performance Contract'. Source: US DOE EERE, Federal Energy Management Program, www.eere.energy.gov/femp; and *Mechanical Engineering Magazine/ME Power, 1999.*
- Northern Nevada Correctional Center, Carson City NV, 'Renewable Energy Prison': Wood-fired biomass boiler, combined with 30 kW PV system; wood chips are sourced from regional forest thinning and beetle-killed forests. Excess electrical power is sold to power company. *Source: Alternative Energy News, Oct 2, 2006.*
- Allenwood Federal Correctional Complex, Lycoming County Pennsylvania: On-site county landfill for landfill gas capture, thermal and electrical generation. *Source: DOJ Solicitation, Sept 30, 2006.*
- Ironwood State Prison and Chuckawalla Valley State Prison, both near Blythe, CA: Imagevoltaic

(PV) installations in partnership with SunEdison power utility, 1.18 MW and 1.16 MW, respectively. *Source: Tom Cheyney, www.pv-tech.com, June 11, 2008.*

- Alameda County Juvenile Justice Center, Alameda Co. CA: LEED 'Silver' certification, despite counter-sustainable aspects of prison program requirements; energy efficiency emphasized. Source: *Doors and Hardware Magazine, June 1, 2008.*
- Penitentiary/Prison, Tucson AZ: Insulated tilt-up concrete panel construction offers high-performance thermal envelope. *Source: Concrete Monthly, September 2004.*
- Washington State Penitentiary North Close Custody expansion: LEED 'Silver,' exploring claimed "… link between greener prison environments and prisoner rehabilitation. *Source: Doors & Hardware Magazine, June 1, 2008.*
- Prisons in developing countries such as Zimbabwe are powered, heated and fueled (cooking gas) by anaerobic digestion biogas, converting facility and urban sewage, animal wastes, food and municipal wastes to usable energy. *Source: www.zimbabwemetro.com, Sep 10, 2008.*

SITE ASSESSMENT METHODOLOGY

Analytical Sequence to Create the High-Performance Prison

Renewable energy resource and technology screening should not be the first action on an agenda directed at creation of an energy-efficient, high-performance, 'low-carbon' facility of any sort. The initial purpose of this portion of the site suitability study was formulated as an inventory and assessment of renewable energy alternatives that may be available at the Rush Valley site.

Awareness has grown in the professional planning and design community, however, as well as among facility owners and operators, that buildings and groups of buildings can be made far more efficient and effective in their use of supplemental energy—that is, to use less energy, to be 'de-energized' by some factor—than conventional facilities of their type. Whether energy comes from the utility grid or from localized renewable energy sources, a system energy balance benefits if the facilities drawing on those sources minimize the energy required to function as desired. An appropriate *analytical sequence would be to* first envision an energy-neutral, inertial facility (a single building, a campus of buildings, an industrial complex, a city) and what it takes to get there, and then create energy inputs from grid and on-site renewables to provide the remainder of what is needed for the facility to function fully. Even when the day arrives when the utility grid provides 100% renewable energy, this thought process will still be appropriate.

Energy optimization of a new correctional facility must consider not only best practices in mechanical-electrical systems design, construction, and O&M (operations and maintenance), but also design integration of whole-building efficiencies. Beyond these steps toward minimizing energy demand, we then consider utilization of renewable energy and complementary energy alternatives. A prison imposes rigid design constraints, precluding many of the energy efficiency and renewable energy options that could be considered for office, institutional or other occupancy types. On the other hand, a correctional facility is a city, in many ways, or a fortress-village at the very least, affording energy integration opportunities not feasible under virtually any other circumstance.

Imperatives for isolation, containment and self-sufficiency, may be seen as rationale for renewable energy integration with high-performance building design, with opportunities of scale, and with 'closed-loop' systems integration for maximum facility independence from conventional resource supply grids. Reaching beyond 'conventional' facility design, it may be possible to create a truly 'high-performance' correctional facility by application of 'district-scale' renewable energy systems to clusters of buildings so well designed for thermal inertia that energy inputs can be relatively restrained and cost-effective, possibly allowing intermittent energy export to the utility grid.

Integrative Design to Minimize Energy Needs and Optimize System Efficiencies

Assurance that basic principles of energy-efficient building design have been fully considered in planning and design is the first step toward creating any high-performance facility. Solar orientation, connection with the earth's thermal inertia, strategic connection with a site's climatic cycles, utilization of natural air movement, strategic manipulation of natural heating, cooling and light—these factors have given form to enduring, traditional buildings for centuries, and they inform the most efficient of advanced modern design and construction. Teams planning and designing high-performance buildings successfully will, of necessity, be interdisciplinary from the beginning and throughout the process. Internalizing the Owner's unique set of goals, objectives, needs and constraints forms a vision within which the planning/design team seeks to answer the question, "What is the best we can design here, for this Owner, for this programmatically defined purpose?"

