Technical Appendix C

Technical - Environmental

1. Micro-climate assessment
2. Weather-shift climate predictions
3. District energy systems presentation
4. BMP sizing memorandum
5. Water recycling exec. summary presentation

C-ii
C-xlii
C-xlviii
C-cxx
C-cxxiv

Sacramento Valley Station
Area Plan

City of SACRAMENTO

Perkins&Will

May 2021
i. Micro-climate assessment

Sacramento Valley Station

Microclimate Assessment
March 6th, 2020

ARUP
Aim

The aim of this microclimate assessment is to determine the windiness and outdoor thermal comfort on the Sacramento Valley Station site.

This assessment is meant to indicate potential areas of wind and thermal discomfort throughout a typical year for two massing options.
Site Geometry

Massing Options
Massing Options

Massing Option A

E-W Orientation

Tower

Massing Option B

N-S Orientation

No tower
Climate
Weather stations

The site is located in downtown Sacramento, between Sacramento Intl Airport and Sacramento Executive Airport.

Sacramento Executive Airport is located in an urban environment, which is expected to have a strong influence on the recorded wind speeds, and therefore will not be used for this assessment.

Sacramento Intl Airport is on the northern side of the city, in a more exposed location, and will be used for this assessment.

Sacramento International Airport
Sacramento | Wind

- The airport data shows that wind is predominantly from the South-Southeast directions (150 & 180 deg) and, to a lesser extent, from the Northwest (330 deg).
- The wind speeds are generally not above 10 m/s (~22 mph) and are on average closer to 3.4 m/s (7.6 mph).
- During the summer months, the wind is predominantly from the south.
- In Spring and Fall, the wind is from the South and Northwest.
- In Winter, wind comes from the South-southeast and Northwest directions.
Sacramento | Average Air Temperatures

- The site is mild to warm during Spring and Fall.
- During summer, high average temperatures can be seen in noon and afternoon times.
- Winter temperatures are on the cool to cold side, particularly in the morning times.
Results

Wind Assessment
Arup developed a 3D web visualization tool to serve as a companion to this report.

It shows seasonal results for the average conditions during selected times of morning (7-10am), afternoon (12-3pm), and evening (4-7pm).

The web visualization shows results for comfort, wind and solar conditions on the site and points of interest.

The website can be accessed at http://52.27.53.30:3000/
  - Username: svs
  - Password: svs123
Wind comfort is assessed by simulating a typical weather year and mapping wind speeds against a space use scale. This helps identify areas of high and low windiness as well as appropriate space use.

The results shown compare the windiness of the site for Option A.

In general, the site is suitable for short periods of standing and sitting, which is acceptable for outdoor spaces where people switch between standing and sitting.

This shows that there is low windiness on the site.
Wind Comfort Criteria | Option B

The results shown compare the windiness of the site for Option B.

In general, the site is suitable for short periods of standing and sitting, which is acceptable for outdoor spaces where people switch between standing and sitting.

This shows that there is low windiness on the site and is comparable to Option A.
Results

Yearly Cumulative Solar Assessment
Cumulative Solar

The plots above show the cumulative solar radiation for a year on the site for Massing Options A and B. The majority of the site is similar. However, Option A leads to more shading on G Street. This shading is provided by the tower in Option A.
Results

Outdoor Thermal Comfort Assessment
Points of Interest

- Six locations of interest were chosen to be evaluated for outdoor thermal comfort for both massing options A & B
- The results indicate comfort conditions during “occupied” hours of 7 am to 7 pm
Option A and Option B lead to same comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the regenerative garden.

**Seasonal Summary:**
- Winter: Cool to cold conditions for about 30-40% of the season. Rest of time is comfortable
- Spring/Fall: Mostly comfortable to warm with <10% of hours that are too hot.
- Summer: 40-47% of season is too hot. Shading strategies can mitigate these hot conditions.
Option A and Option B lead to same comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the park area under the freeway.

**Seasonal Summary:**

- **Winter:** Cool to cold conditions for about 30-56% of the season. Rest of time is comfortable.
- **Spring/Fall:** Mostly comfortable to warm with <3% of hours that are too hot.
- **Summer:** About 20% of season is too hot. This is due to the shading provided by the freeway.
Outdoor Comfort | Civic Plaza

Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Civic Plaza.

**Seasonal Summary:**
- **Winter:** Cool to cold conditions for about 40% of the season. Rest of time is comfortable.
- **Spring/Fall:** Mostly comfortable to warm with <10% of hours that are too hot.
- **Summer:** About 37% of season is too hot. Shading strategies can mitigate these hot conditions.
Outdoor Comfort | Transit Plaza

Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Transit Plaza.

**Seasonal Summary:**

- **Winter:** Cool to cold conditions for about 36-47% of the season. Rest of time is comfortable.
- **Spring/Fall:** Mostly comfortable to warm with <10% of hours that are too hot.
- **Summer:** About 40% of season is too hot. Shading strategies can mitigate these hot conditions.
Option A and Option B lead to similar comfort results. This is because the buildings of interest in the different massing options do not affect the conditions at the Bus Center platform.

**Seasonal Summary:**

- **Winter:** Cool to cold conditions for about 40% of the season. Rest of time is comfortable.
- **Spring/Fall:** Mostly comfortable to warm with <4% of hours that are too hot.
- **Summer:** About 20% of season is too hot. This is due to the shading provided by the roof.
Option A and Option B lead to slightly different comfort results. This is because the tower in massing Option A provides more shading that Option B.

**Seasonal Summary:**

- **Winter:** Cool to cold conditions for about 40% of the season. Rest of time is comfortable.
- **Spring/Fall:** Mostly comfortable to warm with <3% of hours that are too hot.
- **Summer:** Option A provides more shading than Option B. About 30% (Option A) to 40% (Option B) of season is too hot.
Mitigation Strategies
Provided Program Areas by Zone
Point A | Regenerative Garden, Zone B

**Program Types:** bike and pedestrian path, window shopping, look-out area

The results for this area indicate that a majority of occupied hours during the year (54%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 40% of hours that are deemed hot. **Local shading from the retail stores** will improve comfort for window shoppers. Since the expected use of the space is for transit and is transient in nature, additional cooling or ventilation may not be necessary.
Point B | Park Under Freeway, Zone A

**Program Types:** retail spill-out, outdoor dining, community events, active sports

The results for this area indicate that a majority of occupied hours during the year (53%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 20% of hours that are deemed hot. The freeway already provides shading and that improves comfort. To further improve comfort, **adding misting or additional ventilation to dining or event areas** is recommended.
The results for this area indicate that a majority of occupied hours during the year (52%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 36% of hours that are deemed hot. **Local or seasonal shading** in the Civic Plaza will reduce these hot periods. To further improve comfort, **misting or increased ventilation via fans** is recommended if long dwell times or dining areas are expected.
Point D | Transit Plaza, Zone A

Program Types: retail spill-out, outdoor dining, community events, active sports

The results for this area indicate that a majority of occupied hours during the year (55%) will be deemed as comfortable. During the summer months of June, July, and August, there will be about 30-40% of hours that are deemed hot. **Local or seasonal shading** in the Transit Plaza will improve comfort during warm months. To further improve comfort, adding **misting or additional ventilation to dining or event areas** is recommended.
Appendix

Average Wind Velocities on Site by Season
Average Wind Velocities on Site by Times for **Winter**

**Option A**
- **Morning**: 7.6 mph
- **Afternoon**: 8.7 mph
- **Evening**: 7.2 mph

**Option B**
- **Morning**: 7.6 mph
- **Afternoon**: 8.7 mph
- **Evening**: 7.2 mph
Average Wind Velocities on Site by Times for **Spring**

**Option A**
- **Morning**: 0 mph
- **Afternoon**: 0 mph
- **Evening**: 0 mph

**Option B**
- **Morning**: 0 mph
- **Afternoon**: 0 mph
- **Evening**: 0 mph
Average Wind Velocities on Site by Times for **Summer**

