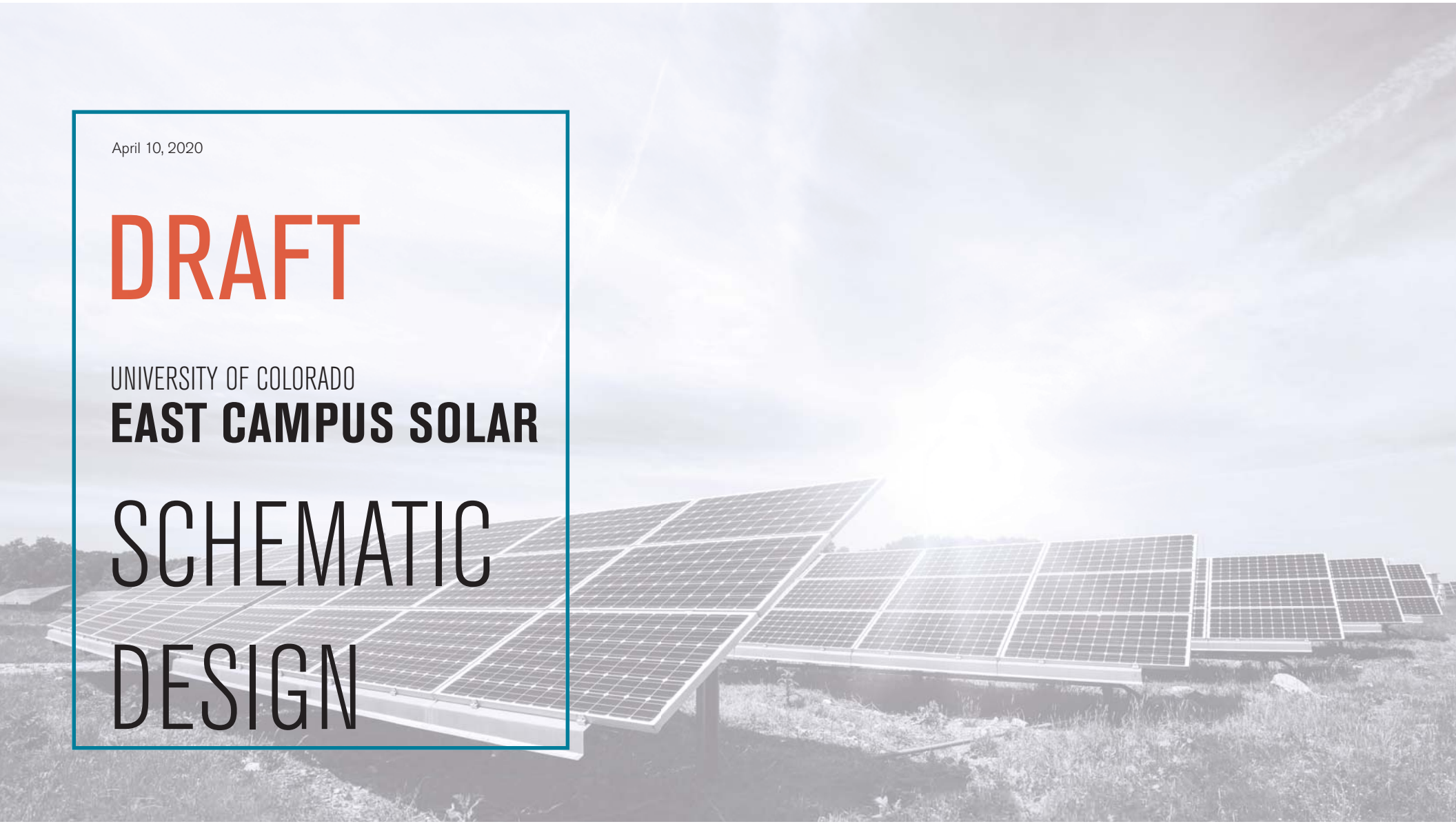
April 10, 2020

DRAFT

UNIVERSITY OF COLORADO

EAST CAMPUS SOLAR

SCHEMATIC DESIGN



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AGENDA

01 DRB Recap

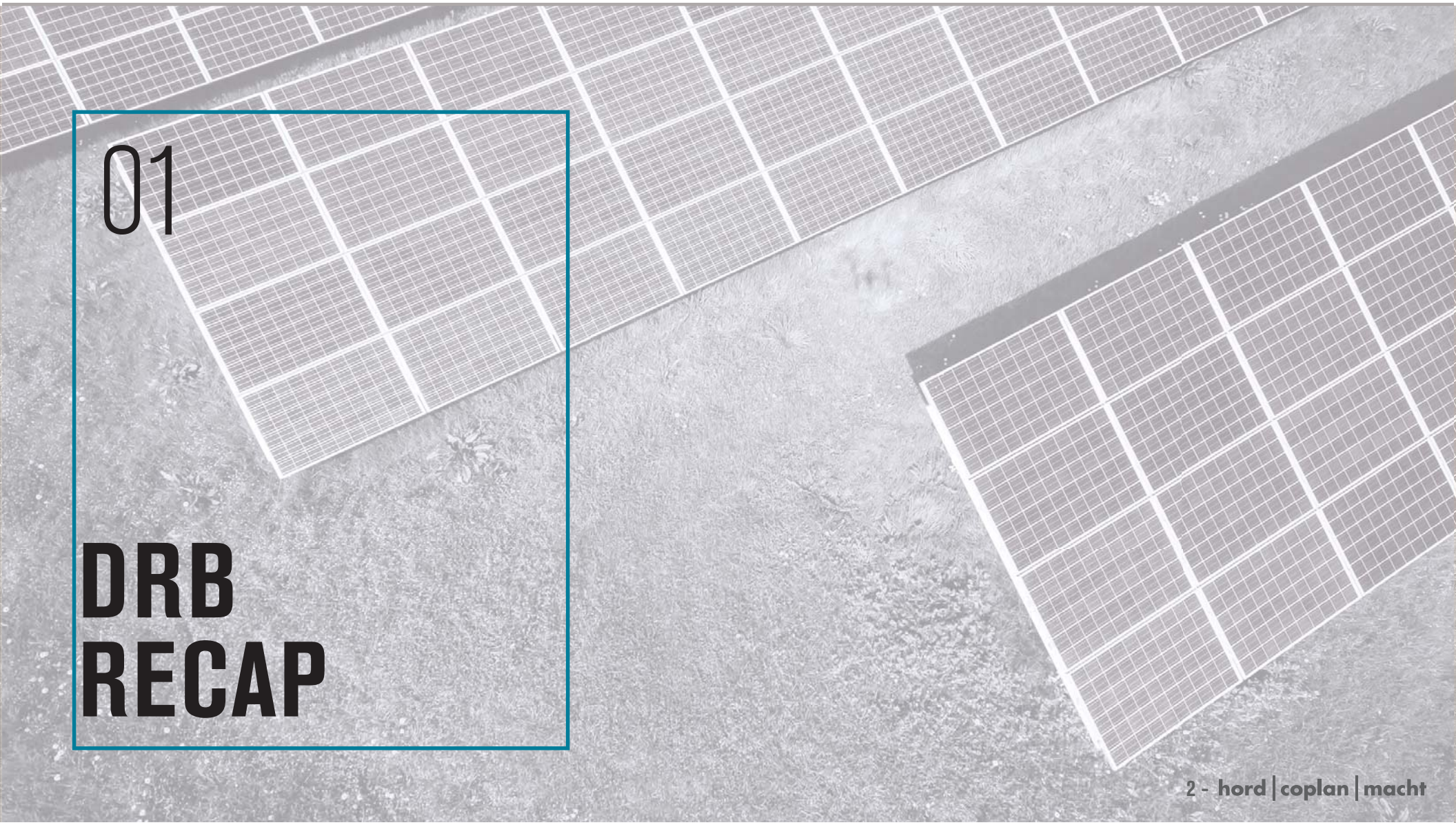
02 Goals

03 Site Analysis

04 Schematic Design

05 Solar Design

06 Next Steps



01

DRB RECAP

DRB RECAP
LOT 560: PREVIOUS CONCEPT (4/11/19)

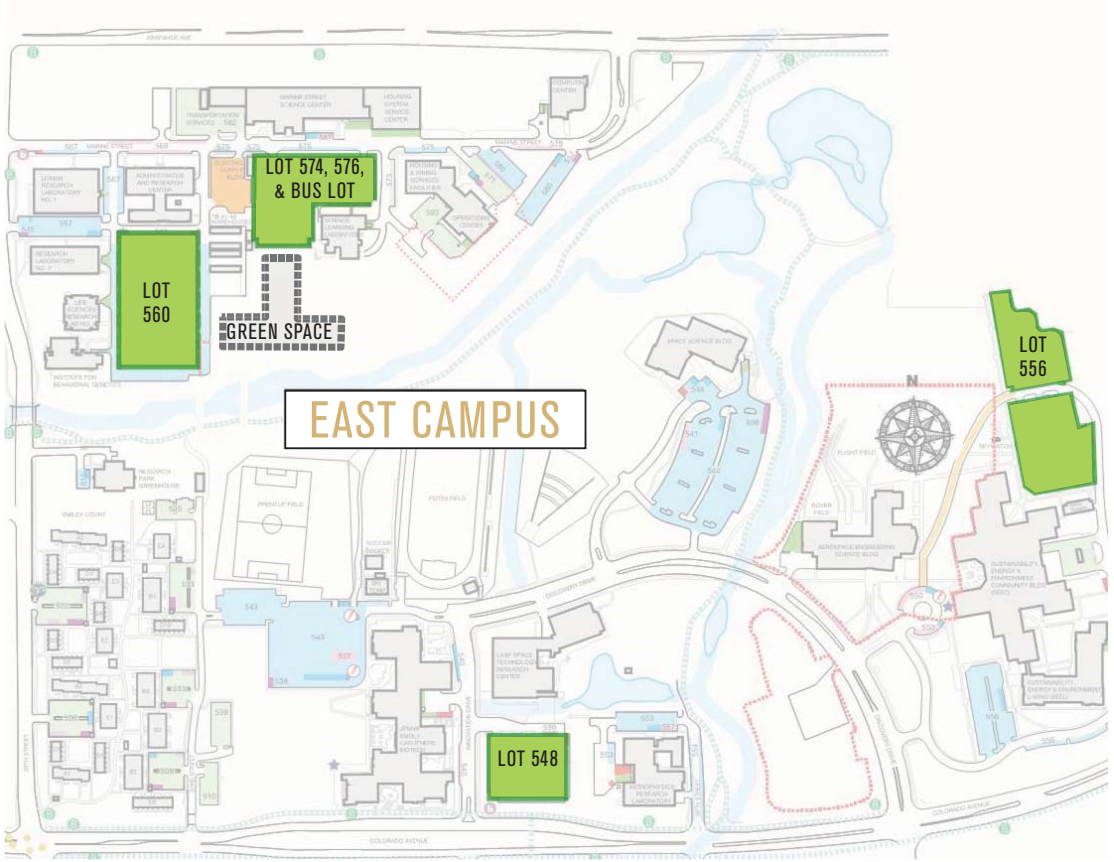
Further the design based on approved program and framework at Concept level: apply to other parking lot sites* including Lots 574, 576, and the Bus Lot; Lot 548; and Lot 556

Investigate and detail the Structural Design improvements.

Explore and illustrate Site Design improvements - on and off site.

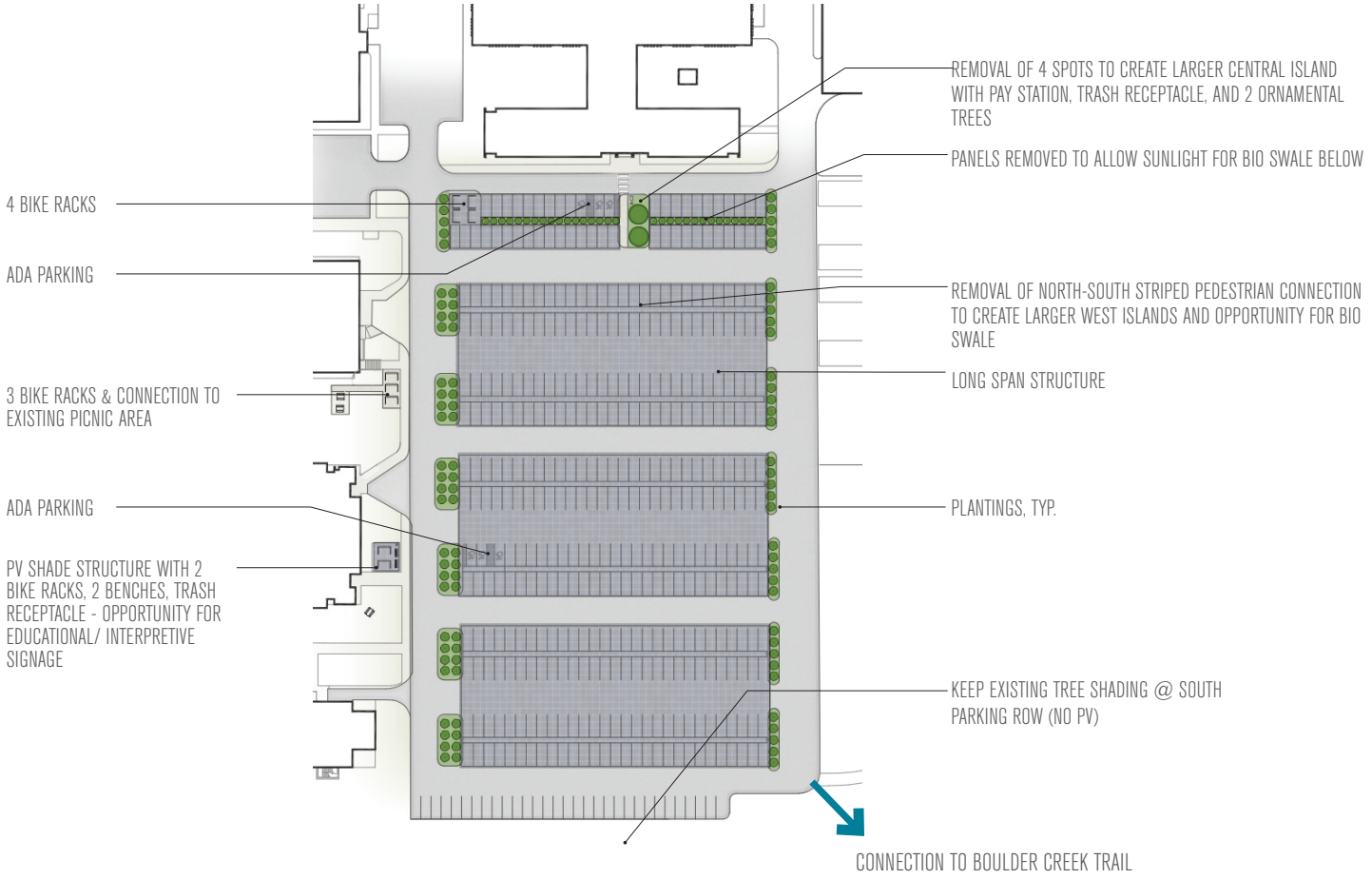
Evaluate parking lot configurations & how they relate to solar layout.