Starting with 'the basics,' within identified constraints, interacting adaptively as design progresses, the design team asks, "What is the best energy performance that can be created for this facility?" Some process must be generated and maintained to cause the best possible answers to these questions to emerge, coalesce in design, and to be constructed economically.

Fundamental questions affecting energy expectations need to be answered in order for a planning/design team to progress responsibly:

- For what 'lifespan' will the facility be built? 50 years? 100 years? 200 years?
- What is the ultimate 'carrying capacity' or facility population within the projected facility lifespan, and how is it affected by energy supplies?
- How would the facility adapt to a future of more constrained energy availability?
- What energy resource, technology, market and regulatory changes are anticipated during this facility's lifespan? How could a 'carbon tax' affect energy fossil fuel pricing?
- What are energy price fluctuations projected during this time?
- In what ways may energy cost financing change in the future?
- How important is it to restrain energy costs?
- What changes are projected to occur for site geography, climate, demographic context, and the surrounding environment?
- At a site now surrounded by open space, what changes of land use are projected for the vicinity that may become constraints to energy systems and renewable energy choices?

Inventory and Assess Renewable and Complementary Energy Options

An inventory of renewable energy resources that may be utilized at the Rush Valley site is constrained by recognition that no single resource or technology for utilizing a resource is available to meet the energy needs of a prison facility. The corollary is that more attention is necessary to possible combinations of resources and technologies in order to create a balance of reduced demand with optimized energy supply from diversified, redundant sources. We must pay particular attention to possible complementarities among resources and technologies, because no one possibility may offer sufficient energy supply.

Wind electrical generation; geothermal energy at low and medium heat levels; multiple forms of solar energy capture for heat and electricity generation; biomass conversion to heat, fuels and electricity; and small-scale hydropower generation will be considered. In addition, strategies and technologies for modifying energy supply timing, for transforming from one form to another, and for energy storage for strategic purposes.

INTEGRATIVE DESIGN AND ENERGY DEMAND REDUCTION

Effective utilization of energy, whether grid-sourced, fossil fuel generated, or produced by conversion of any renewable energy source, begins with minimization of facility energy demand. If the thermal envelope of each building is as inertial—i.e., as low in demand—as possible, then the quantity of energy that must flow into the facility is thereby minimized. A significant demand reduction may dramatically alter the relative feasibility of renewable energy utilization.

Efficient Building Envelope, Daylighting and Energy Systems

Passive Thermal Inertia

Buildings can readily be engineered with massive or highly insulated thermal envelopes, strategically engages with the earth's relatively constant temperatures. Concrete or masonry structures with thick, massive walls; partially buried, or 'earth-sheltered' structures; and buildings made of sod, adobe, soil or straw are all traditional methods used to create stable, thermally consistent interior environments. Keeping out cold or hot winds by sealing structures is a related strategy.

Daylight Optimization

Natural light is a valuable form of renewable solar energy, one that avoids need for other energy to get rid of unwanted heat produced by artificial lighting. At least 75-80% of electrical energy put into all but the most efficient light fixtures is converted not to light but to heat, an unintended byproduct of limited energy technology. Daylight captured and controlled without unwanted heat gain, therefore, offers valuable service to many building interiors. Correctional institutions have obvious limitations on placement of windows and accessible glazed openings, so daylighting opportunities may be restricted to clerestories, skylights, courtyards and other core open areas where security is not compromised.

Passive and Low-Energy Ventilation

Where possible, induced ventilation through controllable openings to natural exposures where desirable temperatures exist at any given time can avoid need for artificial cooling. Where windows are not permissible for security reasons, other design strategies may be considered, including 'earth tubes' and air draw into a space through small openings through massive structural elements. Tower-like chimneys have been utilized since ancient times in buildings world-wide to induce controlled circulation.

Passive Solar Heat

Solar heating is the most ancient of all architectural design strategies for tempering interior environments. Massive south-facing walls and floors can absorb heat and release it to an interior through most of the space's cool nighttime hours, effectively deferring the benefit of the sun's energy to the time when it's needed. Winter sun can be allowed into interior spaces when and where heat gain is desirable. Countless variations on passive solar heating have been invented, with varying degrees of success. Some combination of passive solar heating should be possible for a correctional institution, which, when combined with thermal inertia, greatly reduces need for supplementary energy in cool seasons or diurnal cycles typical of desert mountain climates.