**Option A**

<table>
<thead>
<tr>
<th>Time</th>
<th>Morning</th>
<th>Afternoon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 mph</td>
<td>10.5 mph</td>
<td>15.8 mph</td>
</tr>
</tbody>
</table>

**Option B**

<table>
<thead>
<tr>
<th>Time</th>
<th>Morning</th>
<th>Afternoon</th>
<th>Evening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.8 mph</td>
<td>10.6 mph</td>
<td>16.3 mph</td>
</tr>
</tbody>
</table>
Average Wind Velocities on Site by Times for Fall

**Option A**

<table>
<thead>
<tr>
<th>Time</th>
<th>Option A Velocities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>0 8.6 mph</td>
</tr>
<tr>
<td>Afternoon</td>
<td>0 8.7 mph</td>
</tr>
<tr>
<td>Evening</td>
<td>0 7.6 mph</td>
</tr>
</tbody>
</table>

**Option B**

<table>
<thead>
<tr>
<th>Time</th>
<th>Option B Velocities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>0 8.8 mph</td>
</tr>
<tr>
<td>Afternoon</td>
<td>0 9.2 mph</td>
</tr>
<tr>
<td>Evening</td>
<td>0 8.3 mph</td>
</tr>
</tbody>
</table>
Appendix

Wind Velocities Ratios by Major Wind Directions
Major Wind Directions - Wind Ratios | Northwest

Option A

Wind Direction: 330

Wind Direction: 300

Option B

1 (no change in incoming wind speed)

2 (twice as fast)

0.5 (half as fast)

0
Major Wind Directions - Wind Ratios | Southeast

Wind Direction: 150

Option A

Wind Direction: 180

Option B

ARUP
Methodology
Wind Comfort Criteria

- The Lawson comfort criteria estimates the likeliness of wind-related risk for pedestrians in external areas and categorizes the areas by typical activities for which they could be used. Table 1 provides a summary of the Lawson comfort criteria.

- Figure 1 illustrates how climate data and analysis is used to obtain the wind comfort for the site to be compared against the Lawson comfort scale.

<table>
<thead>
<tr>
<th>Comfort Criteria</th>
<th>Activity Description</th>
<th>Equivalent Beaufort Wind Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>Reading a newspaper and eating and drinking</td>
<td>Category 2 – Light Breeze (wind speed less than 7mph)</td>
</tr>
<tr>
<td>Standing or short-term sitting</td>
<td>Bus stops, window shopping, and building entrances</td>
<td>Category 3 – Gentle Breeze (wind speed less than 12mph)</td>
</tr>
<tr>
<td>Walking or strolling</td>
<td>General areas of walking and sightseeing</td>
<td>Category 4 – Moderate Breeze (wind speed less than 17mph)</td>
</tr>
<tr>
<td>Fast or business walking</td>
<td>Local areas around tall buildings where people are not expected to linger</td>
<td>Category 5 – Fresh Breeze (wind speed less than 24mph)</td>
</tr>
<tr>
<td>Potentially dangerous</td>
<td>Areas that could limit movement — umbrellas become difficult to use</td>
<td>Category 6 and higher – Strong Breeze (wind speed greater than 25mph)</td>
</tr>
</tbody>
</table>

Table 1: Lawson comfort criteria

Figure 1: Description of Wind data

- Wind data is recorded for the site.
- The 95th percentile threshold wind speed is mapped against the Lawson comfort scale.
- The 95th percentile threshold wind speed is mapped against the Lawson comfort scale.
- The Lawson Criteria indicates the suitability of carrying out different levels of activity for the given site.
The Beaufort scale bins wind velocities into classes of increasing wind intensity and describes the conditions during those wind bins. It is used to measure wind strength. Figure 1 illustrates the wind speed bins and the observed conditions during those wind speeds.
# Outdoor Thermal Comfort

## Factors Affecting Thermal Comfort

### Personal Factors

- **Metabolic rate**
  - The level of transformation of chemical energy into heat and mechanical work by metabolic activities within an organism, usually expressed in terms of unit area of the total body surface.

- **Clothing level**
  - The amount of thermal insulation worn by a person has a substantial impact on thermal comfort, because it influences the heat loss and consequently the thermal balance.

### Environmental Factors

- **Air temperature**
  - The air temperature is the average temperature of the air surrounding the occupant.

- **Mean radiant temperature**
  - The mean radiant temperature depends on the temperatures and emissivity of the surrounding surfaces as well as the view factor, or the amount of the surface that is “seen” by the object.

- **Air speed**
  - Air speed is defined as the rate of air movement at a point, without regard to direction.

- **Relative Humidity**
  - Relative humidity is the ratio of the amount of water vapor in the air to the amount of water vapor that the air could hold at the specific temperature and pressure.

## Thermal Comfort Metric: Universal Thermal Climate Index (UTCI)

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Cold</td>
</tr>
<tr>
<td>32</td>
<td>Cool</td>
</tr>
<tr>
<td>48</td>
<td>Comfortable</td>
</tr>
<tr>
<td>79</td>
<td>Warm</td>
</tr>
<tr>
<td>90</td>
<td>Hot</td>
</tr>
<tr>
<td>115</td>
<td></td>
</tr>
</tbody>
</table>

Universal Thermal Climate Index (°F)

ii. Weather-shift climate predictions

Sacramento Valley Station:
Initial Future Climate Capacity Assessment

Arup
April 24, 2020
Selected Scenarios

- **RCP8.5**
  - Limited/No Global Emissions Reduction
  - Business-as-usual
  - 2.1 trillion tons carbon

- **RCP4.5**
  - Moderate Global Emissions Reduction

Outcomes from different climate simulations vary

March 2020

RCP8.5 @ Year 2090

RCP4.5 @ Year 2035

50th – 95th Percentiles
10-Year Storm Intensity Comparison, Sacramento

10-year Storm

- Historic
- 50th RCP4.5@2035
- 95th RCP4.5@2035
- 50th RCP8.5@2090
- 95th RCP8.5@2090

2-18% Increase by 2035*
14-47% Increase by 2090*

*24-hour duration
100-Year Storm Intensity Comparison, Sacramento

100-year Storm

Intensity (in/hr) vs. Duration (hours)

- Historic
- 50th RCP4.5@2035
- 95th RCP4.5@2035
- 50th RCP8.5@2090
- 95th RCP8.5@2090

1-23% Increase by 2035*
16-51% Increase by 2090*

*24-hour duration

Technical Appendix C
Preliminary Capacity Assessment

RAILYARDS DMP REPORT, KIMLEY HORN, OCT 2016

Planned Total Peak Flow Capacity = 378 cfs
(37% above modeled 10-year storm)

FINAL SUBSEQUENT EIR, ESA, OCT 2016

Planned 100-year Peak Design Flow = 450 cfs
Planned Total Peak Flow Capacity = 600 cfs
(117% above modeled 10-year storm)
(39% above modeled 100-year storm)

WEATHERSHIFT PRELIMINARY CAPACITY ASSESSMENT

<table>
<thead>
<tr>
<th>RCP4.5 @ Year 2035</th>
<th>RCP8.5 @ Year 2090</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>10-year Pump Station Inflow (cfs)</strong></td>
<td><strong>10-year Pump Station Inflow (cfs)</strong></td>
</tr>
<tr>
<td>Existing</td>
<td>276</td>
</tr>
<tr>
<td>RCP4.5 50th%</td>
<td>288</td>
</tr>
<tr>
<td>ΔQ</td>
<td>12</td>
</tr>
<tr>
<td>% Increase</td>
<td>4%</td>
</tr>
<tr>
<td>RCP4.5 95th%</td>
<td>366</td>
</tr>
<tr>
<td>ΔQ</td>
<td>90</td>
</tr>
<tr>
<td>% Increase</td>
<td>33%</td>
</tr>
<tr>
<td><strong>100-year Pump Station Inflow (cfs)</strong></td>
<td><strong>100-year Pump Station Inflow (cfs)</strong></td>
</tr>
<tr>
<td>Existing</td>
<td>431</td>
</tr>
<tr>
<td>RCP4.5 50th%</td>
<td>452</td>
</tr>
<tr>
<td>ΔQ</td>
<td>21</td>
</tr>
<tr>
<td>% Increase</td>
<td>5%</td>
</tr>
<tr>
<td>RCP4.5 95th%</td>
<td>533</td>
</tr>
<tr>
<td>ΔQ</td>
<td>102</td>
</tr>
<tr>
<td>% Increase</td>
<td>24%</td>
</tr>
</tbody>
</table>