** Note to DRB: The project scope has evolved. CU Staff has since directed the design team to proceed with Lot 560, Lot 576 & the adjacent Green Space to obtain the solar production needed.*



DRB RECAP
LOT 560: PREVIOUS CONCEPT (4/11/19)

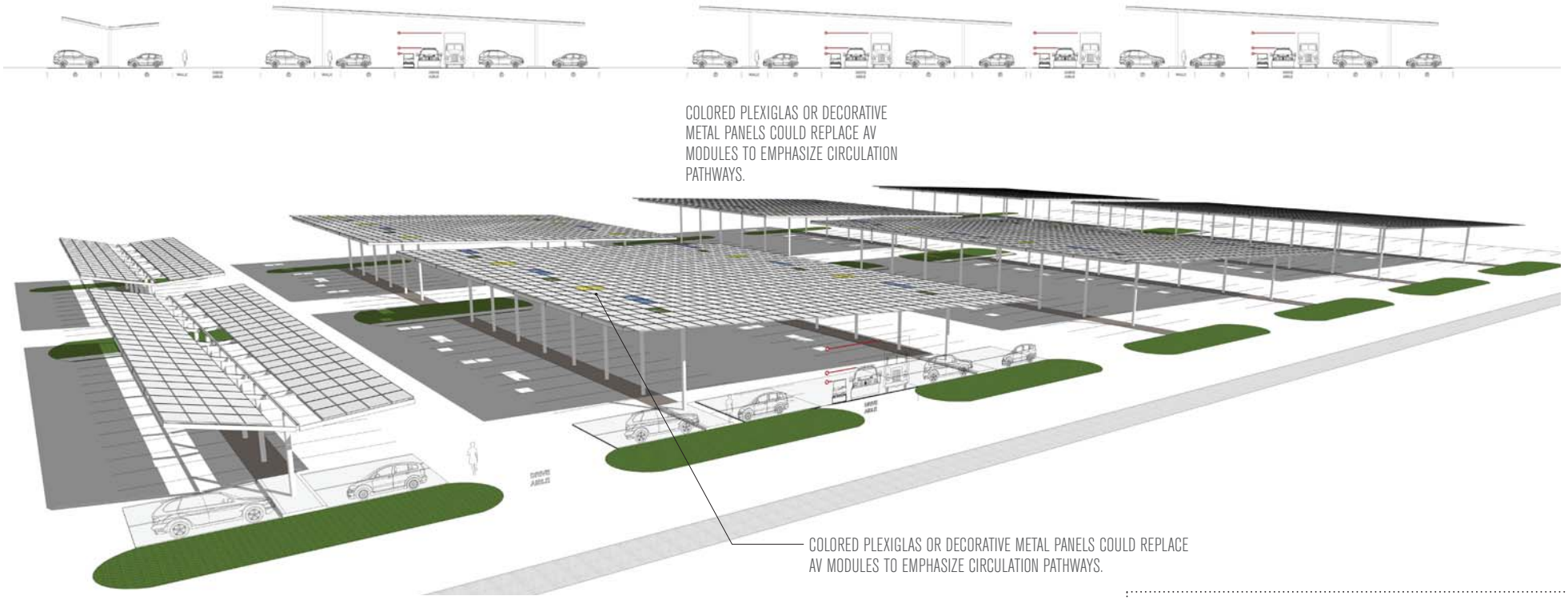
~ 1750 kW Capacity



- 4 parking spaces lost from the visitor's lot (+/- 443 remain)
- The existing striped north/south path (~9' width) removed from the Permit Lot and added to the west islands
- Shade structure with PV panels is added with bike racks and seating opportunities outside the Life Science Lab building.

DRB RECAP
LOT 560: PREVIOUS CONCEPT (4/11/19)

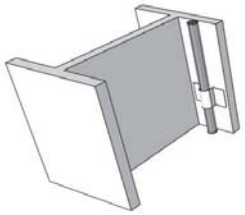
~ 1872 kW Capacity



Note: This model is a hybrid version of the preferred concept; the direction was for no separate structures to provide north-south walkway.

DRB RECAP
LOT 560: PREVIOUS DESIGN CONSIDERATIONS (4/11/19)

WIDE FLANGE STEEL & CONCEALED CONDUIT



- IDEAL FOR LONG-SPAN OPTIONS
- HIDES CONDUIT INSIDE FLANGE
- HIDES INVERTERS & CHARGERS
- BIRD-DETERRENT NEEDED

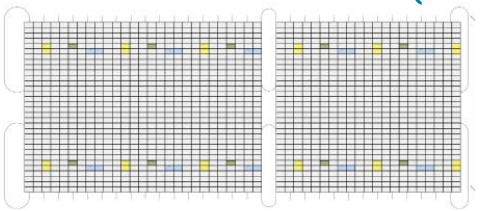
SQUARE BASE

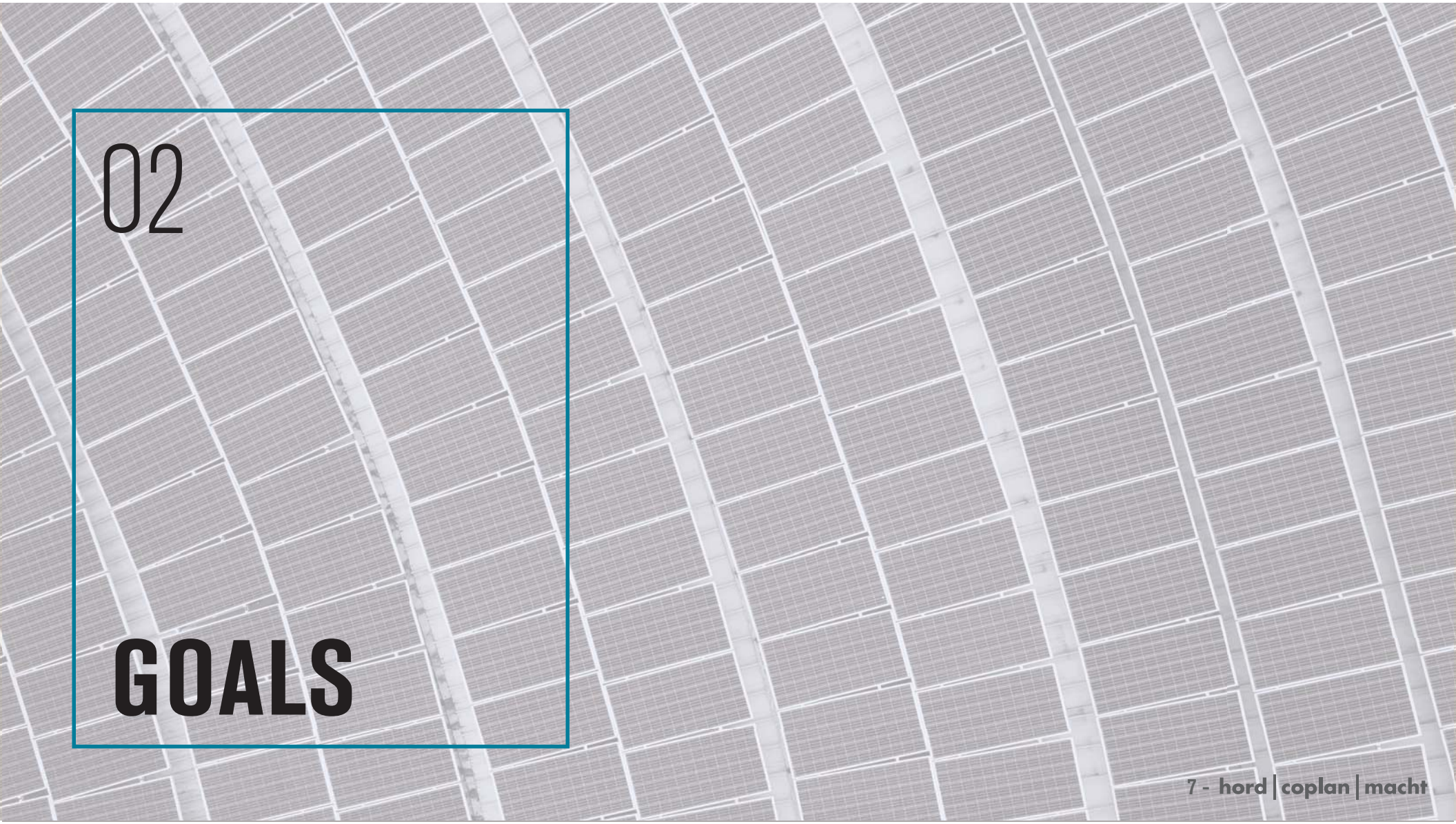
BOLTED CONNECTIONS

EV CHARGING STATION & INVERTER INTEGRATION

CAN/STRIP LIGHTS - VERTICAL MOUNT

COLORED PLEXIGLASS 'MODULES' (NON-PV)





02

GOALS

PROJECT GOALS:

Study Lot 560, Lot 576 and adjacent Green Space to maximize solar energy production at this location to help meet the campus goal.

Accentuate the Visitor experience at Lot 560 with an aesthetic solution to highlight entry.

Prioritize design & structural honesty.

Tie design elements to CU campus precedents.

Integrate pedestrian circulation & improve ADA access to buildings.

Incorporate temporary bus parking & emergency vehicle circulation.

Manage floodplain requirements, grading & drainage, and existing utilities.

Provide appropriate cost-benefit ratio.

PROJECT GOALS:

SOLAR ENERGY GOALS:

CU has a 4 mW goal for campus (4,000 kW)

Currently CU has 1.3 mW of solar tied to the microgrid

2.5-3.0 mW range acceptable

4
MW (DC)
Campus Capacity Goal
Indicated by NREL REOpt Study
(from current 1.3 mW)

$0.13
per kWh
Target PPA
(hard + soft costs)

VARIED
ORIENTATIONS

PPA
(Power Purchase Agreement)
Owned by 3rd Party Financier
25 years

03

SITE ANALYSIS

SITE ANALYSIS
LOCATION

PRIMARY USERS:

Permit Lots:

- CU Facilities & Fleet Vehicles
- CU Faculty
- CU Administration
- Shops Staff/Equipment
- Buff Bus Temporary Parking

Visitor Lot:

- Short-term Visitors

SCALE

0 100 200 400 FT

N

SITE ANALYSIS
CIRCULATION, VIEWS, ADJACENCIES, SUN

LEGEND

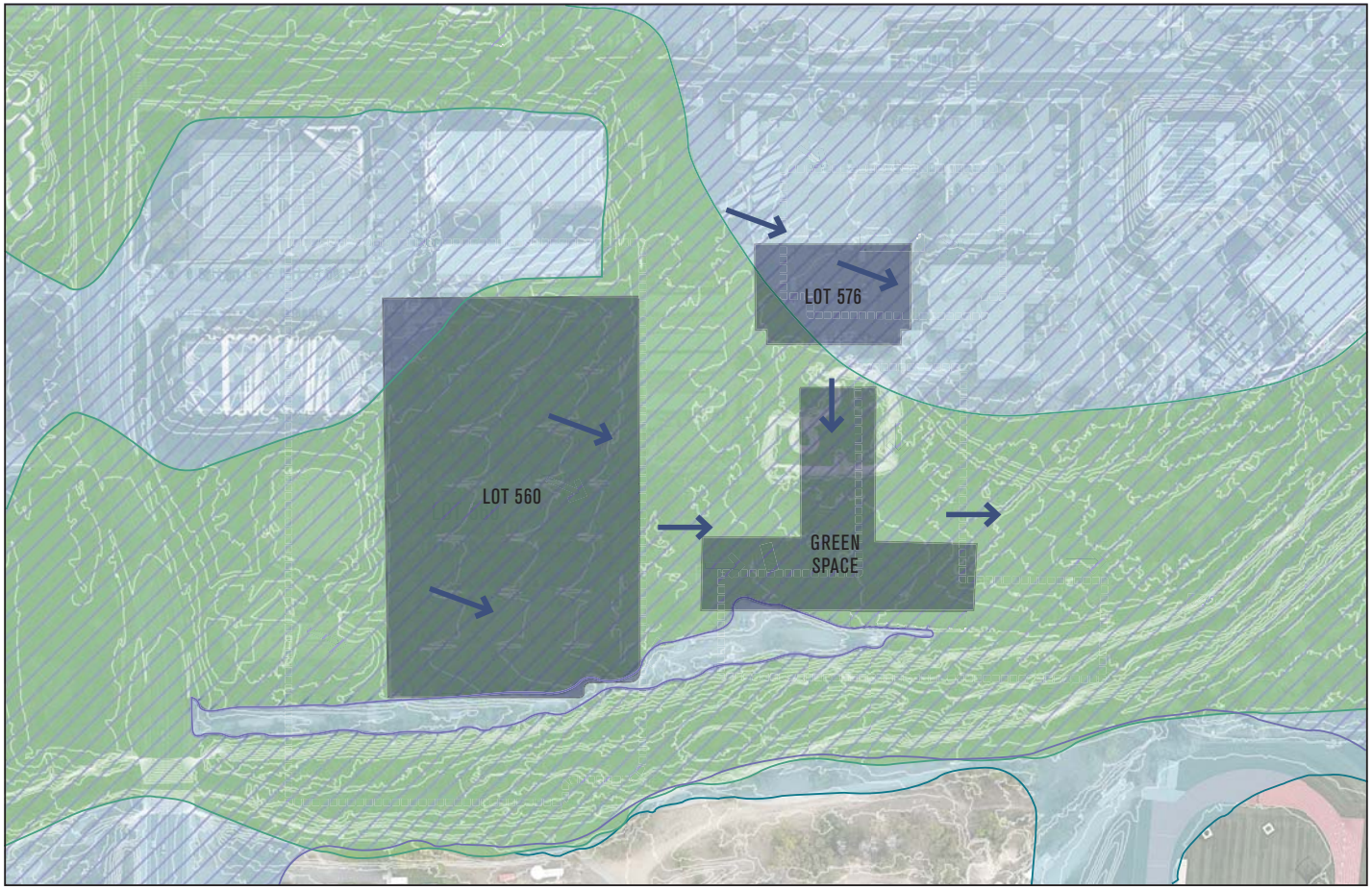
- Visitor Lot
- Permit Lot
- Green Space
- Pedestrian Circulation
- Informal Dirt Path
- Primary Vehicular Circulation
- Views Into Site
- ADA Parking (Not to Code)
- Bike Parking
- Seating Area