High-Efficiency Lighting

A correctional facility is a perfect place for extremely high-efficiency lighting technologies at current state of technology. Objections often heard about LED (light-emitting diode) lighting contend that light quality is not consistent, or that light color changes over time. In commercial, retail or office environments, these objections may be legitimate. This should not be the case in a prison. Although LED first-costs are presently high, electricity savings due to very high efficiencies, approaching 90% compared to less than 40% for the best of conventional lighting types, would pay back rapidly.

Low-Energy Cooling

For essentially all of each warm season, evaporative cooling, combined with adequate ventilation and thermal inertia of the building envelope, can cool virtually any building in a desert environment. Whether utilizing a downdraft passive system in which a moistened pad chills air by evaporation in a tower, as is done in the Zion National Park transportation center, or utilizing a more technologically complex 'direct-indirect' evaporative cooler, there are few justifications for choosing energy-intensive, refrigerative cooling systems. Evaporative cooling is highly efficient as a supplement to a well-conceptualized building that maintains relatively cool conditions passively.

Commissioning

Buildings can be extremely complex mechanisms, requiring assurance of proper functioning. Even those that rely on passive and simple systems are dependent on the quality and integrity of primary thermal envelope, solar insolation control, daylighting through glazing and other openings, passive ventilation, and so forth, in order to function as designed and engineered. Buildings incorporating complex systems require monitoring of construction for verification that all components are assembled and controlled as intended, and that the finished, whole building is functioning properly. Commissioning is the discipline that performs this observation, monitoring and verification of assembly and functioning in compliance with design. Third-party, independent commissioning agents perform an extremely important service for the energy performance optimization of a facility.

Operations and Energy Management

Systematic energy management plans and procedures are necessary for optimizing energy performance scientifically, based on accurate data on all systems variables and equipment. Systems and controls designs should anticipate that O&M and energy management systems will be employed. Utilization of a formalized energy management plan is advisable, following on the O&M manuals and commissioning work at construction completion, adaptively carrying forward these disciplines throughout a building's operating existence.

Sustainable Facilities O&M

Integrative approaches to sustainable facilities management have been in development, notably for office and commercial buildings under BOMA (Building Owners and Managers Association) and US Green Building Council's 'LEED' programs. In 2008, a major revision of the 'LEED-EB' certification system (LEED for Existing Buildings: Operations & Maintenance) was put into use, completely focused on the provision of sustainable facility management tools to facility owners and managers.

Consideration of new or retrofit construction is left to other LEED certification systems, such as LEED-New Construction, LEED-Core & Shell or LEED-Commercial Interiors. This new LEED-EB: O&M system is the most comprehensive guide to sustainable operations and maintenance available (table of contents to 'LEED-EB: O&M Rating System' is attached). By mandating or encouraging development and implementation of written management plans and 'best practices' formulations, to be updated periodically for LEED-certified facilities, LEED-EB: O&M addresses at least the following sets of issues and practices:

- Site and exterior management, including erosion and stormwater control and site heat and light pollution control;
- Pest management;
- Water efficiency, indoor use and in landscaping and cooling towers;
- Energy efficiency, through 'best practices' management plan development and application of 'Energy Star' performance measures, as well as renewable energy incentives and carbon emissions reporting;
- Materials management, encompassing sustainable purchasing of durable goods, food, mercury-content in lamps, and in facility alterations and additions; and solid waste management for durable goods, consumables, facility alterations/ additions, and food through waste stream audit and management techniques;
- Indoor environmental quality, encompassing air quality 'best management practices,' green cleaning and related concerns.

The State of Utah Division of Facilities Construction & Management 'High Performance Building Rating System' (HPBRS), included in the DFCM *Design Manual,* is based on aspects of USGBC's 'LEED-NC' criteria, largely pertaining to energy efficiency. The HPBRS is particularly concerned with commissioning and related mechanisms to verify that energy system designs, along with intended construction and operations, are accountably executed. It is not intended to be a 'certification' system like LEED, involving independent, 3rd-party certifier review and participation, but rather is a DFCM standard required of most new State-owned construction.

Few of the LEED-EB: O&M concerns are addressed other than energy efficiency. Use of LEED-NC without certification, targeting a low level of credit scores, is approximately equivalent to executing the DFCM HPBRS. The weaknesses of the HPBRS lie primarily in site and interior environmental quality concerns.

WATER EFFICIENCY AND ENERGY EFFICIENCY

The use of water within the existing Draper Correctional Facility is reported to be very efficient, at present, equivalent to about 115 gallons per prisoner per day. A level of water efficiency equivalent to that at Draper, or better, is important to maintain in the proposed Rush Valley facility. Of equal importance to this review is the potential opportunity that water presents for integration into efficient, renewable energy and sustainable facilities management planning, design and operations.