Exceeds City design criteria under 10-year event, RCP4.5@2035, 95th%
[Intentionally left blank]
iii. District energy systems presentation

Sacramento Valley Station: District Energy Update

Arup
March 5, 2020

ARUP
Table of Contents

1. Summary of Findings
2. Site Map and Technology Options
3. Baseline Scenarios (Residential + Hotel + Historic Station Only)
4. Baseline + Lot 40 Scenarios
5. Baseline + Railway Scenarios
6. Responses to Questions
Summary of Findings
## Scenarios Evaluated

<table>
<thead>
<tr>
<th></th>
<th>A: Base Area</th>
<th>B: Base + Lot 40</th>
<th>C: Base + Railway Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building) Systems</td>
<td>0A</td>
<td>0B</td>
<td>0C</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers + Cooling Towers, and Air Source Heat Pumps</td>
<td>1A</td>
<td>1B</td>
<td>1C</td>
</tr>
<tr>
<td>2: All-Electric CUP + GSHP (Still includes Chillers + Cooling Towers, Air Source Heat Pumps)</td>
<td>2A</td>
<td>2B</td>
<td>2C</td>
</tr>
<tr>
<td>3: All-Electric CUP + Sewer Heat Recovery (Still includes Chillers + Cooling Towers, Air Source Heat Pumps)</td>
<td>3A</td>
<td>3B</td>
<td>3C</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP) (Still includes Chillers + Cooling Towers, Air Source Heat Pumps)</td>
<td>4A</td>
<td>4B</td>
<td>4C</td>
</tr>
</tbody>
</table>

Not Included in these Results
CUP Connection Options

A: Baseline Area

B: Lot 40

C: Railway Museum
Space Findings

Prior Space Requirement

- Refined calculation reduced space with Lot 40
- Adding GSHP and SHR reduces space further, particularly for above ground equipment
- Railway Museum may require slightly increase required footprint depending on load (currently estimated)
Ground Source Heat Pump + Sewer Heat Recovery

- GSHP provides water savings and reduces open air area at CUP
- SHR only impactful if connecting to Bercut sewer
  - On-site flows achieve 4% of heating
  - Bercut achieves up to 40%
- Combined solution has some risk in permitting
  - Ground source more proven
  - Sewer heat recovery likely requires approval and coordination with public works
Railway Museum Connection

- Load not definitively known
- Estimates of load indicate up to 8” chilled water and 6” heating hot water pipes may be required
  - Likely smaller
- Marginally increases installed capacity requirement, might be achievable in same CUP area
- Increases utilization of GSHP, reducing energy use of system per SF
Connecting Lot 40

- Bring utilities to vault 5’ outside building floor plate, valve and cap in vault

- Connect into building at time of construction via either:
  - Heat exchangers at building (adds some loss to system)
  - Tertiary pumps with bypass

- Header pipe requires upsizing; can likely be achieved without performance impact to SVS, and minimal cost (i.e., 10” CHW to 12” CHW, with slight increase in flow rate)
# Options Summary: Installed Capacity

<table>
<thead>
<tr>
<th></th>
<th>A: Base Area</th>
<th>B: Base + Lot 40</th>
<th>C: Base + Railway Museum</th>
</tr>
</thead>
</table>
## Options Summary: Energy Use

<table>
<thead>
<tr>
<th>Option Description</th>
<th>A: Base Area</th>
<th>B: Base + Lot 40</th>
<th>C: Base + Railway Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>1.60 GWh</td>
<td>3.11 GWh</td>
<td>1.81 GWh</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>0.98 GWh</td>
<td>1.90 GWh</td>
<td>1.10 GWh</td>
</tr>
<tr>
<td></td>
<td>(39% reduction)</td>
<td>(39%)</td>
<td>(39%)</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP)</td>
<td>0.85 GWh</td>
<td>1.65 GWh</td>
<td>0.96 GWh</td>
</tr>
<tr>
<td>(Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>(48% reduction)</td>
<td>(47%)</td>
<td>(47%)</td>
</tr>
</tbody>
</table>
# Options Summary: Space Required

<table>
<thead>
<tr>
<th>Option Description</th>
<th>A: Base Area</th>
<th>B: Base + Lot 40</th>
<th>C: Base + Railway Museum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>Interior: 13.1K SF</td>
<td>Interior: 22.3K SF</td>
<td>Interior: 14.8K SF</td>
</tr>
<tr>
<td></td>
<td>Roof: 12.7K SF</td>
<td>Roof: 21.7K SF</td>
<td>Roof: 14.4K SF</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>Interior: 8.8K SF</td>
<td>Interior: 14.0K SF</td>
<td>Interior: 9.2K SF</td>
</tr>
<tr>
<td></td>
<td>Roof: 8.5K SF</td>
<td>Roof: 12.8K SF</td>
<td>Roof: 8.5K SF</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP)</td>
<td>Interior: 10.5K SF</td>
<td>Interior: 14.6K SF</td>
<td>Interior: 10.8K SF</td>
</tr>
<tr>
<td><em>(Still includes Chillers, Towers, Air Source Heat Pumps)</em></td>
<td>Roof: 4.0 SF</td>
<td>Roof: 7.4K SF</td>
<td>Roof: 4.0K SF</td>
</tr>
</tbody>
</table>
Site Map and Technology Options
CUP Locations Options and Main Trunk

Preferred CUP Location
Location Alternates and Considerations/Constraints

- Location near the bus station reduces piping connection + pumping energy to proposed ground loops below bus station
- Location near residential, hotel buildings reduces piping connection + pumping energy to serve load
- Thermal CUP requires interior space and rooftop/open to air space; can be directly stacked or separated with other uses in between
- Underutilized space in station or residential/hotel blocks may be viable locations
## Scenarios Evaluated

<table>
<thead>
<tr>
<th>Scenario Description</th>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>0A</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>1A</td>
</tr>
<tr>
<td>2: All-Electric CUP + GSHP (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>2A</td>
</tr>
<tr>
<td>3: All-Electric CUP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>3A</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>4A</td>
</tr>
</tbody>
</table>

### Option BAU
- **Grid**
- **Plant**

![Diagram](image-url)
## Technology Systems

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td></td>
<td>0A</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td></td>
<td>1A</td>
</tr>
<tr>
<td>2: All-Electric CUP + GSHP (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td></td>
<td>2A</td>
</tr>
<tr>
<td>3: All-Electric CUP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td></td>
<td>3A</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td></td>
<td>4A</td>
</tr>
</tbody>
</table>

**Diagram:**
- **Option 1**
  - Grid
  - Plant
  - Buildings

---

**Sacramento Valley Station Master Plan**
## Technology Systems

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td></td>
<td>0A</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td></td>
<td>1A</td>
</tr>
<tr>
<td>2: All-Electric CUP + GSHP</td>
<td><em>Still includes Chillers, Towers, Air Source Heat Pumps</em></td>
<td>2A</td>
</tr>
<tr>
<td>3: All-Electric CUP + Sewer Heat Recovery</td>
<td><em>Still includes Chillers, Towers, Air Source Heat Pumps</em></td>
<td>3A</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery</td>
<td><em>Still includes Chillers, Towers, Air Source Heat Pumps</em></td>
<td>4A</td>
</tr>
</tbody>
</table>
Bus Facility Ground Source