SCALE

0 80 160 320 FT

N

SITE ANALYSIS
FLOOD ZONES, TOPOGRAPHY, DRAINAGE FLOW



LEGEND

- FEMA 500-Year Zone
- FEMA 100-Year Zone
- FEMA Conveyance Zone
- Target Area
- Contour
- Flow Direction

SCALE

0 100 200 400 FT

N

*Map information from maps.bouldercolorado.gov

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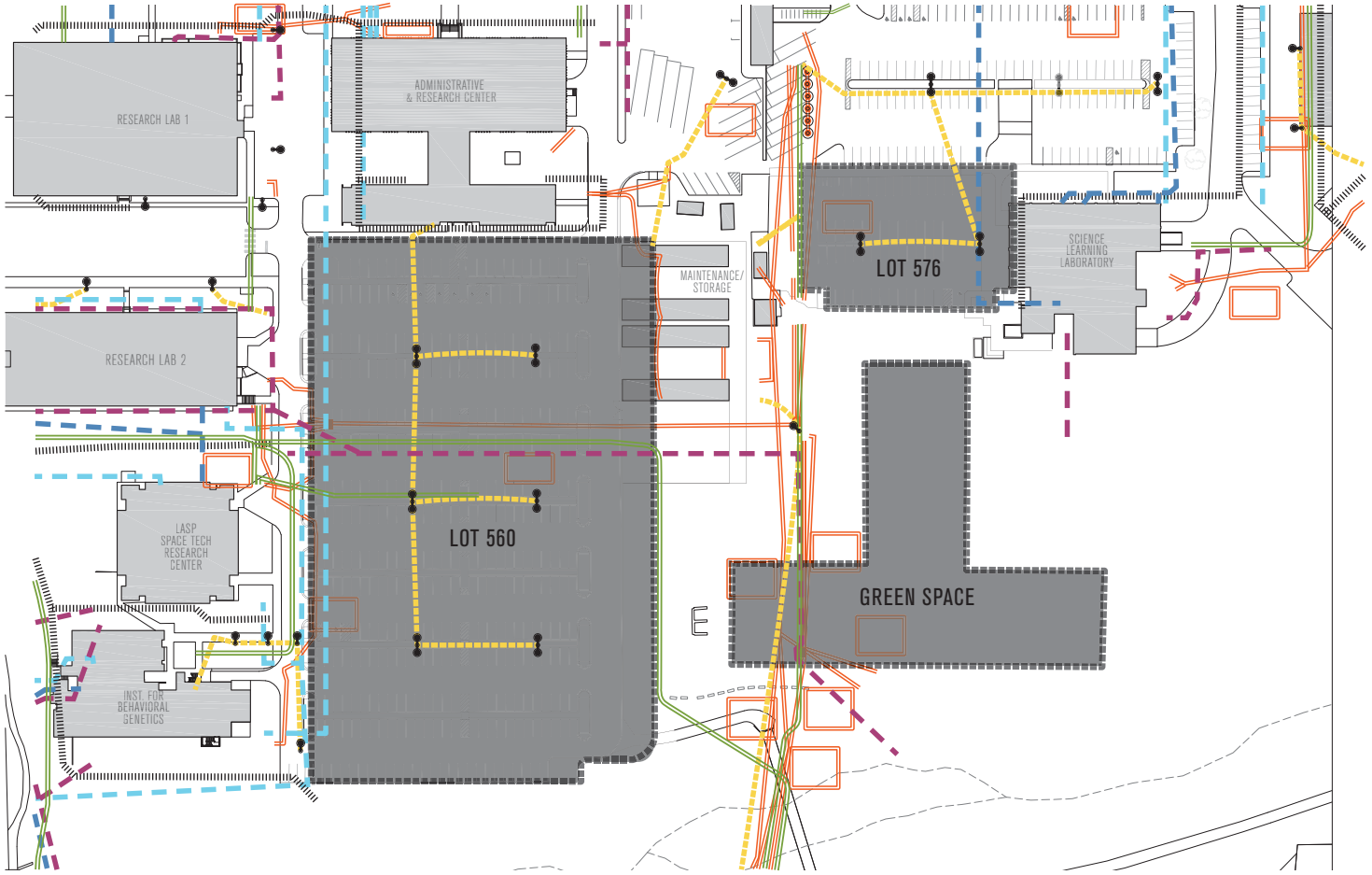
SITE ANALYSIS
EXISTING UTILITIES



LEGEND

- Target Area
- Sanitary Sewer
- Storm Sewer
- Water Line
- Electrical
- Irrigation Main
- Lighting
- Telephone/Fiber Optic
- Light Pole
- Project Site Area

NOTE

- Proposed columns to avoid existing utility corridors.
- Existing light poles to be removed/replaced in areas disturbed by construction.

SCALE

0 60 120 240 FT

N

SITE ANALYSIS
EXISTING VEGETATION

LEGEND

- Target Area
- Tree - To Remain
- Tree - To Be Replaced
- Tree - To Be Removed (no replacement needed)
- Native Area
- Irrigated Landscaped Area

SCALE

0 60 120 240 FT

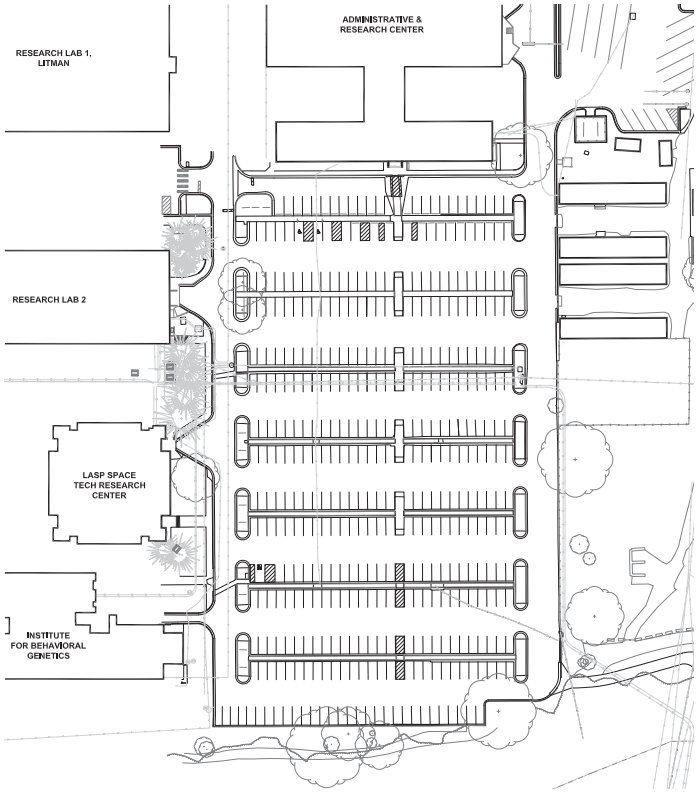
N

04

SCHEMATIC DESIGN

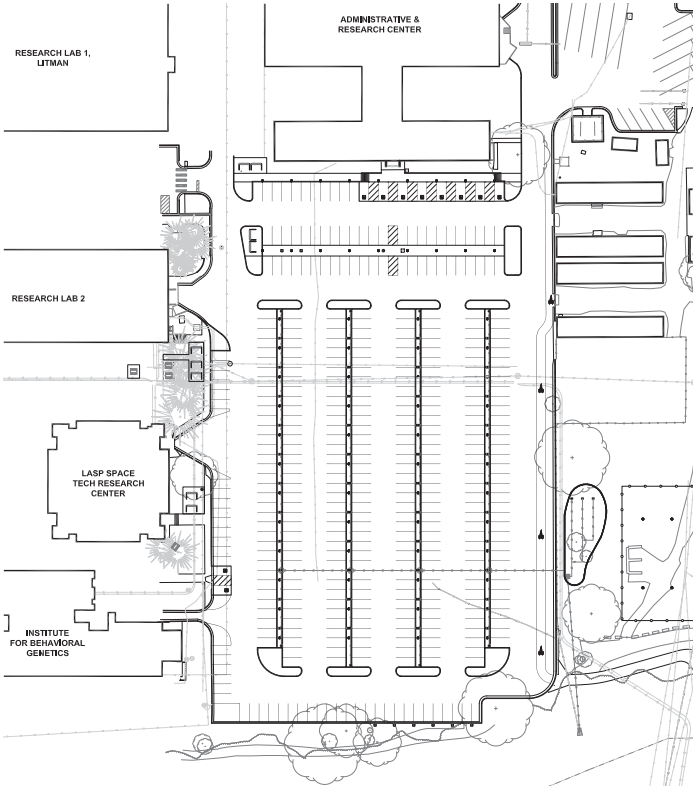
SCHEMATIC DESIGN
LOT 560 PARKING LAYOUT

EXISTING LAYOUT



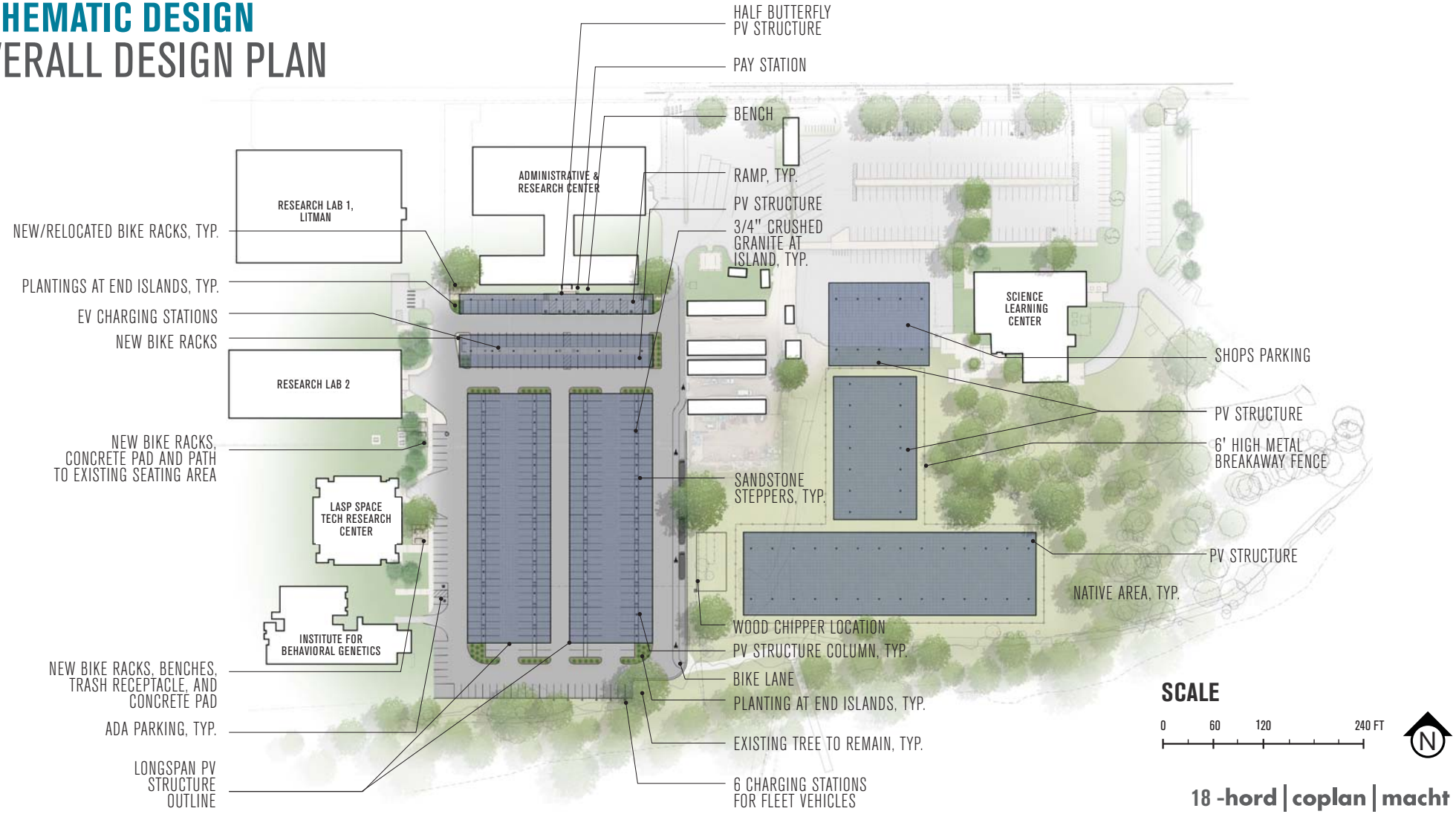
Existing Vehicular Parking Spaces= 412
Existing Bike Parking Spaces = 56