Culinary Uses

Energy is consumed in treating, distributing and heating water for culinary use, in cooking, restroom use, showers and laundries. This 'embodied energy' in water is often overlooked as a significant energy demand activity.

Landscaping

Use of 'engineered' water, treated to culinary standards, for landscaping has been declining dramatically in recent years due to growing awareness of impending water scarcity in urbanizing areas of Utah. Through enlightened choices of low-water, climate-adapted plants, minimization of high-water turf or use of more drought-tolerant turf types, and employment of improved methods of water distribution, government agencies have led the way toward better use of water in creating attractive landscapes.

Wastewater

Processing of wastewater consumes a great deal of energy, as does the disposal of sewage sludge by truck transport to increasingly distant 'land composting' locations. Both the water and the organic constituents of wastewater constitute opportunities, not only for water efficiency, but also for renewable energy production and modification, as well as for soil nutrients. Reuse of water is addressed at the existing Draper Correctional Facility by use in greenhouses and nursery applications, as well as in landscaping. The Rush Valley site may offer opportunities to apply wastewater by-products in ways not possible at most locations.

Energy Use/Applications – Heat and Electricity

Available energy, whether from fossil fuel sources or from renewable energy production, may be used in a number of ways. If a given energy use can be made either significantly more efficient than conventionally, or made to depend on a renewable energy source, then the energy that would have been necessary for that use is 'liberated' for another application, or is saved or avoided entirely. The essential functions of energy in fulfillment of core tasks, however, persist as necessities for a major correctional facility.

- ***Direct Space Heating***: Maintaining inmate and staff spaces at temperatures within ranges appropriate to each use or activity.
- ***Ventilation and Air Conditioning:*** Provision of fresh air and warm weather cooling, within acceptable temperature ranges.
- ***Culinary Hot Water:*** Provision of sufficient hot water for sanitation, showers, food preparation and dishwashing, laundry and other washdown functions.
- ***Food Production, Greenhouses:*** On-site produce farming for facility self-sufficiency and inmate activity may demand heated greenhouses for extended-season or year-round growing.
- ***Security, Site Lighting and Communications:*** Extensive interior, exterior, site and perimeter lighting; pervasive communications.
- ***Emergency and Backup Power:*** Emergency and redundant power capacity for support of all other electrical power functions.

RENEWABLE ENERGY INVENTORY AND ASSESSMENT

The purpose of this renewable energy resource and technology review for the Rush Valley site is to assess the potential for economically and strategically feasible non-grid, non-fossil fuel energy opportunities for a new State correctional facility. Criteria and considerations by which this review have been conducted are summarized here as 'terms of assessment.'

Terms of Assessment

Key Objectives

The State Department of Corrections requires that energy supply to the proposed new facility be economically cost-effective, price-stable in both short and long term, reliable, inexhaustible, and environmentally sustainable to the greatest extent feasible. By 'environmentally sustainable,' we here assume that low net carbon emissions is at the primary measure of this attribute. This report screens renewable energy resources according to these objectives.

Characteristics

The characteristics of an energy resource are functions of the resource and its conversion technologies. Characteristics must reasonably match the Owner's key objectives, either as stand-alone resource or in combination with other another resource-technology, or the resource in question must be disqualified for further consideration.

Certainty/Uncertainty of Resource

A great deal of information is available about some potential energy resources, but almost none about others. The state of available information, as well as interpolative information certainty, must be entered into any discussion of potential energy resources.

Steps to Confirm Resource and Further Assess

Resources vary widely in the costs and timeframes required to confirm or to further assess their magnitude, variability and availability for conversion to use. Resource-technology screening must approximate these variables.

Proximate Regional Supplementary Resources Availability

Consideration should be given to possible energy feedstocks or resources within a feasible distance of the site.

Energy Demand Patterns

Variations through time and facility spaces of energy demand must be considered in a robust assessment of renewable energy suitability. If temporal variations are likely in a renewable energy resource, as may be the case from day to dark or summer to winter, these variations must be considered for their capacity to match with facility energy demand. The capacity of a renewable resource to store energy for release or conversion when needed is another variable worthy of consideration.

Technical Suitability

Whether a renewable energy resource is appropriate for use depends on a number of technical issues, including it capacity to provide energy on demand, at any time. The magnitude of a resource is qualified by its 'capacity factor' (consistency of production).

Economic Approximations

First costs, operating costs and benefits (as facility utilization or as revenue from sale to utility grid) and operating costs need to be analyzed in order to compare resource-technology options. Little information is available to facilitate site-specific estimates, so only approximations can be provided per unit of energy produced. Further study is necessary to refine cost estimates. It is not possible to place values on benefits to Owner for intangibles such as energy independence from the utility grid, redundancy and backup, unless quantification were available for emergency generator fuels, etc., for the anticipated run time of those systems. Additionally, it is not possible to project fuel or electricity prices into the future, certainly not for the anticipated life-cycle of the facility.