Manifold Closet
3’ x 5’ rack per loop set
*Note: Five loops is indicative for concept only; further design required
Bus Facility Energy Piles

65' deep piles with 2-4 pipes per pile

Similar manifold space required in station (3’ x 5’ rack per zone, likely 2-4 zones)
## Technology Systems

<table>
<thead>
<tr>
<th></th>
<th>A: Base Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>0A</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>1A</td>
</tr>
<tr>
<td>2: All-Electric CUP + GSHP (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>2A</td>
</tr>
<tr>
<td>3: All-Electric CUP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>3A</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>4A</td>
</tr>
</tbody>
</table>
On-Site Sewer Heat Recovery

- Total flow available from on-site wastewater recovery: 100,000 gpd
- Heat recovery can be added to treatment train to absorb heat from effluent
  - Possibly can also reject heat; requires further study and not considered as peak capacity
- Assuming flow is continuous, can be counted as peak capacity
- Lower limit of heat absorption defined by fat/oil/grease solidification

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)
Bercut Sewer Heat Recovery

- Total flow available from on-site wastewater recovery: 2,500,000 gpd

- Heat extracted from warm wastewater in sewer and transferred to heating network via heat pump and heat exchanger

- Assuming flow is continuous, can be counted as peak capacity

- Lower limit of heat absorption defined by fat/oil/grease solidification (~10 °C)

- Existing Examples: False Creek, Vancouver, and Wintower in Winterhur, Switzerland

Example Product: Huber Technologies (HUBER ThermWin)
Bercut vs. On-Site Flows
# Technology Systems

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Business as Usual (Building by Building Systems)</td>
<td>0A</td>
</tr>
<tr>
<td>1</td>
<td>All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>1A</td>
</tr>
<tr>
<td>2</td>
<td>All-Electric CUP + GSHP (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>2A</td>
</tr>
<tr>
<td>3</td>
<td>All-Electric CUP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>3A</td>
</tr>
<tr>
<td>4</td>
<td>All-Electric CUP + GSHP + Sewer Heat Recovery (Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>4A</td>
</tr>
</tbody>
</table>
A Options: Serving Station + Residential + Hotel
CUP Connection Options

A: Baseline Area
### Summary of Findings: Base

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scenario</th>
<th>Installed Capacity (MMBH)</th>
<th>Energy Use</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>0A</td>
<td>Heating: 13.0 Cooling: 14.0</td>
<td>1.60 GWh</td>
<td>Interior: 13.1K SF Roof: 12.7K SF</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>1A</td>
<td>Heating: 11.0 Cooling: 12.4</td>
<td>0.98 GWh (39% reduction)</td>
<td>Interior: 8.8K SF Roof: 8.5K SF</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP)</td>
<td>4A</td>
<td>Heating: 12.3 Cooling: 12.1</td>
<td>0.85 GWh (48% reduction)</td>
<td>Interior: 10.5K SF Roof: 4.0K SF</td>
</tr>
</tbody>
</table>

(Still includes Chillers, Towers, Air Source Heat Pumps)
Space: Baseline CUP

CUP BASELINE
2020-03-05

WATER TREATMENT 7,000 SF
INTERIOR SPACE 8,800 SF
OPEN AIR SPACE 8,500 SF

ELEVATION

4,250 SF OPEN AIR SPACE
4,250 SF OPEN AIR SPACE
900 SF INTERIOR
900 SF INTERIOR

7,000 SF WATER TREATMENT
7,000 SF INTERIOR BASEMENT

TOTAL 23,500 SF

REGENERATIVE GARDEN
PLAYGROUND
DOG PARK
ROCK CLIMBING AREA
SKATE PARK
RAIN GARDEN

OLD SACRAMENTO
Space: Innovative CUP (iCUP: GSHP + SHR)
Life Cycle Cost

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>BAU</th>
<th>CUP</th>
<th>CUP + GSHP + big sewage connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal elec fuel cost (NPC 2019 $)</td>
<td>$1.9</td>
<td>$1.1</td>
<td>$1.0</td>
</tr>
<tr>
<td>Total thermal operation costs (NPC 2019 $)</td>
<td>$9.9</td>
<td>$7.3</td>
<td>$4.7</td>
</tr>
<tr>
<td>Total annualised thermal REPEX (NPC 2019 $)</td>
<td>$3.1</td>
<td>$1.5</td>
<td>$1.5</td>
</tr>
<tr>
<td>Total thermal capital costs (NPC 2019 $)</td>
<td>$16.0</td>
<td>$20.2</td>
<td>$17.1</td>
</tr>
<tr>
<td>Carbon (ktCO2)</td>
<td>$1.44</td>
<td>19.22</td>
<td>16.73</td>
</tr>
</tbody>
</table>
Water Consumption (Thermal Systems Only)
B Options: Including Lot 40
CUP Connection Options

A: Baseline Area

B: Lot 40
### Summary of Findings: Base + Lot 40

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Installed Capacity</th>
<th>Energy Use</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: Business as Usual (Building by Building Systems)</td>
<td>Heating: 23.0</td>
<td>3.11 GWh</td>
<td>Interior: 22.3K SF</td>
</tr>
<tr>
<td></td>
<td>Cooling: 32.0</td>
<td></td>
<td>Roof: 21.7K SF</td>
</tr>
<tr>
<td>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</td>
<td>Heating: 16.8</td>
<td>1.90 GWh</td>
<td>Interior: 14.0K SF</td>
</tr>
<tr>
<td></td>
<td>Cooling: 23.5</td>
<td>(39%)</td>
<td>Roof: 12.8K SF</td>
</tr>
<tr>
<td>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP)</td>
<td>Heating: 16.6</td>
<td>1.65 GWh</td>
<td>Interior: 14.6K SF</td>
</tr>
<tr>
<td>(Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td>Cooling: 23.5</td>
<td>(47%)</td>
<td>Roof: 7.4K SF</td>
</tr>
</tbody>
</table>
Space: Baseline CUP

CUP BASELINE WITH LOT 40
2020-03-05

WATER TREATMENT 7,000 SF
INTERIOR SPACE 14,000 SF
OPEN AIR SPACE 12,800 SF

ELEVATION

6,400 SF OPEN AIR SPACE
3,500 SF INTERIOR
7,000 SF WATER TREATMENT
10,500 SF INTERIOR BASEMENT

PLAYGROUND
DOG PARK
ROCK CLIMBING AREA
SKATE PARK
RAINFOREST
Space: Innovative CUP (iCUP: GSHP + SHR)
Life Cycle Cost

<table>
<thead>
<tr>
<th></th>
<th>BAU</th>
<th>CUP</th>
<th>CUP + GSHP + big sewage connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal elec fuel cost (NPC 2019 $)</td>
<td>$2.7</td>
<td>$2.1</td>
<td>$1.9</td>
</tr>
<tr>
<td>Total thermal operation costs (NPC 2019 $)</td>
<td>$20.6</td>
<td>$12.7</td>
<td>$9.7</td>
</tr>
<tr>
<td>Total annualised thermal REPEX (NPC 2019 $)</td>
<td>$5.5</td>
<td>$2.6</td>
<td>$2.6</td>
</tr>
<tr>
<td>Total thermal capital costs (NPC 2019 $)</td>
<td>$27.2</td>
<td>$26.6</td>
<td>$24.4</td>
</tr>
<tr>
<td>Carbon (ktCO2)</td>
<td>60.98</td>
<td>37.29</td>
<td>32.46</td>
</tr>
</tbody>
</table>
Water Consumption (Thermal Systems Only)

![Bar Chart]

- **BAU**
  - Annual Water Consumption: 10.00 MGal

- **CUP + GSHP + big sewage connection**
  - Annual Water Consumption: 5.00 MGal
Benefits to SVS of Including Lot 40