PROPOSED LAYOUT



Proposed Vechicular Parking Spaces= 407
Proposed Bike Parking Spaces= 72

SCHEMATIC DESIGN
OVERALL DESIGN PLAN

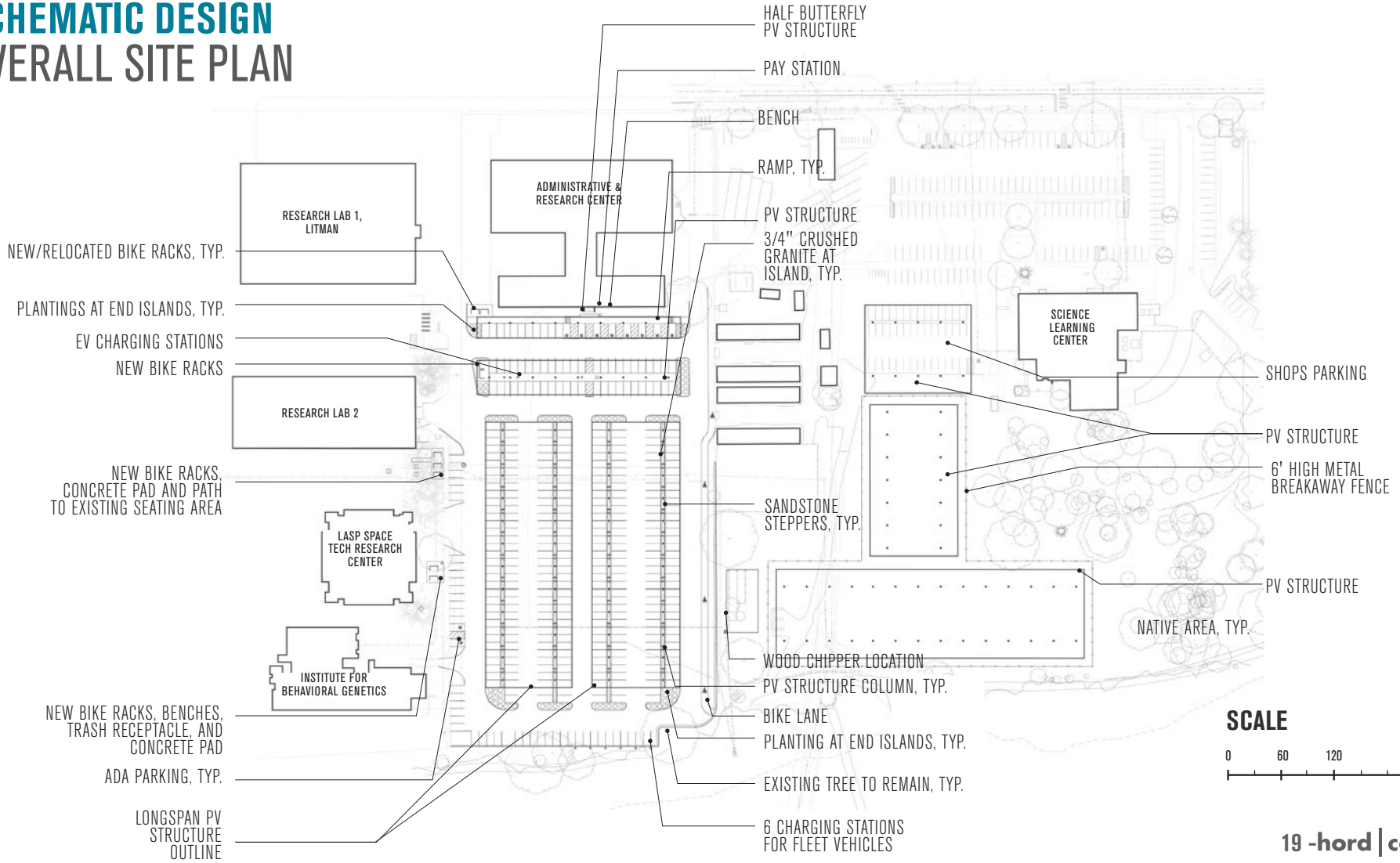


SCALE

0 60 120 240 FT

N

SCHEMATIC DESIGN
OVERALL SITE PLAN

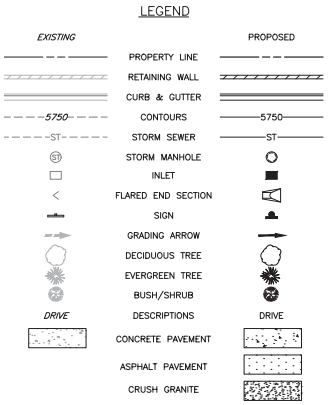


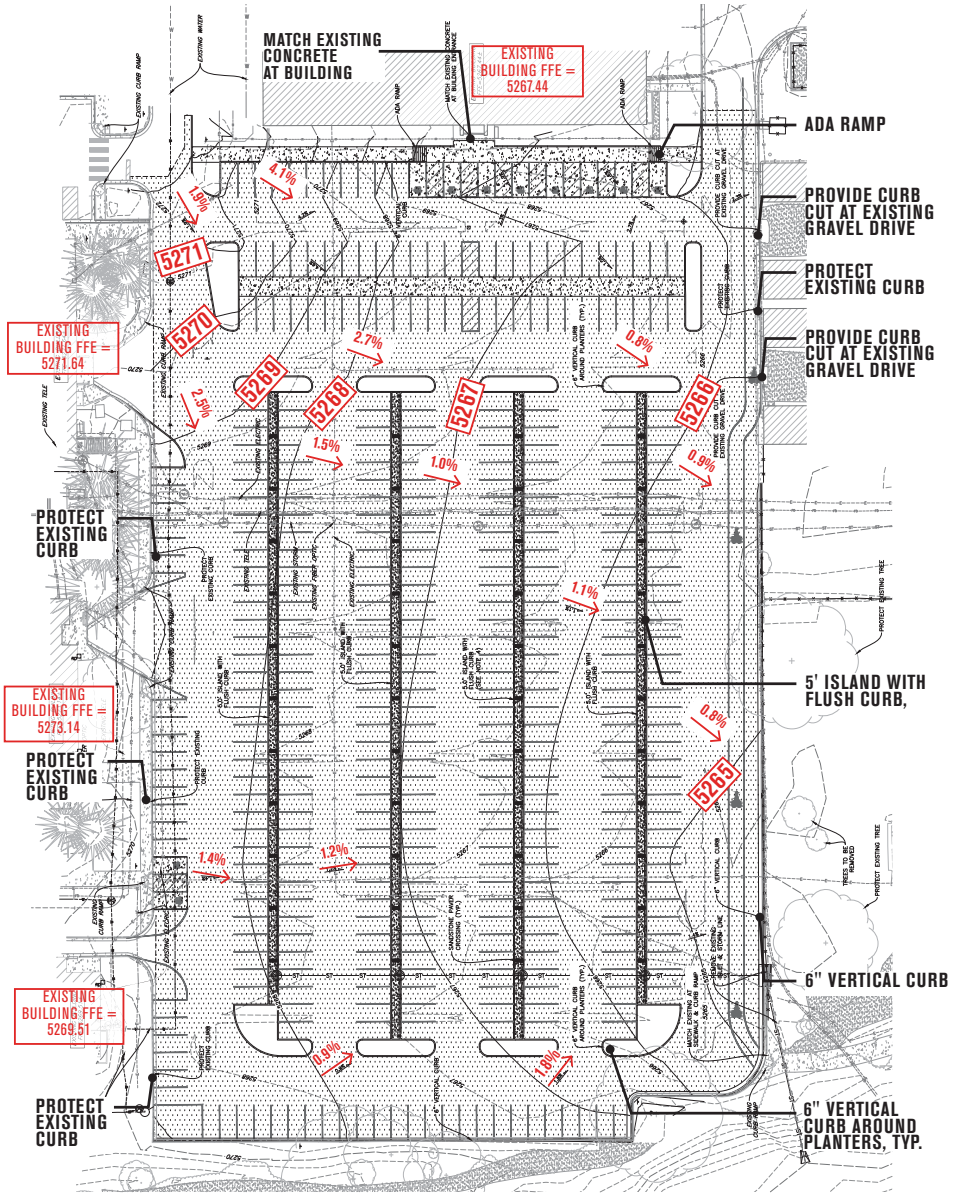
SCALE

0 60 120 240 FT

N

SCHEMATIC DESIGN
LOT 560 GRADING PLAN





NARRATIVE:

Replace the existing surface parking lot to accommodate the proposed solar panel structures. Additional civil improvements include:

Grading & Drainage: Match existing grades at the curb & gutter along the west perimeter. Mitigate floodplain impacts that occur from the solar structure columns by generally lowering the parking lot grades +/-6". Construct parking islands containing crushed granite surrounded by flush curb to allow stormwater to drain into the islands. Install underdrains within the islands to collect runoff and eventually discharge to Boulder Creek.

Accessibility: Relocate the 8 accessible parking stalls associated with the ARCE building along the north end of the parking lot. Relocate the 2 accessible parking stalls associated with the RL-4 and Behavioral Genetics building to the west, directly adjacent to the existing walk.

SCALE

0 30 60 120 FT

N

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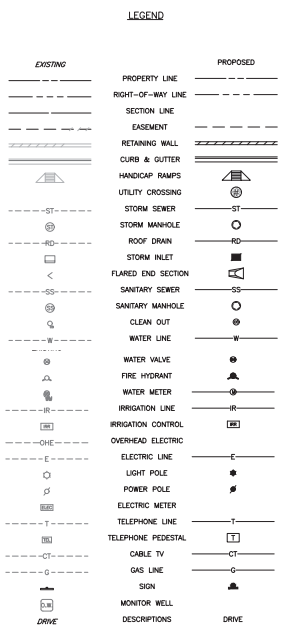
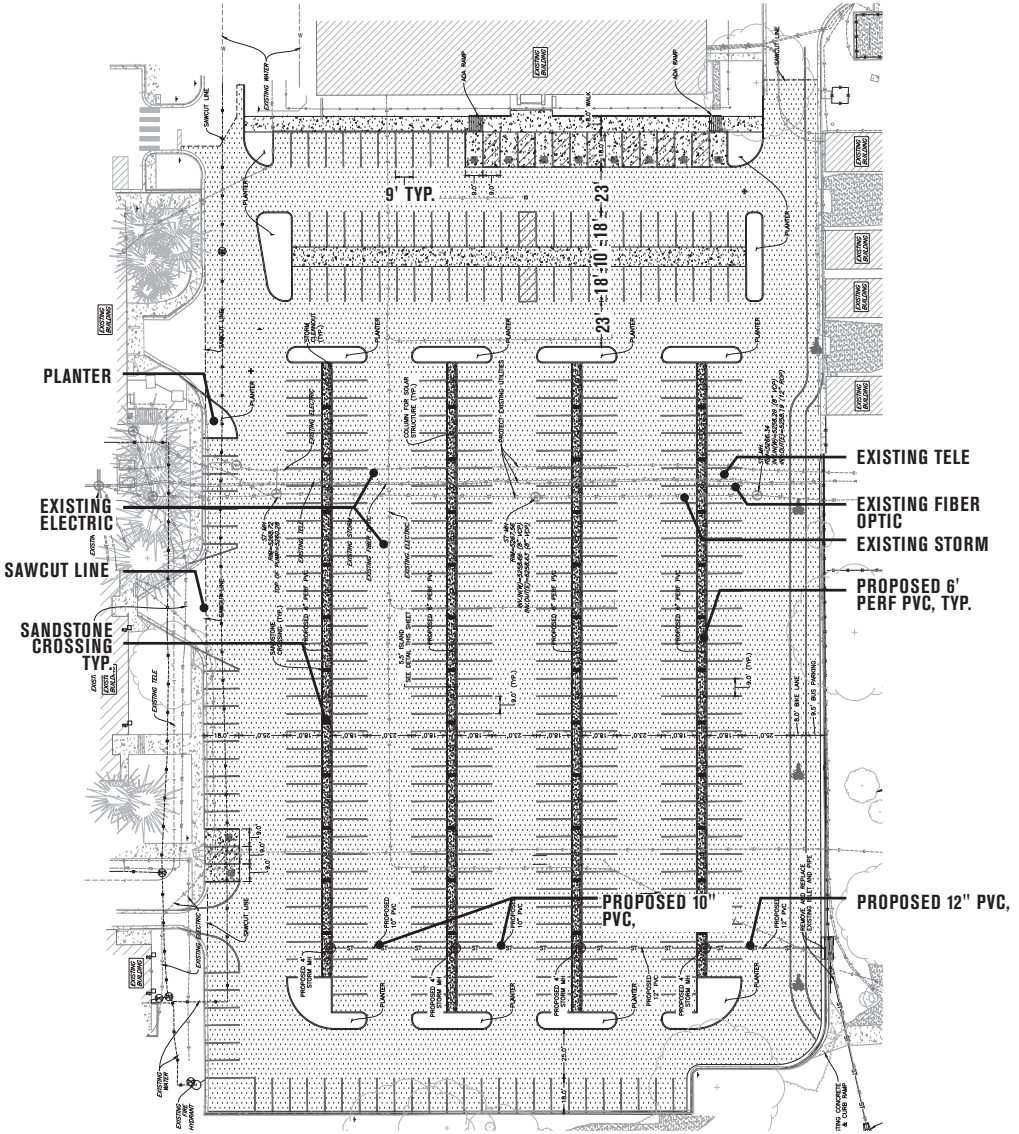
SCHEMATIC DESIGN
LOT 560 UTILITY PLAN





NARRATIVE:

Additional civil improvements include:

Water Quality: Improve water quality stormwater releases from the parking lot. Two alternatives are proposed:

1. Install varied layers of filter material in islands,

or

2. Provide no filter material in the islands and install rain garden east of parking lot.

SCALE

0 30 60 120 FT

N

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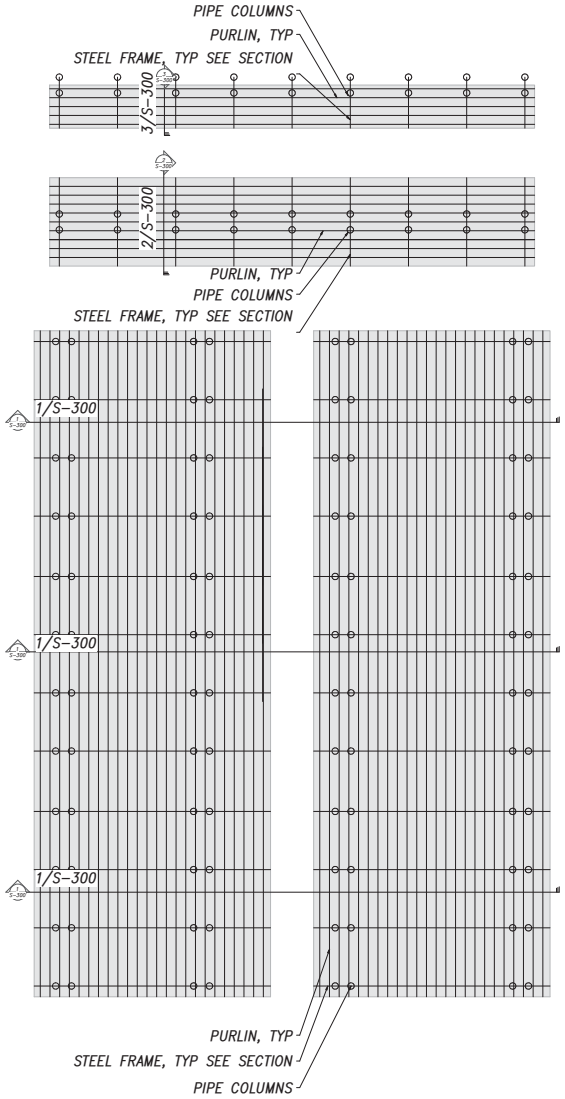
SCHEMATIC DESIGN
LOT 560 STRUCTURAL PLAN



NARRATIVE:

The structure is anticipated to consist of drilled pier foundations, approximately 24" in diameter. The structural support for the solar canopies is anticipated to consist of steel columns at a spacing of 27'.