No regulatory or government tax incentives are considered here. Current costs are sourced primarily from USDOE National Renewable Energy Laboratory (NREL) Energy Analysis Office (EAO), expressed in year 2000 dollars.

Scale of Energy Systems and Applications – Utility Grid, District and Buildings

Renewable energy resources may occur at scales conducive to conversion for use by an entire facility 'district,' sufficient only for an individual building, or at a magnitude to afford energy beyond facility demand, allowing export to the utility grid. It is also possible that a given site may possess excess renewable energy capacity, allowing energy to be sold to the electrical grid, or to be utilized as waste heat by co-located industries, businesses or housing. Scale is a critical variable of energy resource assessment, as a consequence.

Complementary, Hybrid Systems Potential

Renewable energy resources that occur according to a daily cycle, such as solar-electricity, or weather dependent patterns, may be significant only when other, complementary technologies can be matched with them to convert the net, hybrid resource to a supply pattern to match the Owner's key objectives of schedule reliability. Storage is an important possibility for some energy forms, as is the relative financial feasibility of sale to the utility grid when production is beyond facility needs, balanced by purchase from the grid when production is low. Resources that offer the capacity to 'level' other resources, either by storage or by complementary generation timetables, are highlighted for those capacities.

Preliminary Renewables Screen for Applicability at Appropriate Scales

Only a few of the many possible forms of renewable energy survive a preliminary screening process. (Refer to Table 1 – Technologies Screen for Owner's Objectives, and to Figure 1 – Renewable Energy Schematic Site Map).

If we conceptualize these 'survivors' according to their potential, functional services to the proposed Rush Valley Correctional Facility, the list narrows to the following probable candidates, all assuming that demand has been minimized to the greatest possible degree by integrative, high-performance building planning and design:

Heating

- Ground-Sourced (or Water-Sourced) Heat Pumps / Scale: Multiple Central Plants or by Quad
- Salt Gradient Solar Ponds / Scale: Central Plant
- Solar-Thermal – Evacuated Tube and Flat Plate Collector Arrays / Scale: Multiple Central Plants or by Quad