- Higher diversity of heating and cooling across uses means greater use of CUP equipment
- Ground source heat pump and sewer heat recovery have better payback with added diversity due to greater annual use and heat recovery
- Operations cost is spread across greater floor area, reducing cost for Sacramento Valley Station operations (non-linear operations cost)
Connecting Lot 40

- Bring utilities to vault 5’ outside building floor plate
- Provide valves and cap within utility vault
- Connect into building at time of construction via either:
  - Heat exchangers at building (adds some loss to system)
  - Tertiary pumps with bypass
  - Btu meter (temperature + flow meter)
C Options: Including Railway Museum
CUP Connection Options

A: Baseline Area

C: Railway Museum
Railway Museum Connection Concept

Connection Pathway to Railway Museum

Preferred CUP Location

On-Site Trench/Utility Pathway
Potential Value

- Additional diversity for CUP (especially without Lot 40)
  - Reduced total capacity of installed cooling and heating equipment

- Eliminate rooftop or interior mounted heating and cooling supply equipment for Railway Museum
  - Reduced structural cost
  - Increased interior space flexibility

- Higher efficiency heating and cooling for Railway Museum
  - Reduced energy cost
## Summary of Findings: Base + Railway Museum

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Installed Capacity</th>
<th>Energy Use</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0: Business as Usual (Building by Building Systems)</strong></td>
<td>0A</td>
<td>Heating: 13.8</td>
<td>1.81 GWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooling: 16.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interior: 14.8K SF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roof: 14.4K SF</td>
</tr>
<tr>
<td><strong>1: All-Electric Baseline CUP: Chillers, Towers, and Air Source Heat Pumps</strong></td>
<td>1A</td>
<td>Heating: 11.5</td>
<td>1.1GWh (39%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooling: 13.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interior: 9.2K SF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roof: 8.5K SF</td>
</tr>
<tr>
<td><strong>4: All-Electric CUP + GSHP + Sewer Heat Recovery (iCUP)</strong></td>
<td>4A</td>
<td>Heating: 12.1</td>
<td>0.96 GWh (47%)</td>
</tr>
<tr>
<td>(Still includes Chillers, Towers, Air Source Heat Pumps)</td>
<td></td>
<td>Cooling: 13.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Interior: 10.8K SF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roof: 4.0K SF</td>
</tr>
</tbody>
</table>
Space: Baseline CUP
Space: Innovative CUP (iCUP: GSHP + SHR)
### Life Cycle Cost

<table>
<thead>
<tr>
<th></th>
<th>BAU</th>
<th>CUP</th>
<th>CLP + GSHP + big sewage connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal elec fuel cost (NPC 2019 $)</td>
<td>$2.2</td>
<td>$1.3</td>
<td>$1.1</td>
</tr>
<tr>
<td>Total thermal operation costs (NPC 2019 $)</td>
<td>$11.2</td>
<td>$7.9</td>
<td>$5.8</td>
</tr>
<tr>
<td>Total annualised thermal REPEX (NPC 2019 $)</td>
<td>$3.2</td>
<td>$1.5</td>
<td>$6.6</td>
</tr>
<tr>
<td>Total thermal capital costs (NPC 2019 $)</td>
<td>$16.3</td>
<td>$20.2</td>
<td>$18.2</td>
</tr>
<tr>
<td>Carbon (ktCO2)</td>
<td>35.51</td>
<td>21.64</td>
<td>18.82</td>
</tr>
</tbody>
</table>
Water Consumption (Thermal Systems Only)

![Bar Chart: Annual Water Consumption (Mg/a)]

- **BAU**: 7.00 Mg/a
- **CUP + GSHP + big sewage connection**: 3.00 Mg/a
Potential Value to SVS

- Additional diversity for CUP (especially without Lot 40)
  - Reduced total capacity of installed cooling and heating equipment

- Eliminate rooftop or interior mounted heating and cooling supply equipment for Railway Museum
  - Reduced structural cost
  - Increased interior space flexibility

- Higher efficiency heating and cooling for Railway Museum
  - Reduced energy cost
Responses to Questions
### Questions: CUP Space Organization Diagram

#### Space Take Diagrams

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeing this is combined system. However, this is looking quite big for this area</td>
<td>Agreed, it represents a worst-case spatial need; onsite heat/cool sourcing would reduce footprint. The CUP electrical room is also larger than it is likely to be.</td>
</tr>
<tr>
<td>In Grant's diagram, I see a below grade element and the above grade, are they both required?</td>
<td>At the moment, yes</td>
</tr>
<tr>
<td>Does the below grade element take the geothermal into consideration?</td>
<td>Not yet</td>
</tr>
<tr>
<td>Concern over the 75 ft height (higher than freeway)</td>
<td>Is there a maximum height we should target?</td>
</tr>
</tbody>
</table>
Questions: Geothermal

<table>
<thead>
<tr>
<th>Geothermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the heat/cool we get from it? Is it practical to place now, 10-15 years ahead of development?</td>
</tr>
<tr>
<td>Are we still looking at the horizontal loop? What is the pile system and is it more complicated?</td>
</tr>
<tr>
<td>Alternative manifold locations, either at the district center, or clusters at each building, with common condenser water loop; Day 1 installation of in-ground infrastructure, bringing to header, and distributing out;</td>
</tr>
</tbody>
</table>
Distributed Plant Option (Not to Scale)

- Optional Connection to Sewer Heat Recovery
- Individual Heat Pumps Rooms by Building
- Ground Source Manifold + Pumps Connected to Bus Station Loops
- Top-Up Heating and Cooling at CUP
- Condenser Water Loop

Sacramento Valley Station Master Plan
**Questions: Sewer Heat Recovery**

### Sewage Heat Transfer

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the tap mechanism for transferring the heat? Probe? Circumferential jacket?</td>
<td>If tapping into the Bercut sewer, there are two products that can be used. One is a geopipe embedded in a replacement sewer line, which would involve replacing the sewer line (is there a CIP for this?). The other would be to tap into the line and pump sewage out of it, through a heat exchanger in the CUP, and then discharge back to the sewer.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the threshold for the first phase? Hotel?</td>
<td>From Bercut, the hotel would be a good threshold. For on-site WWTP, the size is small enough to be useful with any development.</td>
</tr>
</tbody>
</table>
Questions: Railroad Museum/Lot 40

<table>
<thead>
<tr>
<th>Railroad Museum/Lot 40</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Would this be a multi location plants, tied together? Implications</strong></td>
</tr>
<tr>
<td>The intent would be a single central plant serving CHW and HHW to the museum, but alternatively, with GSHP and multiple heat pumps by building, you could do the same with the Railroad museum. In that case, it is building plants tied together.</td>
</tr>
<tr>
<td><strong>What would be needed for physical connection?</strong></td>
</tr>
<tr>
<td>Up to 8” CHWS/R lines through the tunnel, and up to 6” HHWS/R through the tunnel. There would need to be an agreement for the railway museum to buy from the plant, requiring a BTU meter (i.e., Onicon 10) on each line at the plant and a billing mechanism. At the building, the connection is either via a heat exchanger or isolation valves and a bypass (can add schematic if helpful).</td>
</tr>
<tr>
<td><strong>Future Lot 40 tie-in -- what would need to be in place under ground level improvements?</strong></td>
</tr>
<tr>
<td>Would need a means into the building, so a utility line capped and stubbed that Lot 40 could connect to, and a pathway to the building. If the slab is poured with the first phase of work, there may want to be a stub up into the building, but a utility vault 5’ outside could suffice too. Would need to review the overall approach for getting into the buildings.</td>
</tr>
</tbody>
</table>
Additional Detail: Sewer Heat Recovery
Source: Building Wastewater

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)
Source: Building Wastewater

Other products / manufacturers

Share Energy Systems
(Plate and frame)