The canopy framing is anticipated to be in multiple configurations with varying spans. The larger canopies will have clear spans in excess of 64' with cantilevers on the ends.

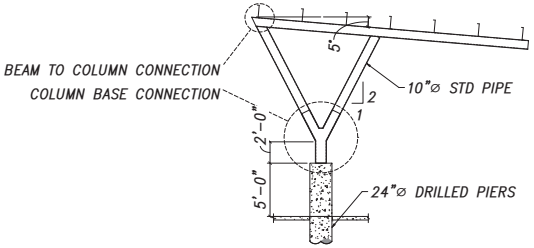
The framing will consist of either rectangular HSS or wide flange beams. The solar arrays will be supported on either 3" metal deck, or metal purlins spanning between beams.

SCALE

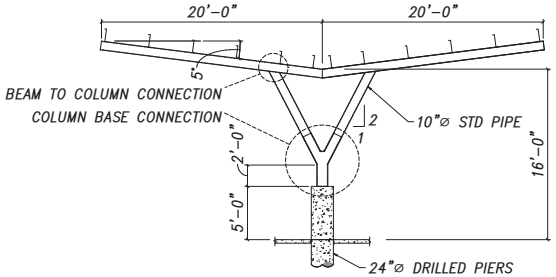
0 20 40 80 FT

N

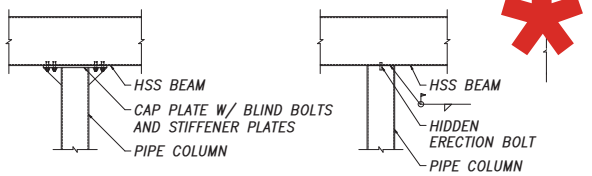
SCHEMATIC DESIGN
STRUCTURAL DETAILS



Cantilever Canopy - Lot 560

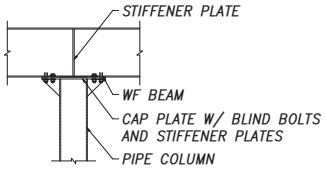


Butterfly Canopy - Lot 560

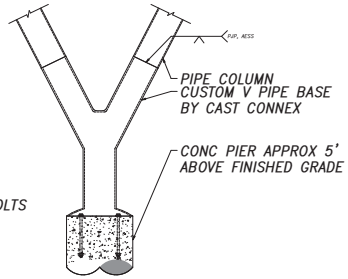


AT HSS BEAM TO COLUMN – BOLTED CONNECTION

AT HSS BEAM TO COLUMN – WELDED CONNECTION

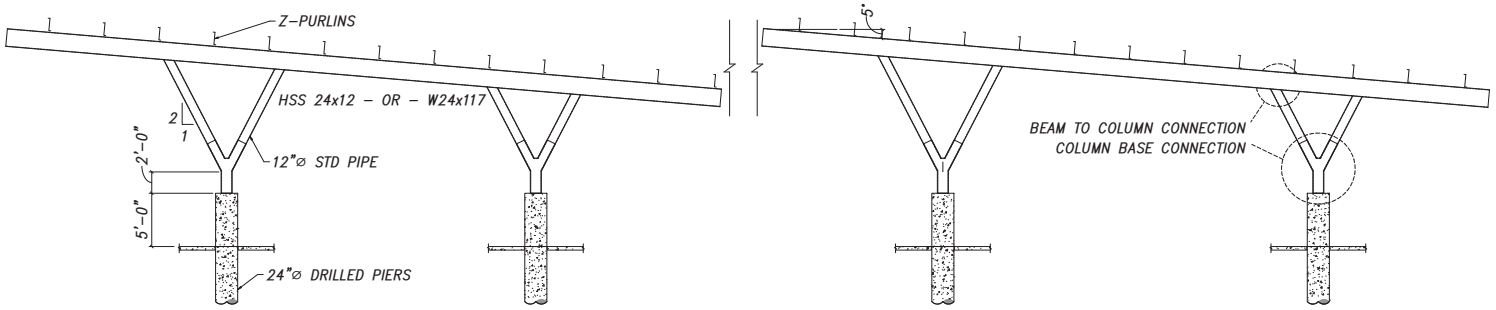


AT WF BEAM TO COLUMN – BOLTED CONNECTION



COLUMN BASE CONNECTION

Top Connection Sections



Longspan Canopy - Lot 560

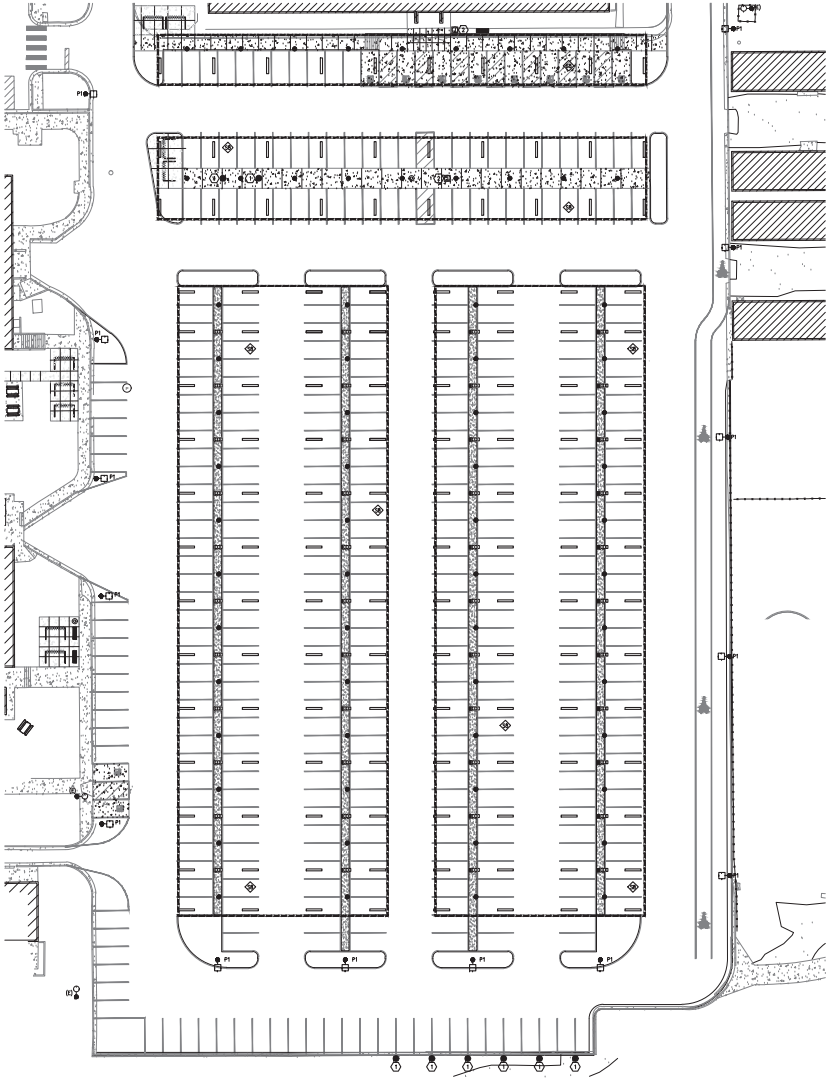
SCHEMATIC DESIGN
LOT 560 ELECTRICAL PLAN

STRIP LIGHT
PAL Microlinea Series 3 Direct

Wet Location - LED

PEDESTRIAN POLE FIXTURE
CREE Edge Series

LED PARKING LOT FIXTURE
CREE Edge Series



NARRATIVE:

Lighting will be provided under the solar canopies using a direct linear fixture mounted to the underside of the canopy.

Electric vehicle charging stations will be provided.

Electrical distribution to the side will be provided and coordinated with UCB Utilities Group.

SCALE

0 40 80 160 FT

N

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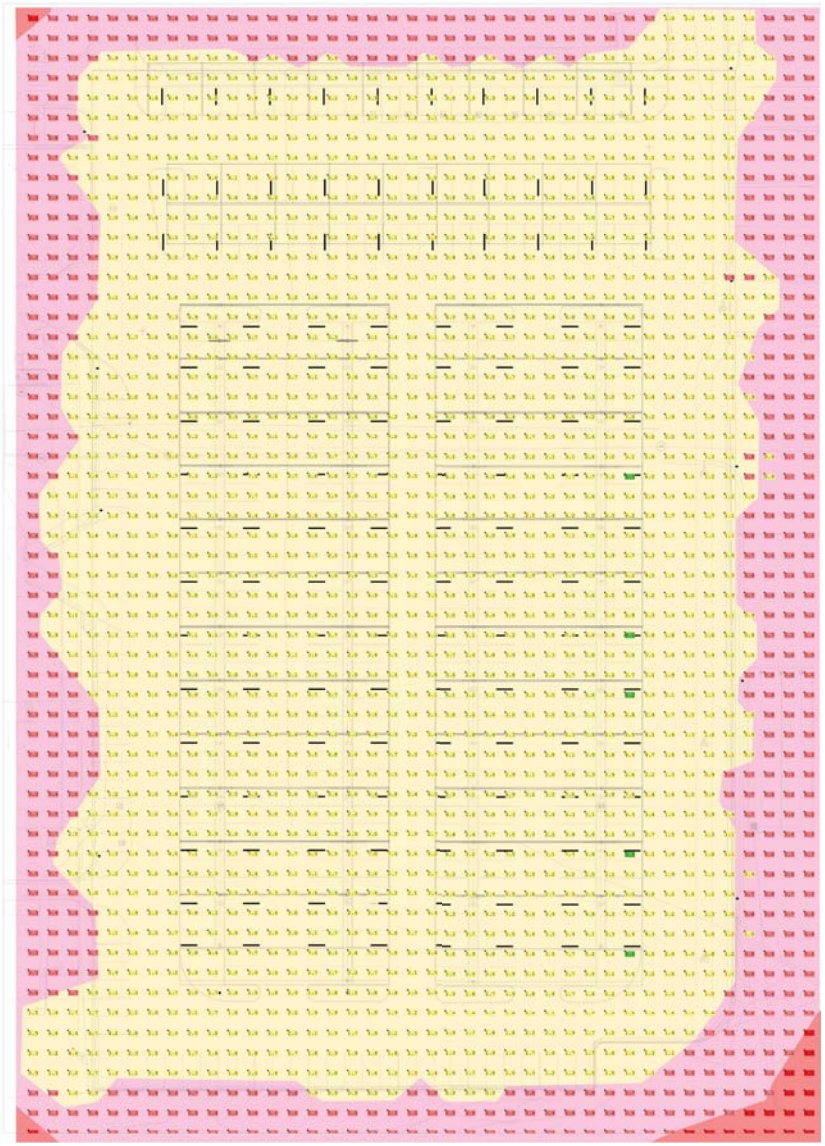
SCHEMATIC DESIGN
LOT 560 PHOTOMETRIC PLAN



LEGEND

- 0.00fc-0.10fc (no/low light - below criteria)
- 0.11fc-0.89fc (low light - below criteria)
- 0.90fc-7.99fc (meets criteria)

SCALE

80 160 FT

25 -hord | coplan | macht

SCHEMATIC DESIGN
PLANT PALETTE

Planted Parking Islands

Achillea 'Moonshine'
Moonshine Yarrow

Bouteloua gracilis 'Blonde Ambition'
B. A. Grama Grass

Deschampsia cespitosa 'Northern Lights'
N. L. Tufted Hair Grass

Euonymus fortunei 'Coloratus'
Purpleleaf Wintercreeper

Helictotrichon sempervirens
Blue Oat Grass

Hermerocallis 'Stella D'Oro'
Dwarf Daylilly

Perovskia atriplicifolia 'Little Spire'
Dwarf Russian Sage

Potentilla neumanniana 'Nana'
Dwarf Spring Potentilla

Schizachyrium scoparium 'Blue Heaven Grass'
Blue Heaven Little Bluestem

Sedum 'Autumn Joy'
Autumn Joy Sedum

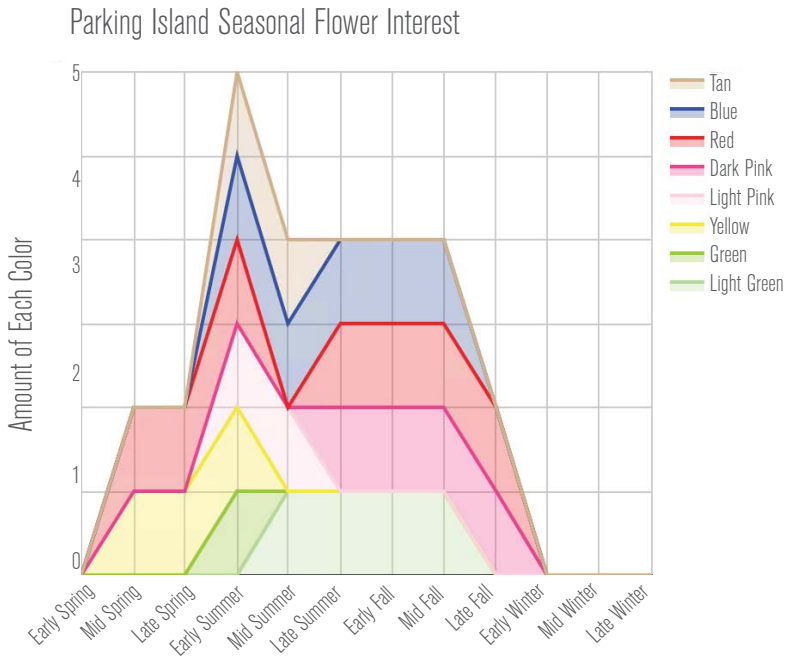
Symphoricarpos x doorenbosii 'Magic Berry'
Magic Berry Snowberry