Rush Valley Renewable Energy Schematic Site Plan

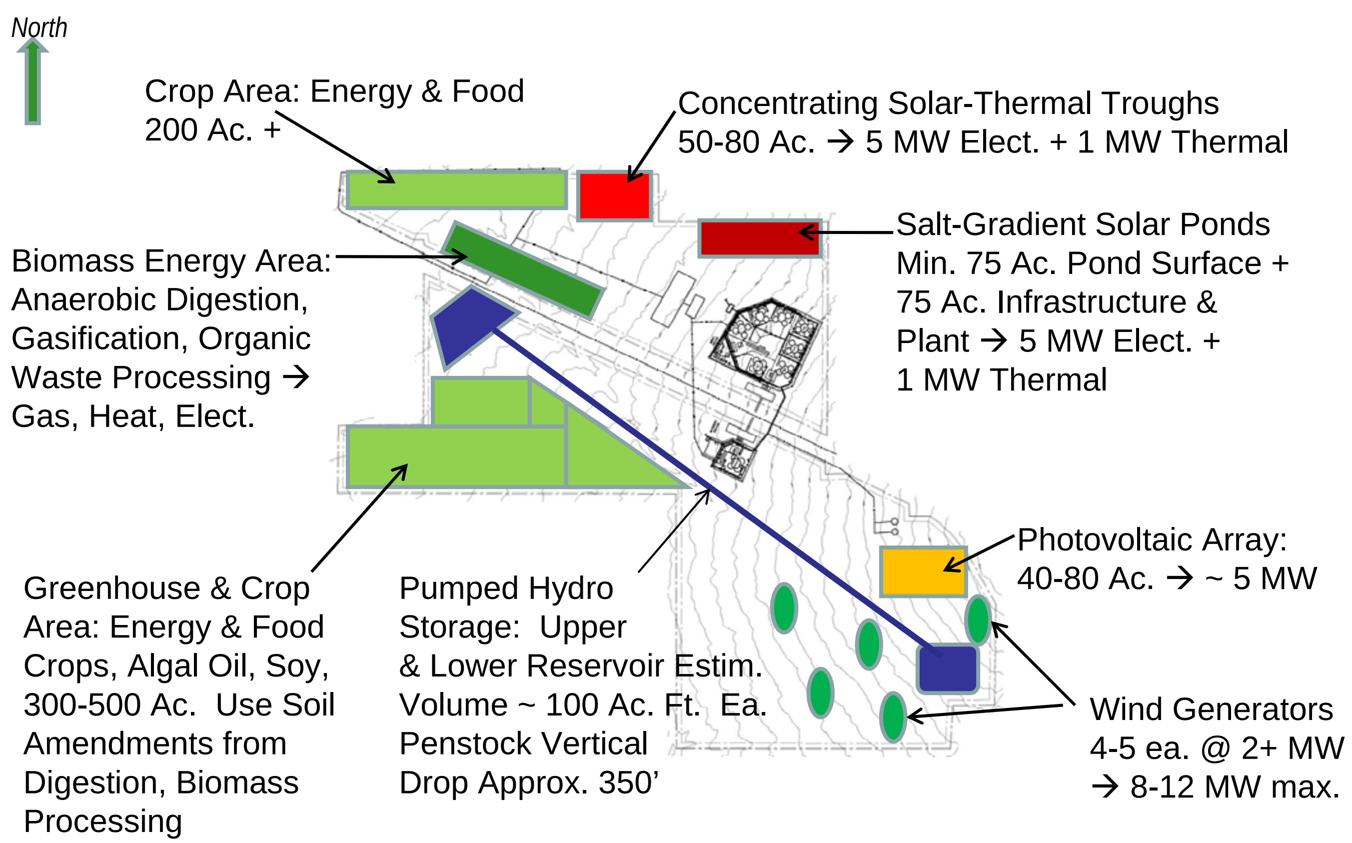


Figure 5.1: Renewable Energy Schematic Site Plan
Note: Energy Sources and Scales Represented are Conceptual, Subject to Field Verification for Greatest Utility to Facility

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Cooling

- Evaporative, with Natural Ventilation (part of High-Performance Building design)
- Ground-Sourced (or Water-Sourced) Heat Pumps / Scale: Multiple Central Plants or by Quad
- Energy Storage: Salt Gradient Solar Ponds – Heat Storage / Scale: Central Plant
- Pumped Hydro – Electricity Storage / Scale: Central Plant

Electricity

- Salt Gradient Solar Ponds & ORC Generator / Scale: Central Plant
- Solar-Updraft Tower Power Plant / Scale: Central Plant
- Solar-PV / Scale: Present, Isolated Small-scale; Near-Future, PV Farm
- Biomass Thermal and Electrical Generation – Anaerobic Digestion à methane / Scale: Central Plant

Gas and Electricity

- Biogas-Anaerobic Digestion / Scale: Central Plant
- Syngas-Biomass Gasification / Central Plant

These resource/technology combinations appear, at this preliminary assessment point, to be worthy of further investigation for the provision of listed functions and services. Others may emerge in the course of site-specific investigation. Rapid technological change may enable some now estimated to be of second-rank priority to rise to the top of the priority list. Site-specific wind resource assessment, for example, may either be found to be greater at 90-meter height above ground than anecdotally estimated, or low-velocity generators may become commercially available soon. Either could move wind into the list of resources worthy of emphasis at facility scale, if not utility scale.

Looking into the earth, further exploratory drilling could uncover the existence of an intermediate-temperature geothermal resource that has not been encountered in water well development. Imposition of a carbon tax or enactment of carbon 'cap and trade' legislation could shuffle priorities significantly and iteratively as our energy economy adjusts and readjusts to changing financial, investment and environmental conditions.

The further evaluation of renewable energy utility to the Rush Valley DOC Facility should be both methodologically rigorous in engineering economic applications of these likely resources, and open to changing possibilities.

RECOMMENDATIONS AND FURTHER INVESTIGATIONS

Gaps and deficiencies exist in data on nearly every form of renewable energy in the Rush Valley area. Site-specific measurement, data-gathering and analysis must be done at the Rush Valley site in order to remedy these gaps and deficiencies. A robust basis in credible data is imperative to consider high-performance facility design for efficiency and energy reduction, and to evaluate renewable energy options at a refined level, based on levels of design needed for each resource/technology combination.

Transition to Renewables: Integral to an advanced energy strategy, an option should be developed for transition from fossil fuel dependence to increasingly high proportions of renewable energy.

A high-resolution, quantitative inventory of possible resources that may be imported from outside the site, but within feasible logistical distances, also should be undertaken. This is especially true for various forms of biomass in municipal solid wastes and sewage sludge in need of disposal solutions, and for agricultural wastes and possible crops for use in biomass-to-energy conversion.