KemcoSystems
(Shell and Tube)
Benefits

- Tanks and equipment installed above ground
- No modification of main sewer system (avoid additional underground tap)
- Design has control of which wastewater streams are directed to the system (e.g. could opt not to divert WC stream to recovery system, which could reduce filtration requirements)

Challenges

- Space/footprint requirements inside the building
- Heat loss between the plumbing fixture and heat recovery device; lower wastewater temperature than heat recovery at the plumbing fixture
Case Study: Nursing Home Hofmatt (Münchenstein, Switzerland)

- Operating since 2012
- 4S HUBER RoWin heat exchanger; ROTAMAT® RoK 1 Storm Screen; additional heat pump and storage tank
- System operation
  - Wastewater at 23-25 deg C
  - Water inside the storage tank is allowed to stratify
    - Upper = 65C (service water)
    - Middle = 30-40C (heating)
    - Lower = 25C (additional cooling of liquefied cooling agent)

Source: Building Wastewater

Example Product: Huber Technologies (HUBER Heat Exchanger RoWin)
Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)

Applications

- Offices
- Nursing homes
- Hospitals
- Schools
- Sports Halls
- Other large buildings
Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)

Guidelines

- dry weather flow at least 10 L/sec
- average temperature in winter should not fall below ~10 °C.
- Ideally a short distance between the sewer and the object to be supplied with the heat
- consider energy supply requirements during peak load periods
Source: Existing Sewers (Mains)

Example Product: Huber Technology (HUBER ThermWin)

Benefits

• Local and free, decentralized heat source

• Minimal interference with existing sewers (drilling two holes)

• Negligible effect on wastewater treatment (sewage cooling by 1 – 2 °C only)

• Lower temperature could be more useful as a heat sink, if operation of the system for cooling is desired

Challenges

• Cost of replacing or modifying existing main sewer lines; coordination with AHJ

• Maintenance or replacement of underground connections, equipment, etc. (may be accessible via manhole, requiring a large diameter sewer)

• Most extreme filtration requirements, most susceptibility to fouling on heat exchanger, least control over the contents of the wastewater stream

• Variance in sewer water flow rates and temperatures (due largely to storm water flow)

• Lowest wastewater temperature, so least efficient heat transfer during heating
Source: Sewers (Main)

*Example Product: Huber Technology (HUBER ThermWin)*

Case Study: Wintower in Winterhur, Switzerland

- 28 stories, 22,000m² office space
- Huber Heat Exchanger RoWin (in the building basement); Huber Pumping Station Screen; Submersible pump (in shaft next to sewer)
- Heating with dry-weather flow:
  - 50 L/s removed and pre-treated
  - Removes 440 kW of heat from sewage
  - Heat pump generates 590kW heating energy using 150kW electrical power
  - Heat pump COP ~4.0
  - Delivers ~75% of heating energy demand
- Heat pump is reversed to provide cooling during the summer
Additional Detail: Ground Source Heat Pump
Energy Piles

Water is circulated through tubing arranged in loops installed within the building piles. Run in balance so that the total heat injected during the cooling season is equal to the heat extracted during the heating system. Performance is less dependant on geology than open loop systems.

**Typical Depth:** Pile depth (e.g. 100 ft)

**Spacing:** 20 ft or pile spacing

**Installation Cost:** Low

**Testing:** Thermal response test, optimally during pile load test

**Thermal balance:** Run in balance

**Performance Risk:** Low
Energy Piles+

Extending building piles beyond the required structural depth to benefit from greater thermal capacity. This option is cost effective because the piling rig is already required for the structure and therefore the added cost is for lengthening the piles (deeper drilling and additional material).

**Typical Depth:** Pile depth (e.g. 500 ft)

**Spacing:** 20 ft or pile spacing

**Installation Cost:** Low

**Testing:** Thermal response test, optimally during pile load test

**Thermal balance:** Run in balance

**Performance Risk:** Low
Closed Loop Vertical Borings

Borings circulate water through tubing arranged in loops. Run in balance so that the total heat injected during the cooling season is equal to the heat extracted during the heating system. Performance is less dependent on geology than open loop systems. Operate in the same way as energy piles.

- Typical Depth: 200 – 500 ft
- Spacing: 20 ft between loops
- No. of Loops: 30 - 100, or max possible
- Installation Cost: $35,000 per loop
- Testing: Thermal Response Test
- Thermal balance: Run in balance
- Performance Risk: Low
Open Loop Vertical Wells

Water is pumped from one well and heat energy transferred for heating or cooling before the water is reinjected into another well. More efficient and cost effective than closed loop systems. Only feasible in sufficiently productive aquifers and where sufficient spacing between wells can be achieved.

**Typical Depth:** 200 – 300 ft (related to permeability and thermal gradient)

**Spacing:** 250 ft between wells

**Installation Cost:** $1M per loop

**Testing:** Aquifer Test

**Thermal balance:** Can run out of balance

**Performance Risk:** High, until testing is performed – up front costs needed
iv. BMP sizing memorandum

The masterplan framework for the Sacramento Valley Station (SVS) site includes Best Management Practices (BMPs) for treatment of the site’s stormwater. The purpose of the BMPs are to collect, convey, and treat the site’s stormwater before it either infiltrates into the ground or enters the city’s stormwater system. The city utilizes the Sacramento Region Stormwater Quality Design Manual and Low Impact Development (LID) Credits Worksheet to determine what amount of BMPs are needed to adequately treat a site. See the attached SVS LID Credits Worksheet.

As design of the SVS site is still in its preliminary stages, high level estimates have been input to complete the worksheet. Assumptions are as follows:

- Step 1, Item 1.b.d. – 30% of the total site is estimated to be landscape area/park.
- Step 2, Option 1 Porous Pavement – 1.5 acres are estimated to be porous pavement, with a conservative efficiency factor of 0.4.
- Step 3, Bioretention/Infiltration Credits – The preliminary design provides bioretention and infiltration areas within each drainage area, sized to be at minimum, 4% of the drainage area. Where feasible, these are intended to utilize infiltration, but where this is not possible due to site constraints, a bioretention area will be used. For this step, half of the total site’s BMPs are assumed to be bioretention, and half are assumed to be infiltration.

Arup has reviewed the SVS LID Credits Worksheet through phone calls and emails with the City’s Fernando Duenas, and he has confirmed that the 127.4 LID Credit total is compliant with the City’s requirements.

---

### Appendix D-2: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Common Drainage Plan Area</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Step 2</td>
<td>Project Drainage Shed Area (Total)</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Step 3</td>
<td>Common Drainage Plan Open Space (Off-project)</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>a. Natural storage reservoirs and drainage corridors</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>b. Buffer zones for natural water bodies</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>c. Natural areas including existing trees, other vegetation, and soil</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>d. Corridor landscape area/park</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>e. Regional Flood Control/Drainage basins</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Project-Specific Open Space (In-project, common)**</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>a. Natural storage reservoirs and drainage corridors</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>b. Buffer zones for natural water bodies</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>c. Natural areas including existing trees, other vegetation, and soil</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>d. Landscape area/park</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>e. Flood Control/Drainage basins</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

** Does not include impervious areas within individual lots and surrounding impervious area. Use values from Form D-1a in Step 2.