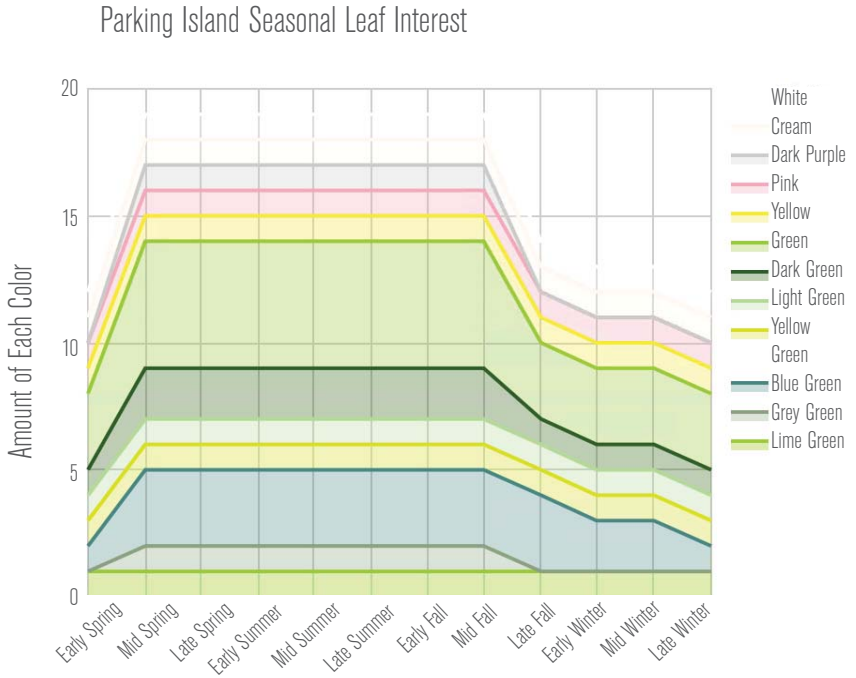
SCALE

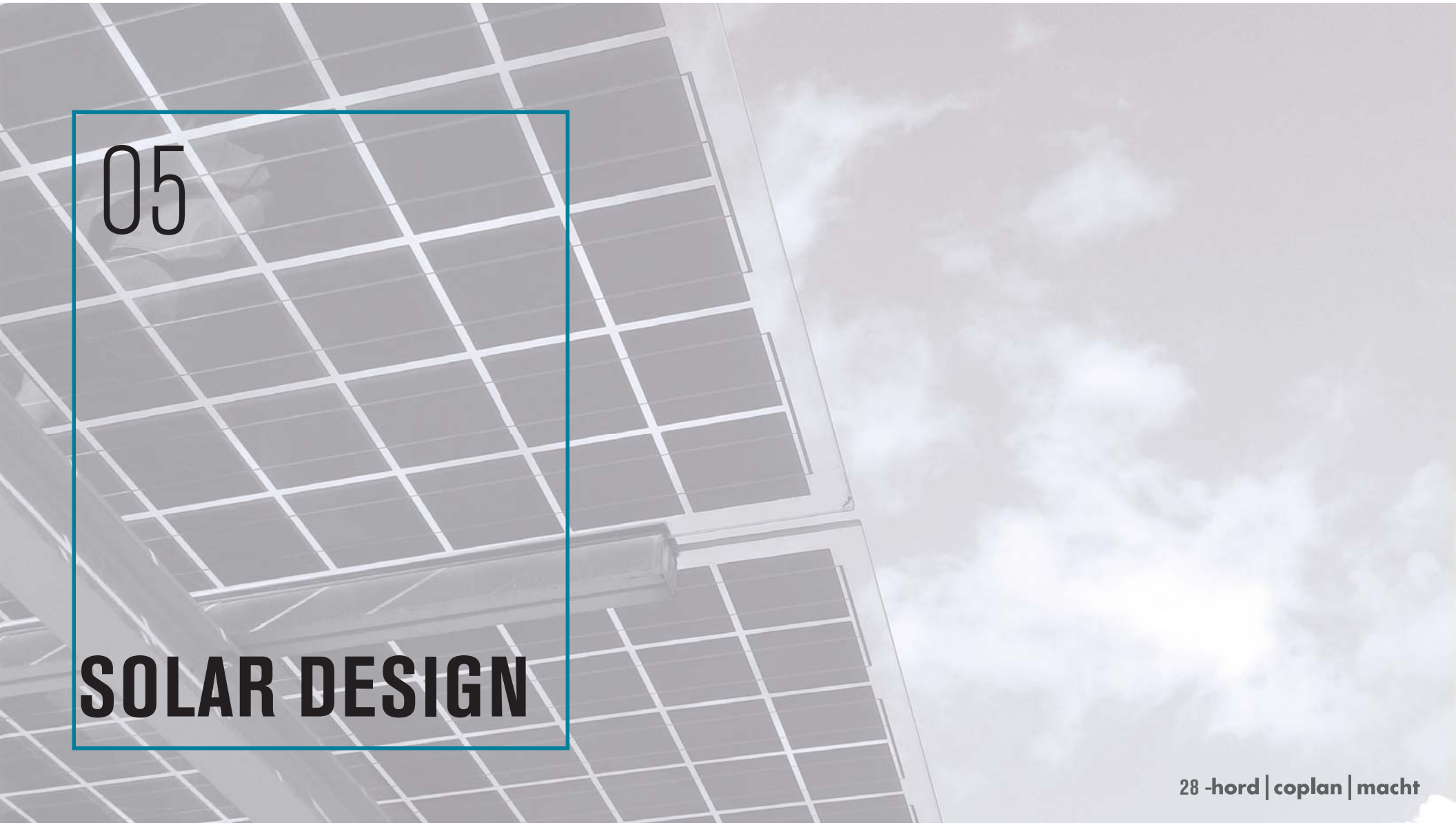
0 40 80 160 FT

N

SCHEMATIC DESIGN
PLANT COLOR DIAGRAMS



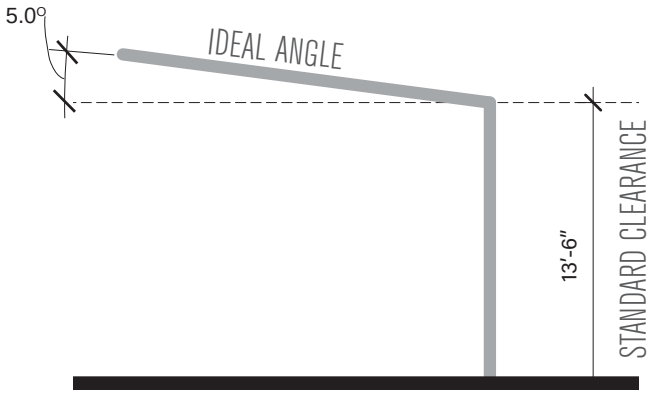




05

SOLAR DESIGN

SOLAR DESIGN:
PARAMETERS



SOLAR PARAMETERS

At Colorado's latitude, the steeper the slope, the better the generation (kW-h/kW), but increased environmental loads. The 'ideal' is to identify a preferred configuration (kW) and then maximize for generation kW-h/kW).

South-facing solar is the most productive, followed closely by east/west-facing.

At slopes below 7.5^0, the greatest structural economy is achieved.

STRUCTURAL PARAMETERS

To minimize cost and maximize modularity, parking layouts set structural parameters.

Provide structural design for 3 solar carports, based on parking layout.

Solar provider to finesse final application of solar modules onto optimized structural concepts.

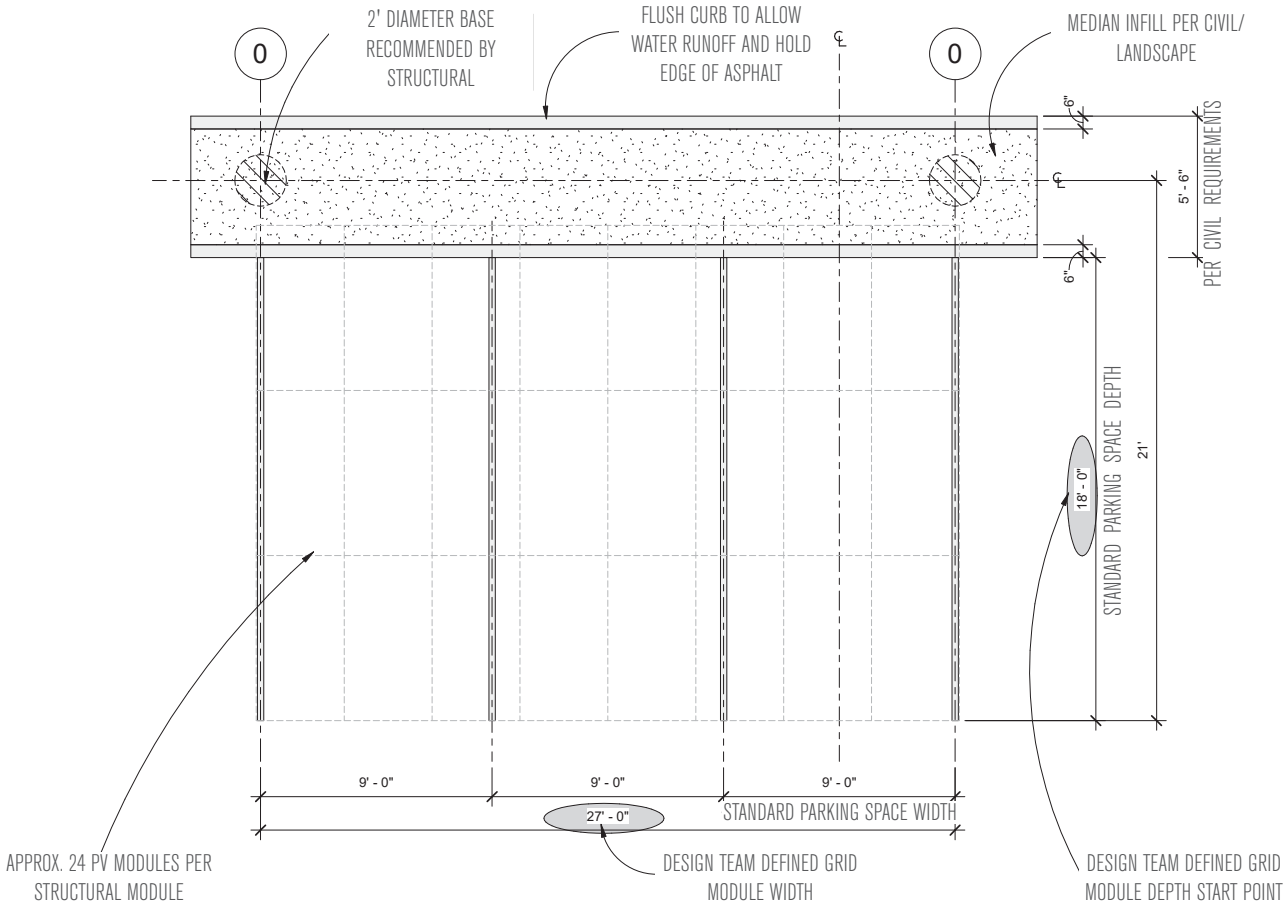
7lb/ft2 Snow Load: Structural & PV Recommendation (within local code of 30lb/ft2)

Wind Uplift: 155 MPH local code requirements for structural capacity. 5 degree slope reduces wind uplift.

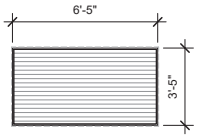
Maintenance:

- Bird Deterrence - Tube Steel Preferred.
- String Inverter - mounted on poles or pad mounted nearby, or potentially below roof of structure.
- Owner must commit to snow plowing and occasional asphalt maintenance below structure.