Wind resource assessment should be done formally, without expectation that a first-class wind resource will be identified, but with the possibility in mind that sufficient wind resource may be present to complement other renewables, and that wind generation technology may improve rapidly in the next few years. A marginal wind resource now may become economically and energetically viable within the next few years. Having credible data on hand will speed iterative feasibility review in future.

Environmental and regulatory permitting issues should be studied in detail for each of the candidate forms of renewable energy that pass screening. This is true for all renewable energy technologies; each has its critics and its practical challenges:

- Avian mortality studies for wind generation, though large generation units move so slowly that this has become nearly moot; small generation is still high-speed, for the most part.

- Aviation safety concerns where towers are proposed to be erected, especially proximate to a military facility, or in possible flight paths near other military facilities.

- Groundwater contamination concerns must be addressed for salt-gradient solar ponds, in order to define regulatory expectations in Utah for subsurface preparation, containment liners and O&M compliance. Any limitations on salts and compounds that can be present in salts need to be understood at the outset. Salt sources and logistics for procurement of the thousands of tons of salts needed must also be explored.

- Community concerns must be approached methodically and transparently.

Practical, operational concerns must be explored candidly with Department of Corrections management and staff, to assure that no barriers would be created to effective security and inmate containment, as well as to practical management of energy systems serving the facility.

Integration of planning and design: Energy review process can most effectively proceed by a series of intensive workshops or charrettes, attended by key stakeholders, planning and design experts, prior to committing to building the facility on the site at Rush Valley. Without promises or expectations, a focused group of creative, knowledgeable and technically prepared individuals can advance a vision and consensus for facility creation in a matter of days.

Key deficiencies and gaps, particularly, can be identified for further investigation. The question cited earlier in this report can be answered substantially through this process: "What is the best we can design here, for this Owner, for this programmatically defined purpose?" It will be possible, especially, to bring focus to the manner by which renewable energy can be balanced with conventional energy supplies from utilities, progressively over time shifting to an increasingly carbon-free, economically and environmentally sustainable facility.

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Section 6: Project Costs

OPERATIONAL COST COMPARISONS

Changing the location of the main prison facility or adding a third site to the current prison system will result in additional operational costs. Wikstrom worked with the budget manager at the Division of Institutional Operations to determine which costs would change if the prison were to move location. Categories taken into consideration were medical, supplies, natural gas, trash, transportation and freight. Of these categories, most costs currently incurred for operations and maintenance are contracted through the DOC. Current contracts state that the contract holder is responsible for delivery costs. Since these contracts are already in place they will not change until the contract expires. A contract holder may be able to renegotiate their rate at the end of the contract period if the location is changed; however, impacts of these potential changes cannot currently be quantified due to the difficult nature of predicting the outcome to contract negotiations. The one area where a change in cost can be quantified is transportation. Transportation related expenditures represent approximately four percent of the Draper facility's $73.7 million budget.

The cost of providing prisoner transportation is directly related to the change in distance between the prison and the destination. A model was created to estimate the potential cost of a new prison site on operational budgets. The model was designed to estimate the number of trips and mileage to and from Draper and Rush Valley. The number of trips was grown proportionally to the number of average daily prisoners at each facility. In each of the scenarios presented in this section, the maximum average daily prisoners was obtained by using the assumption that the greatest number of prisoners any facility could hold was 95 percent of total available beds based on information from the Bureau of Research and Planning at the DOC.

Prisoner transport trips can be classified into five main categories: inmate placement program ("IPP"), board of pardons and parole ("BOPP"), court appointments (e.g. appeals, hearings, custody issues, etc.), medical needs, and assignment. Each trip type is associated with a different location. Based on the location for each trip, the number of miles between the proposed site and the destination can be calculated. The percentage each trip type of total prisoner trips is located in Table 6.1.

All trip data was provided for the entire prison system. To better represent trips actually borne by the Draper facility, all trips were proportionally allocated based on the number of prisoners, where programs are housed, and where prisoners attend BOPP meetings.

Table 6.1. Distribution of Trips by Five Main Trip Types, 2007

Trip Type	Percent of Total
Inmate Placement Program	24%
Board of Pardons and Parole	10%
Court	33%
Medical	27%
Assignment	7%
Total	**100%**

Source: Department of Corrections

The Inmate Placement Program allows the Utah State Department of Corrections to lease bed facilities in county jails to house state prisoners. Currently 22 county jails lease beds to the state. Trips classified under the IPP take place between leased beds at county facilities and state prison facilities. To model these trips, the total number of IPP trips was distributed by the percentage of leased bed space each county holds. Across the state there are a total of 1,596 leased beds. The county with the most leased space available is Beaver County with 360 beds.