---

### Step 2: Runoff Reduction Credit

<table>
<thead>
<tr>
<th>BMP Type</th>
<th>Effective Area Managed (Ac)</th>
<th>Efficiency Factor (EF)</th>
<th>Effective Area Managed (AE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous Pavement</td>
<td>1.0</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

---

### Appendix D-3: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3-1</td>
<td>Bioretention Credit</td>
<td>Ac</td>
<td>Ac</td>
</tr>
<tr>
<td>Step 3-2</td>
<td>Infiltration Credit</td>
<td>Ac</td>
<td>Ac</td>
</tr>
</tbody>
</table>

---

### Appendix D-4: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3-3</td>
<td>Existing Tree Canopy</td>
<td>Ac</td>
<td>Ac</td>
</tr>
</tbody>
</table>

---

### Appendix D-5: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3-4</td>
<td>New Evergreen Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
<tr>
<td>Step 3-5</td>
<td>New Deciduous Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
</tbody>
</table>

---

### Appendix D-6: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3-6</td>
<td>New Evergreen Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
<tr>
<td>Step 3-7</td>
<td>New Deciduous Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
</tbody>
</table>

---

### Appendix D-7: Commercial Sites: Low Impact Development (LID) Credits and Treatment BMP Sizing Calculations

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
<th>Calculation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 3-8</td>
<td>New Evergreen Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
<tr>
<td>Step 3-9</td>
<td>New Deciduous Trees</td>
<td>Ac</td>
<td>Ac</td>
</tr>
</tbody>
</table>
### Table D-2a: Porous Pavement Type

<table>
<thead>
<tr>
<th>Porous Pavement Type</th>
<th>Efficiency Multiplier</th>
<th>Minimum roof size</th>
<th>Maximum roof size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular Block Pavement &amp; Reinforced Grass Pavement</td>
<td>1.00</td>
<td>≤ 3,500 sq ft</td>
<td>≤ 10,000 sq ft</td>
</tr>
<tr>
<td>Modular Block Pavement &amp; Reinforced Grass Pavement</td>
<td>0.75</td>
<td>≤ 3,500 sq ft</td>
<td>≤ 10,000 sq ft</td>
</tr>
<tr>
<td>Reinforced Grass Pavement</td>
<td>0.50</td>
<td>≤ 3,500 sq ft</td>
<td>≤ 10,000 sq ft</td>
</tr>
<tr>
<td>Porous Concrete/Asphalt</td>
<td>0.20</td>
<td>≤ 6,000 sq ft</td>
<td>≤ 10,000 sq ft</td>
</tr>
</tbody>
</table>

### Technical Appendix C

#### Table D-3b: Form D-2b: Interceptor Tree Worksheet

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Enter number of new evergreen trees that qualify as Interceptor Trees in Box L1. trees Box L1</td>
</tr>
<tr>
<td>2.</td>
<td>Multiply Box L1 by 200 and enter result in Box L2.</td>
</tr>
<tr>
<td>3.</td>
<td>Enter number of new deciduous trees that qualify as Interceptor Trees in Box L3. trees Box L3</td>
</tr>
<tr>
<td>4.</td>
<td>Multiply Box L3 by 100 and enter result in Box L4. sq ft. Box L4</td>
</tr>
<tr>
<td>5.</td>
<td>Enter square footage of existing tree canopy that qualifies as Existing Tree Canopy in Box L5. sq ft. Box L5</td>
</tr>
<tr>
<td>6.</td>
<td>Multiply Box L5 by 5 and enter the result in Box L6. sq ft. Box L6</td>
</tr>
<tr>
<td>7.</td>
<td>Multiply Boxes L1, L2, and L5 and enter the result in Box K7. Acres Box K7</td>
</tr>
<tr>
<td>8.</td>
<td>Add Boxes L5 to Box L7 and multiply by 60, and enter the result in Box K8. Acres Box K8</td>
</tr>
</tbody>
</table>

#### Table D-3c: Form D-2a: Disconnected Poraction Worksheet

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Enter area draining onto Porous Pavement. Acres Box K1</td>
</tr>
<tr>
<td>2.</td>
<td>Enter area of Receiving Porous Pavement (excludes area entered in Step 2 under Porous Pavement). Acres Box K2</td>
</tr>
<tr>
<td>3.</td>
<td>Enter ratio of Areas (Box K1/Box K2). Multiplier Box K3</td>
</tr>
<tr>
<td>4.</td>
<td>Select multiplier using ratio from Box K3 and enter into Box K4. Multiplier Box K4</td>
</tr>
<tr>
<td>5.</td>
<td>Multiply Box K2 by Box K5 and enter into Box K6. Acres Box K6</td>
</tr>
<tr>
<td>6.</td>
<td>Multiply Boxes K1, K4, and K5 and enter the result in Box K7. Acres Box K7</td>
</tr>
</tbody>
</table>

#### Table D-3d: Step 3 - Runoff Management Credits

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Obtain P from figures E-1 to E-4.</td>
</tr>
<tr>
<td>2.</td>
<td>Obtain A from Step 1.</td>
</tr>
<tr>
<td>3.</td>
<td>Look up value for i in Table D-2c (Rainfall Intensity).</td>
</tr>
<tr>
<td>4.</td>
<td>Calculate treatment flow (cfs): Flow = 0.95 * i * A</td>
</tr>
<tr>
<td>5.</td>
<td>Calculate water quality volume (Acre-Feet): WQV = Area x Maximized Detention Volume (P)</td>
</tr>
<tr>
<td>6.</td>
<td>Calculate treatment volume (acre-ft): Treatment volume = A x (P + 12)</td>
</tr>
</tbody>
</table>

#### Table D-3e: Step 4a - Treatment - Flow-Based (Rainfall Method)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Calculate treatment flow (cfs): Flow = Rainfall Coefficient x Rainfall intensity x Area</td>
</tr>
<tr>
<td>2.</td>
<td>Calculate infiltration volume (gallons for simple rain barrels): I = rain intensity * Impervious area managed by system</td>
</tr>
<tr>
<td>3.</td>
<td>Calculate Total Effective Area Managed by Capture-and-Use/Bioretention/Bioporous BMPs: Total Effective Area Managed by Capture-and-Use/Bioretention/Bioporous BMPs</td>
</tr>
<tr>
<td>4.</td>
<td>Enter Effective Area Managed by Amended Soil/ Mulch Beds.</td>
</tr>
<tr>
<td>5.</td>
<td>Enter Effective Area Managed by LID BMPs.</td>
</tr>
<tr>
<td>6.</td>
<td>Enter Effective Area Managed by Amended Soil/ Mulch Beds.</td>
</tr>
</tbody>
</table>

#### Table D-3f: Step 4b - Treatment - Volume-Based (ASCE-WEF)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Calculate water quality volume (acre-ft): WQV = Area x Maximized Detention Volume (P)</td>
</tr>
<tr>
<td>2.</td>
<td>Calculate infiltration volume (gallons for simple rain barrels): I = rain intensity * Impervious area managed by system</td>
</tr>
<tr>
<td>3.</td>
<td>Enter Effective Area Managed by Capture-and-Use/Bioretention/Bioporous BMPs.</td>
</tr>
<tr>
<td>4.</td>
<td>Enter Effective Area Managed by Amended Soil/ Mulch Beds.</td>
</tr>
<tr>
<td>5.</td>
<td>Enter Effective Area Managed by LID BMPs.</td>
</tr>
<tr>
<td>6.</td>
<td>Enter Effective Area Managed by Amended Soil/ Mulch Beds.</td>
</tr>
</tbody>
</table>
If that is the case-then yes, the LID point total complies with the City’s requirements. Please go ahead and add the LID spreadsheet in any studies produced for the SVS. We will use it as a reference document when the project comes across my section.

The project looks exciting and it will be a great addition to the downtown area. Thank you for reaching out to me and let me know if anything else comes up.

Fernando Dueñas, PE
Department of Utilities
Environmental Regulatory Compliance Section
1395 35th Ave, Sacramento, CA 95822
916-808-4953

Hi Maribel:

I had a chance to take a look at the LID worksheet here are my comments. I noticed the square footage was exactly the same for the biofiltration areas (cell G165) and the infiltration area (cell G175)—these are two distinct BMP’s and you may have inadvertently doubled-counted the biofiltration area. I took out the infiltration area value and I got an LID point score of 75. As an alternative, you can have some of the impervious areas drain into adjacent compost-amended soil areas. Amended soils can be used in areas set aside for landscaping and accept drainage from paved areas like parking lots or walkways and even roofs. The advantage of compost-amended soil is that you don’t have to design a dedicated bioretention BMP and you can use the existing landscaping. This an excerpt from the Stormwater Quality design guide manual:

Compost-Amended Soil

The compost-amended soil BMP is an option in the BMP toolbox that has a smaller footprint than impervious surface disconnection. This BMP option is intended to be a less complex alternative compared to bioretention and engineered infiltration BMPs. Compost-amended soil is also ideal as a design feature in landscape and open space areas. The volume of water to be infiltrated is assumed to be captured within pore spaces of a simple, depressed bed of mulch and compost-amended soil that overlies the native soil (with no underdrain). The mulch and amended soil provide short-term storage for the water until it can infiltrate the native underlying soil. Refer to the Compost-Amended Soil BMP Fact Sheet for additional information.