SOLAR DESIGN
STRUCTURAL LAYOUT STUDY



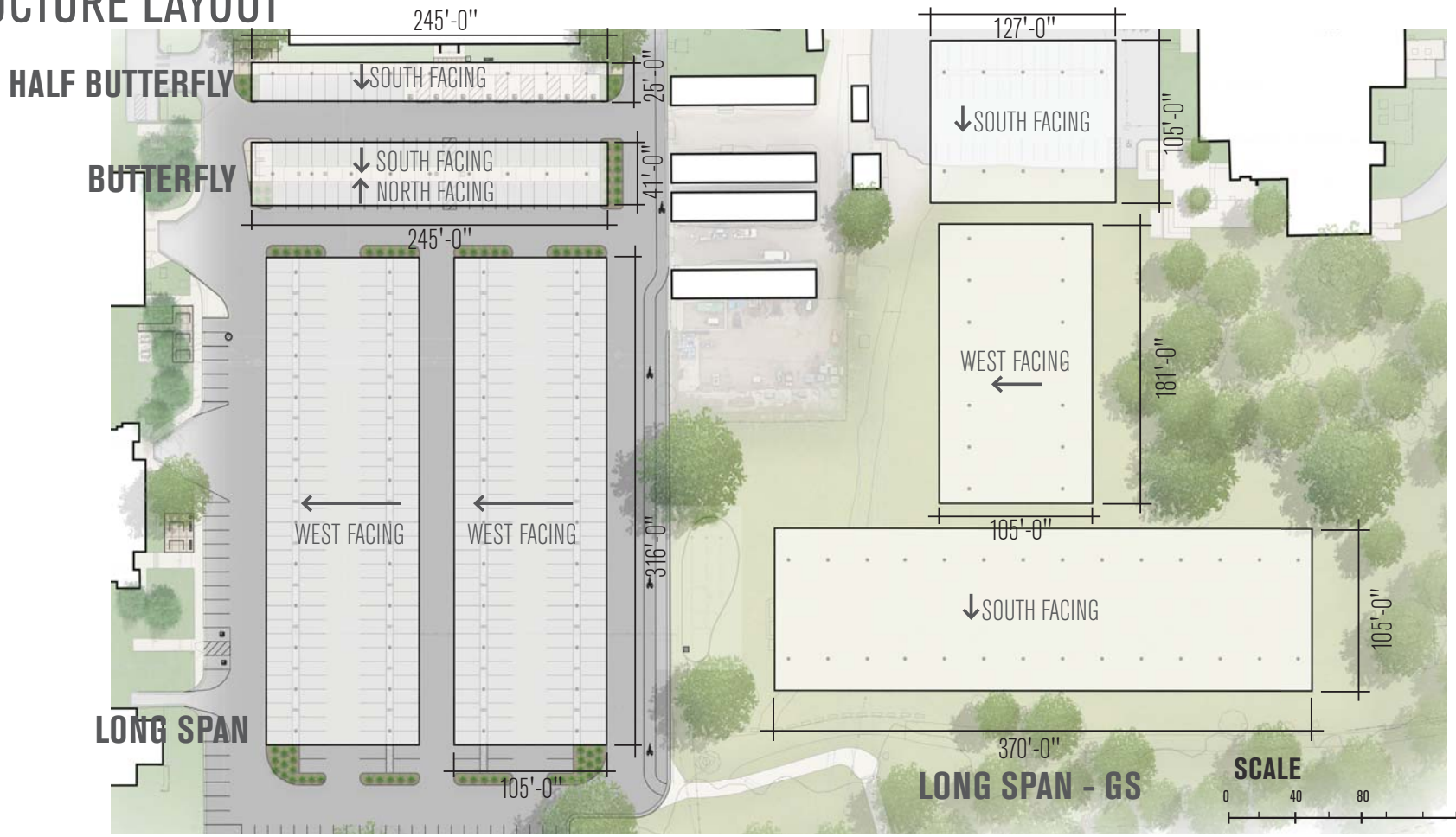
Industry Standard PV Panel Size



1: ACTUAL SIZE WILL VARY PER SOLAR PROVIDER.

2: ASSUME 1/2" SPACING BETWEEN PANELS.

SOLAR DESIGN
PV STRUCTURE LAYOUT

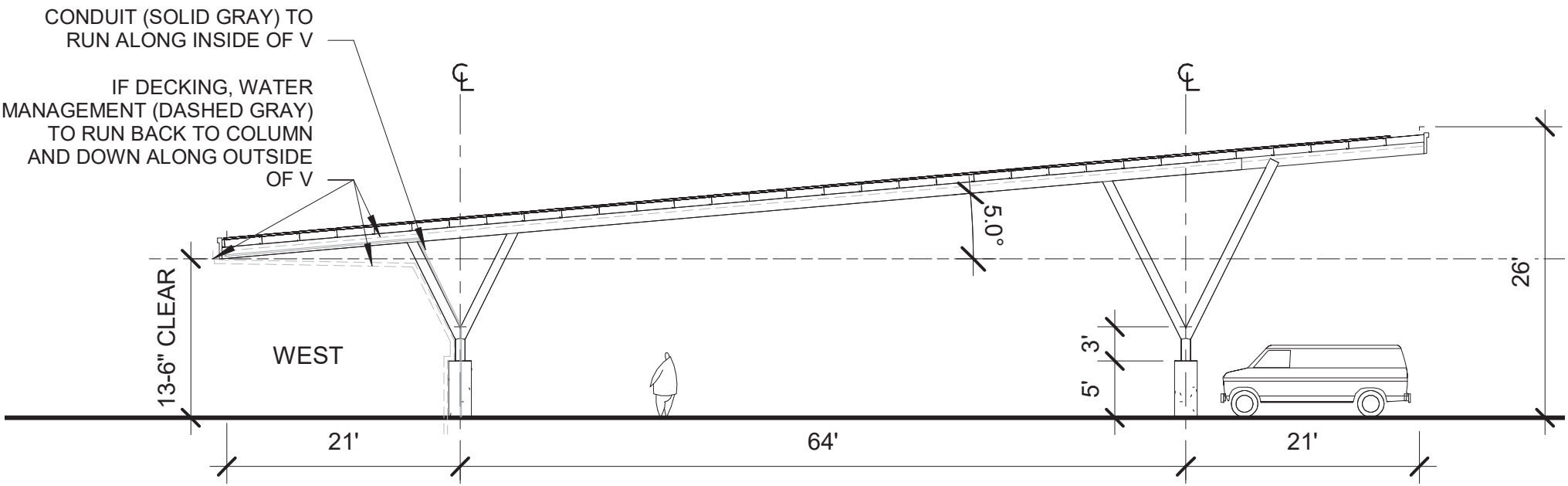


SOLAR DESIGN
STRUCTURE A

A **Monolithic:**
LONG SPAN

APPLICATION: back-of-house power generation

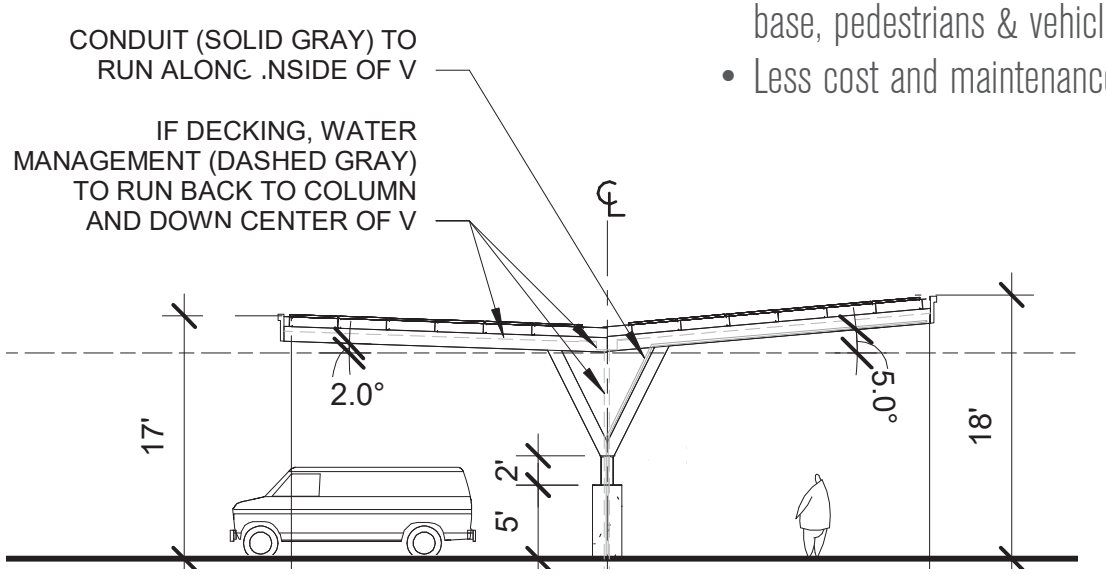
- Design-Team-Defined monolithic structure with cantilever over parking spaces.



SOLAR DESIGN
STRUCTURE B

B

Cantilever:
BUTTERFLY



APPLICATION: double-row locations with walk between parking

- 10' wide flush concrete island to accommodate structure base, pedestrians & vehicle bumpers
- Less cost and maintenance

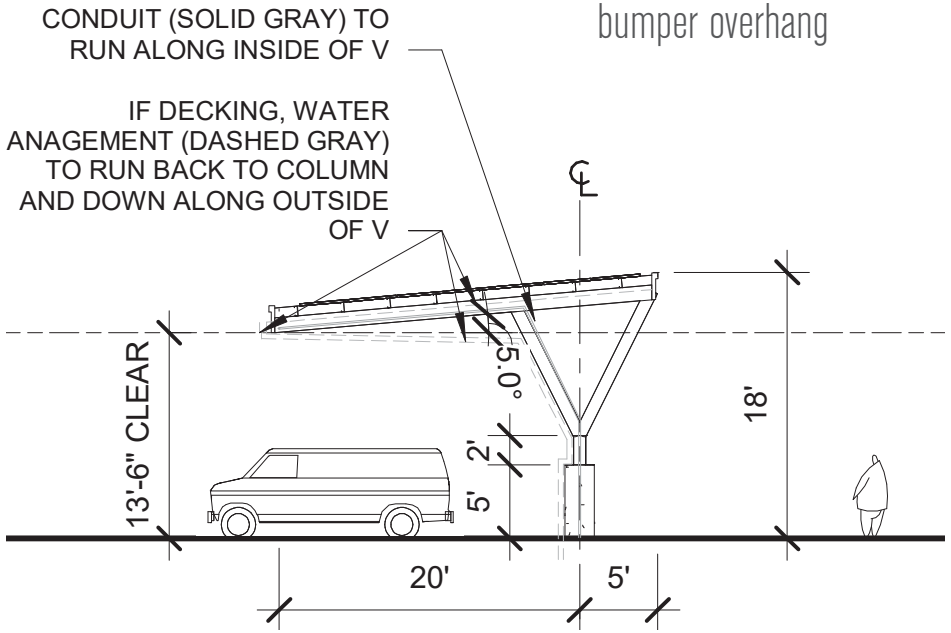
SOLAR DESIGN
STRUCTURE C

C **Cantilever:**

HALF BUTTERFLY

APPLICATION: single row locations adjacent to buildings

- 8’ walk in front of vehicle for ADA access & allows for bumper overhang

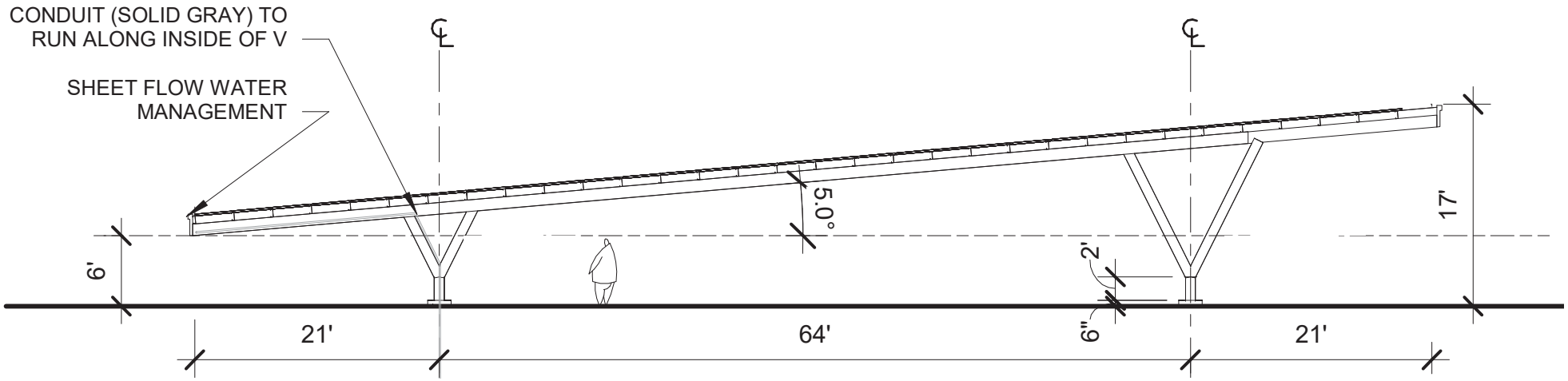


SOLAR DESIGN
STRUCTURE D

APPLICATION: maximum power generation at Green Space

D **Monolithic:**

LONG SPAN - GS



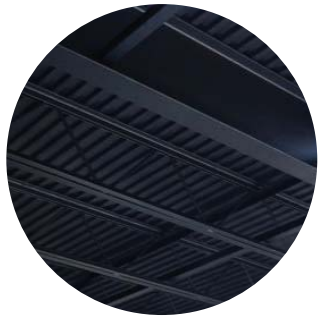
PARAMETERS:

- Same as structure A, except lower to the ground
- No concrete base above grade to minimize debris blockage

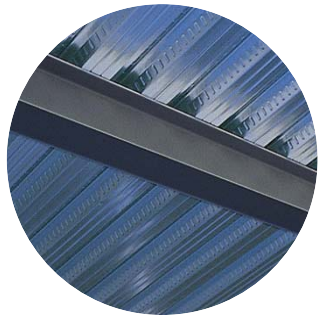
SOLAR DESIGN
ARCHITECTURAL COLOR PALETTE

STRUCTURE

NEUTRAL: Clear adonized metal deck, beams & columns



MONOCHROMATIC: CU black deck, beams & columns



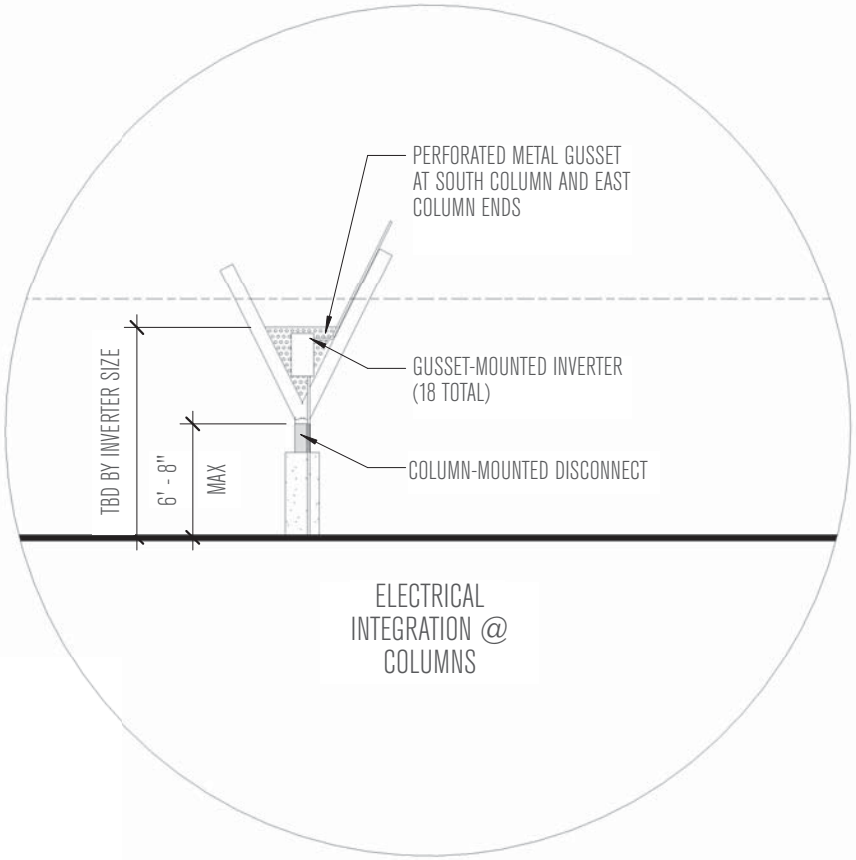
HIGH CONTRAST: Clear adonized metal deck & CU black beams & columns