Board of Pardons and Parole meetings are held at three prison facilities in the state for DOC prisoners: Draper, Gunnison and Beaver. All IPP prisoners that need to attend a BOPP meeting must be transported back to the nearest facility that holds BOPP meetings. Based on a shortest distance assumption, Draper would hold BOPP meeting for IPP prisoners in 12 of the 22 counties participating in the IPP.

Court trips occur between the prison and the prisoner's court of conviction. The percentage of prisoners convicted from each county was used to distribute these trips. 39 percent of all prisoners were convicted in Salt Lake County. Table 6.2 shows the top five counties for percent of prisoner convictions in the system.

Table 6.2. Top 5 Courts of Conviction with the Utah Prison System

County of Conviction	% of prisoners
Salt Lake	39%
Weber	20%
Davis	11%
Utah	7%
Washington	3%

Source: DOC, Wikstrom

Most medical primary care takes place within the prison facilities. If a prisoner requires a specialized test beyond the capabilities of the internal staff, that prisoner is taken to the University of Utah Medical Center ("UUMC"). To maximize efficiencies, all chronically ill prisoners are housed at the Draper prison. The vast majority of all trips classified as medical occur between Draper and the UUMC.

Assignment trips are trips between the two main prison facilities, Draper and Gunnison. In the case of a full relocation these trips will be between Rush Valley and Gunnison. In the case of a partial relocation, where the Draper site remains open and a third satellite site is added, it is assumed that trips will be split evenly between the three sites.

Two transportation scenarios were run. One compared the cost of providing transportation for Rush Valley as a replacement for the current Draper facility. The second scenario assumed Draper would remain as the main prison facility and Rush Valley would be added as a third prison site.

Table 6.3 shows that in a full relocation scenario, transportation costs for the Rush Valley site will be greater than for the current Draper site. Transportation costs are consistently 30 percent higher for the Rush Valley site assuming both locations have the same number of beds. Table 6.3 shows the cost estimates related to transportation for both Draper and Rush Valley assuming a 4,000- (Draper's current size), 6,000- and 10,000-bed facility.

Table 6.3. Transportation Cost Comparison

Beds	Draper	Rush Valley	Difference from Draper	Percent Change from Draper
4,000	$3,767,192	$4,890,915	$1,123,722	30%
6,000	$5,515,635	$7,162,137	$1,646,502	30%
10,000	$9,012,521	$11,704,581	$2,692,060	30%

Note: Assumes all bed are filled to 95% capacity

Under a three site scenario (assuming 4,000 beds at Draper and 6,000 beds at Rush Valley) the costs borne by Draper increase from the full relocation scenario, since Draper retains BOPP and medical trips, while the costs for Rush Valley are slightly lower. Overall, the cost of providing transportation for 10,000 beds under a three site scenario is lower than providing these transportation costs under the full relocation scenario to Rush Valley. Keeping all beds at the Draper facility is still the most cost effective method for transportation due to its closer proximity to transportation destinations. Table 6.4 shows the transportation costs for a three site scenario with 10,000 beds.

Table 6.4. Transportation Cost Comparison: Three Site Scenario

Location	Beds	Cost
Draper	4,000	$4,685,881
Rush Valley	6,000	$6,177,819
Total	**10,000**	**$10,863,700**

Note: Assumes all bed are filled to 95% capacity

In addition to computing the three-site and full-relocation scenarios for Rush Valley, the costs of relocating a 6,000-bed facility to sites in Juab County and Box Elder County were run. This calculation shows that the transportation costs associated with new facilities in these counties is higher than the costs associated with a similar facility being relocated to Rush Valley. Of the two alternative sites, Rush Valley is much closer in transportation costs to Juab County than to Box Elder County. Of the three sites (Rush Valley, Eastern Box Elder County, and Northeastern Juab County), Rush Valley would have the lowest transportation costs.

Table 6.5. Transportation Cost Comparison by Site Alternatives all with 6,000 Beds

Site	Cost
Draper	$5,515,635
Rush Valley	$7,162,137
Juab	$7,189,626
Box Elder	$9,287,614

Note: Assumes all bed are filled to 95% capacity

Juab County's surprisingly similar anticipated transportation costs to Rush Valley's costs are in spite of its distance from Salt Lake City. The reason for this is that Juab County's more southern location reduces the mileage for many of the IPP trips since most of the beds available to the state are located south of Juab.

Although transportation costs estimated in these calculations are on par with Rush Valley, other operational costs will likely be higher in Juab County and Box Elder County than Rush Valley since both Juab County and Box Elder County are much farther from service centers than Rush Valley. If these additional operational costs were able to be quantified they would most likely be greater at Juab County than at Rush Valley. This would make the difference in total operational cost between Rush Valley and Juab County greater than what is shown in Table 6.5.