I plugged an amended soil area of 26,000 square feet in the spreadsheet and I got a total of 99.3 points—this is sufficient for a master plan level document. According to the spreadsheet, up to 2.39 acres of hard surfaces can be drained into the amended soil areas and this can be distributed across the project site.

Please review the attached spreadsheet and let me know if you would consider the amended soil for SVS. I’ll be available all day if you want to discuss further.
Hi Maribel:

I had a chance to take a look at the LID worksheet and here are my comments. I noticed the square footage was exactly the same for the biofiltration areas (cell G165) and the infiltration area (cell G175)—these are two distinct BMP’s and you may have inadvertently doubled-counted the biofiltration area. I took out the infiltration area value and I got an LID point score of 75. As an alternative, you can have some of the impervious areas drain into adjacent compost-amended soil areas. Amended soils can be used in areas set aside for landscaping and accept drainage from paved areas like parking lots or walkways and even roofs. The advantage of compost-amended soil is that you don’t have to design a dedicated bioretention BMP and you can use the existing landscaping. This an excerpt from the Stormwater Quality design guide manual:

**Compost-Amended Soil**

The compost-amended soil BMP is an option in the BMP toolbox that has a smaller footprint than impervious surface disconnection. This BMP option is intended to be a less complex alternative compared to bioretention and engineered infiltration BMPs. Compost-amended soil is also ideal as a design feature in landscape and open space areas. The volume of water to be infiltrated is assumed to be captured within pore spaces of a simple, depressed bed of mulch and compost-amended soil that overlies the native soil (with no underdrain). The mulch and amended soil provide short-term storage for the water until it can infiltrate the native underlying soil. Refer to the Compost-Amended Soil BMP Fact Sheet for additional information.

I plugged an amended soil area of 26,000 square feet in the spreadsheet and I got a total of 99.3 points—this is sufficient for a master plan level document. According to the spreadsheet, up to 2.39 acres of hard surfaces can be drained into the amended soil areas and this can be distributed across the project site.

Please review the attached spreadsheet and let me know if you would consider the amended soil for SVS. I’ll be available all day if you want to discuss further.

Fernando Dueñas, PE
Department of Utilities
Environmental Regulatory Compliance Section
1395 35th Ave, Sacramento, CA  95822
916-808-4953
Sacramento Valley Station: Wastewater Recycling Plant Executive Summary

Arup
May 12, 2020
Gravity sewers drain toward the Regenerative Utility Center (RUC) located in the Historic Station Expansion.
Lot 40 optional (sleeves to be installed below RT rail and platforms)
• Compact wastewater recycling plant located in basement, but visible to the general public
• 100% wastewater treated to CA Title 22 recycled water standard
• Emergency overflow provided to 3rd Street sewer for temporary shutdown/maintenance
• Includes onsite sludge treatment; compost collected weekly
• Baseline 150,000 GPD with expansion capacity up to 250,000 GPD (to include Lot 40)
• Access from the west side includes gantry to install additional MBR units
• Recycled water storage tanks outside the building
• Consider starting with small pilot project by treating flow from nearby Bercut sewer
• Recycled water delivered to buildings and parks via purple pipe to supply flushing, irrigation and HVAC cooling demands
• Recycled water feeds wetland park at the Regenerative Garden
• Consider exporting recycled water to nearby projects and/or landscape areas
• Lot 40 optional (sleeves to be installed below RT rail and platforms)
• Infiltrate any unused recycled water to the ground or discharge to City sanitary sewer (as last resort)
**Projected Water and Wastewater Service Charges (Rates)**

City of Sacramento Domestic Water Service Charges (Rates)
MONTHLY METERED WATER USE, PER 100 CF (CCF)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2035</th>
<th>2040</th>
<th>2045</th>
<th>2050 (Projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Rate</td>
<td>$1.0959</td>
<td>$1.2055</td>
<td>$1.3261</td>
<td>$1.4587</td>
<td>$4.3117</td>
<td>$6.0497</td>
<td>$8.4884</td>
<td>$11.9100</td>
</tr>
<tr>
<td>Rate Increase %</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>7.0083%</td>
<td>(avg from 1985-2020)</td>
</tr>
</tbody>
</table>

City of Sacramento Wastewater Service Charges (Rates)
MONTHLY METERED WASTEWATER USE, PER 100 CF (CCF)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2035</th>
<th>2040</th>
<th>2045</th>
<th>2050 (Projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Rate</td>
<td>$1.0002</td>
<td>$1.0902</td>
<td>$1.1883</td>
<td>$1.2953</td>
<td>$4.8529</td>
<td>$7.3327</td>
<td>$11.0796</td>
<td>$15.7411</td>
</tr>
<tr>
<td>Rate Increase %</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>8.6056%</td>
<td>(avg from 1985-2020)</td>
</tr>
</tbody>
</table>

Combined Water & Wastewater Service Charges (Rates), per 100 CF (CCF)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2035</th>
<th>2040</th>
<th>2045</th>
<th>2050 (Projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Rate</td>
<td>$2.0961</td>
<td>$2.2957</td>
<td>$2.5144</td>
<td>$2.7540</td>
<td>$9.1646</td>
<td>$13.3824</td>
<td>$19.5679</td>
<td>$28.6511</td>
</tr>
</tbody>
</table>

**Preliminary Payback Estimate on Water Treatment Plant Investment**

<table>
<thead>
<tr>
<th>Baseline: Treatment Demand (150,000 GPD)</th>
<th>Baseline + Lot 40: Treatment Demand (250,000 GPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150,000 GPD</td>
<td>Average Daily</td>
</tr>
<tr>
<td>54,750,000 gallons</td>
<td>Average Annual</td>
</tr>
<tr>
<td>7,319,519 cu.ft.</td>
<td>Average Annual</td>
</tr>
<tr>
<td>73,195 CCF</td>
<td>Average Annual</td>
</tr>
<tr>
<td>$6,000,000</td>
<td>CAPEX$1,2</td>
</tr>
<tr>
<td>$350,000</td>
<td>Annual OPEX$1,2</td>
</tr>
<tr>
<td>$13.20</td>
<td>Projected Service Charge ($/CCF)$3</td>
</tr>
<tr>
<td>$4.78</td>
<td>Service Charge for OPEX Only ($/CCF)$1</td>
</tr>
<tr>
<td>$8.41</td>
<td>Remaining Service Charge for CAPEX ($/CCF)</td>
</tr>
<tr>
<td>9.1</td>
<td>Estimated Payback (Years)$4</td>
</tr>
</tbody>
</table>

**Notes**

1) Year 2035 dollars
2) Per Natural Systems Utilities (NSU) preliminary estimate, March 2020
3) Average projected combined water & wastewater rate over the payback period starting in Year 2035
4) Assumes all generated recycled water is sold

• Preliminary CAPEX/OPEX estimates provided by NSU for two options:
  1) Baseline
  2) Baseline + Lot 40

• Recycled water rate assumed to equal the average of projected water + sewer rates over estimated payback period

• Projected water and sewer rates assume annual increase as seen over last 35 years (7.0% & 8.6%)

• Recycled water rate first covers OPEX, then remaining pays back the CAPEX

• Payback estimate assumes no operator markup

• DOU to negotiate connection fees