CONCRETE BASE

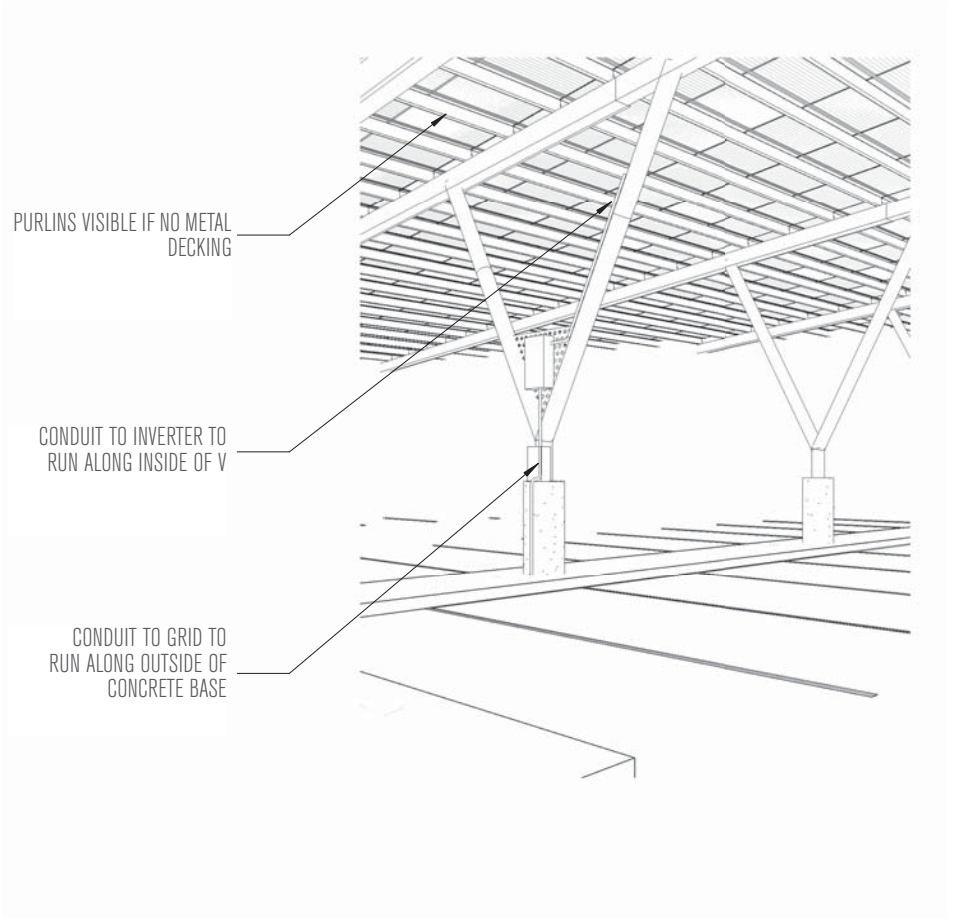
BOARDFORM CONCRETE:
Natural finish or integral color

FORMED CONCRETE BASE:
Natural finish

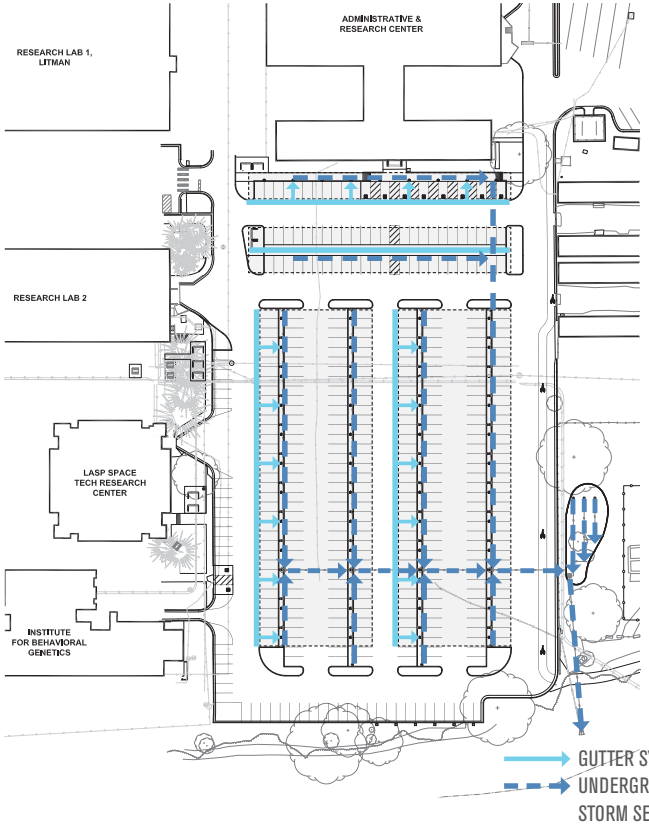
SOLAR DESIGN
ELECTRICAL INTEGRATION



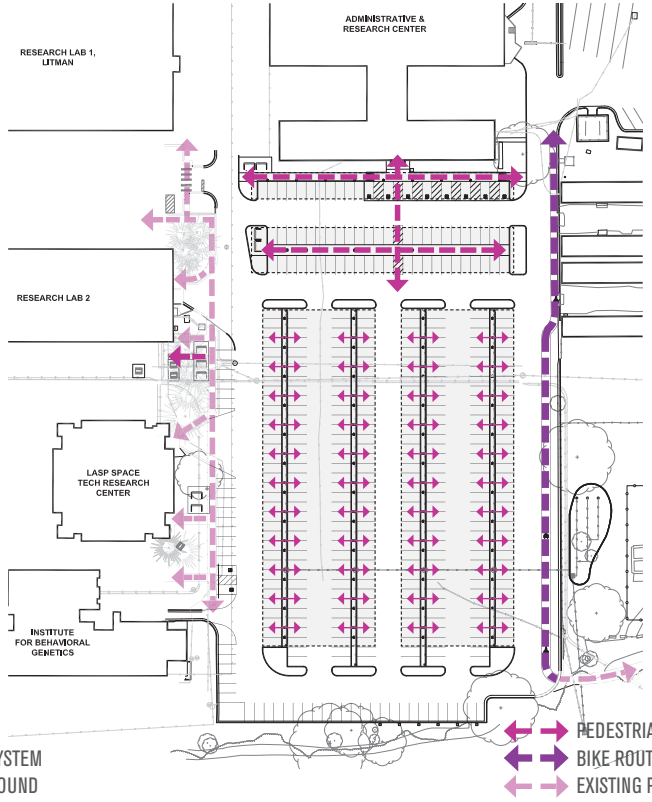
Longspan Canopy Electrical Integration



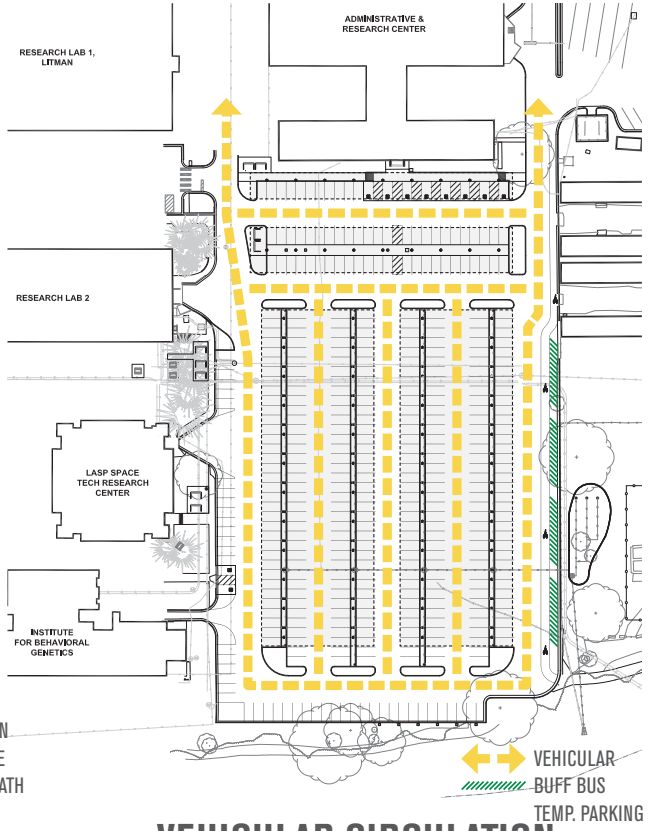
SOLAR DESIGN
LOT 560 DESIGN STRATEGIES



STORM WATER

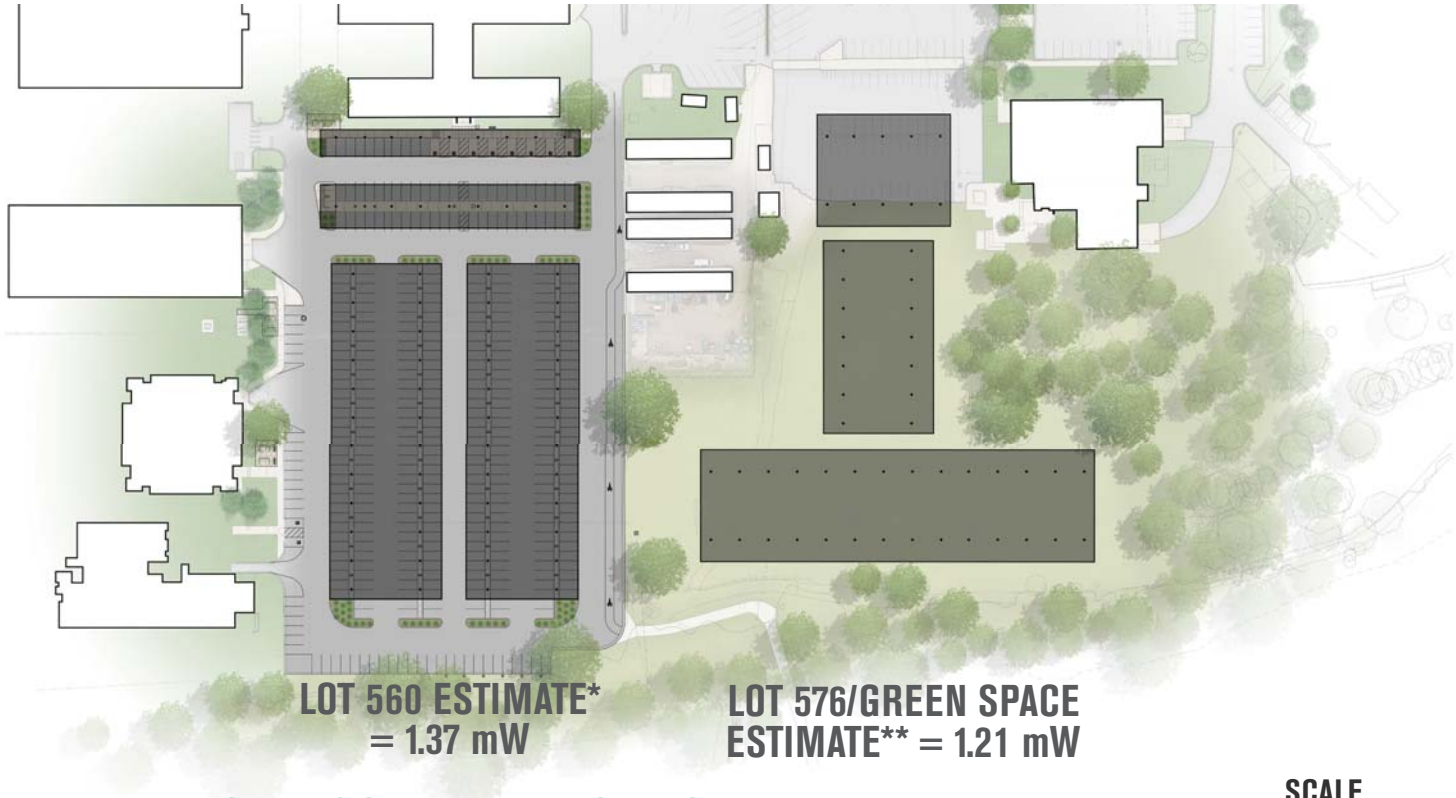


PEDESTRIAN/BIKE CIRCULATION



VEHICULAR CIRCULATION

SOLAR DESIGN
ENERGY PRODUCTION ESTIMATES



TOTAL SOLAR ENERGY POTENTIAL = 2.58 mW

*Estimate based on modified design by Namaste Solar

**Estimate extrapolated from Lot 560.

Note: Solar energy production is a preliminary estimate and subject to change.

SCALE

0 60 120 240 FT

N

SOLAR DESIGN

VIEW FACING EAST AT LOT 560 VISITOR LOT STRUCTURES

SOLAR DESIGN
VIEW FACING NORTHWEST AT LOT 560

SOLAR DESIGN
VIEW FACING NORTHEAST AT LOT 560

NEXT STEPS

SOLAR DESIGN

SAWTOOTH OPTION - DESIGN EXPLORED BUT NOT SELECTED