I-5 Lid Feasibility Study

Preliminary Structural Feasibility

I-5 Lid Feasibility Study Committee

August 22, 2019

WSP

Seattle
Office of Planning &
Community Development

Workshop Purpose and Goals

- Agenda review
- Introductions
- Goals:
  - Address the question “where can a lid be built?”
  - Examine preliminary structural feasibility of lid geometrical layouts and structural assessment
  - Create an engaging workshop that encourages committee dialogue and input

Committee Ground Rules

- Listen to understand one another's perspectives
- Make space to listen to all the voices in the room
- Minimize interruptions and side conversations
- Follow facilitator's lead
- Stick to agenda and allotted timeframes

SDON Outreach Update

SDON Outreach Update

Outreach Goals:

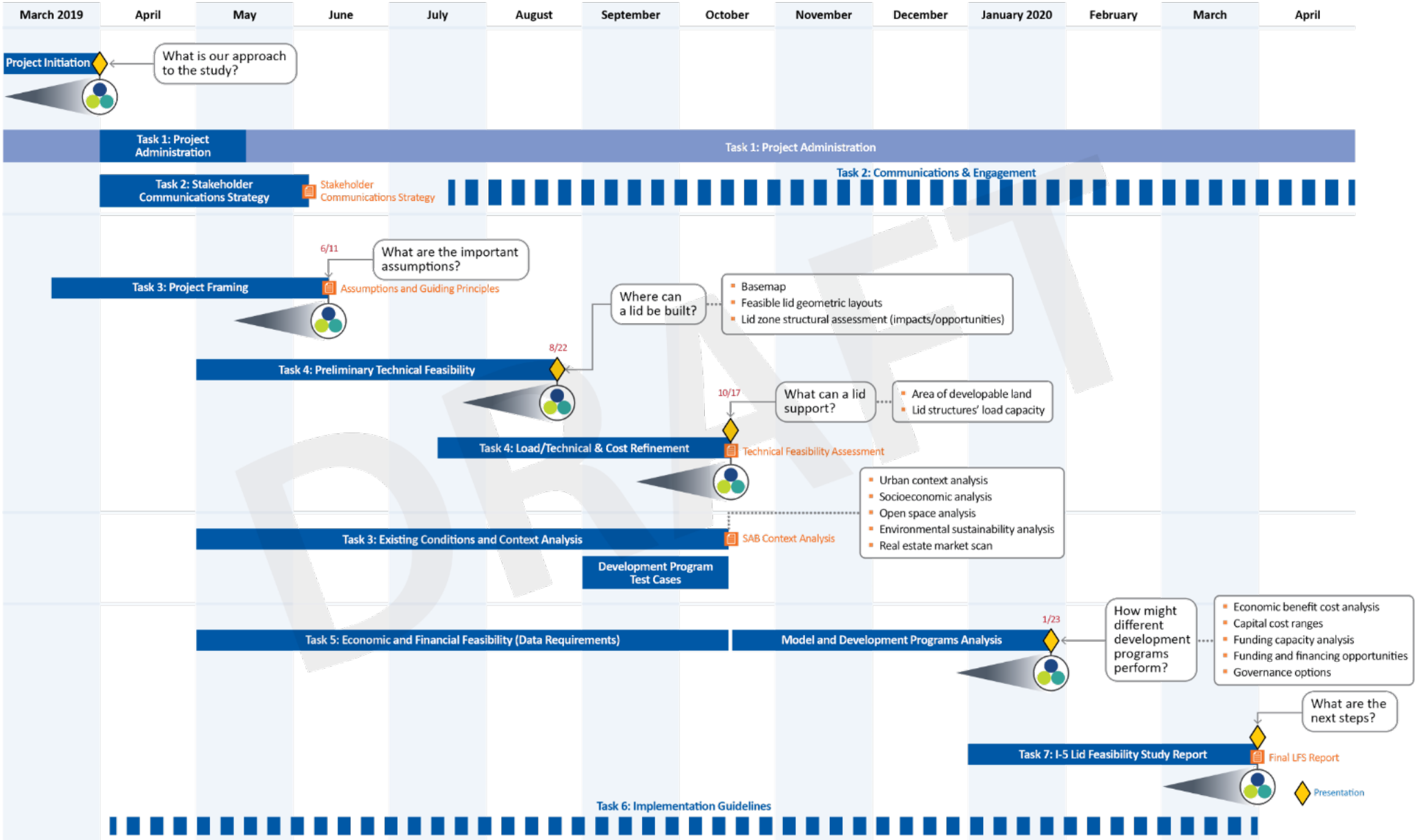
- Work with underrepresented community members to inform them of feasibility study
- Hear and document community members' visions, ideas and concerns for a lid over I-5
- Give them ways to keep informed and updated on the process

Feedback To Date:

- Concerns around equity and access to newly created space were central to support
- Interested to share lid concept with communities and stakeholders, and wanted to continue to be a part of the conversation

Work Plan and Study Committee Look-Ahead

I-5 Lid Feasibility Study Work Plan Diagram



Draft 08-14-2019

LEGEND Project Milestone | Engagement with Study Community | Outcome

Study Committee Look-Ahead Plan

6/11
2-5 pm

Study outcome:
Key study assumptions and guiding principles

Question answered:
What are the important key study assumptions?

Meeting purpose:
Share, confirm and test key study assumptions and guiding principles

8/22
2-5 pm

Study outcome:
Preliminary technical feasibility

Question answered:
Where can a lid be built?

Meeting purpose:
Examine feasible lid geometrical layouts and structural assessment

10/15
12:30-4:30 pm

Study outcome:
Technical assessment, load capacity, and site context analysis

Question answered:
What can a lid support?

Meeting purpose:
Examine what a lid can support and potential development program test cases

1/23
10 am-2 pm

Study outcome:
Economic and financial feasibility assessment

Question answered:
How might development programs perform?

Meeting purpose:
Examine economic benefit cost analysis, capital cost ranges, financing opportunities and governance options

April
TBD

Study outcome:
Final I-5 Lid Feasibility Study report

Question answered:
What are the next steps?

Meeting purpose:
Learn about the final study results and a blueprint for next steps

Dates and times shown are proposed and to be confirmed.

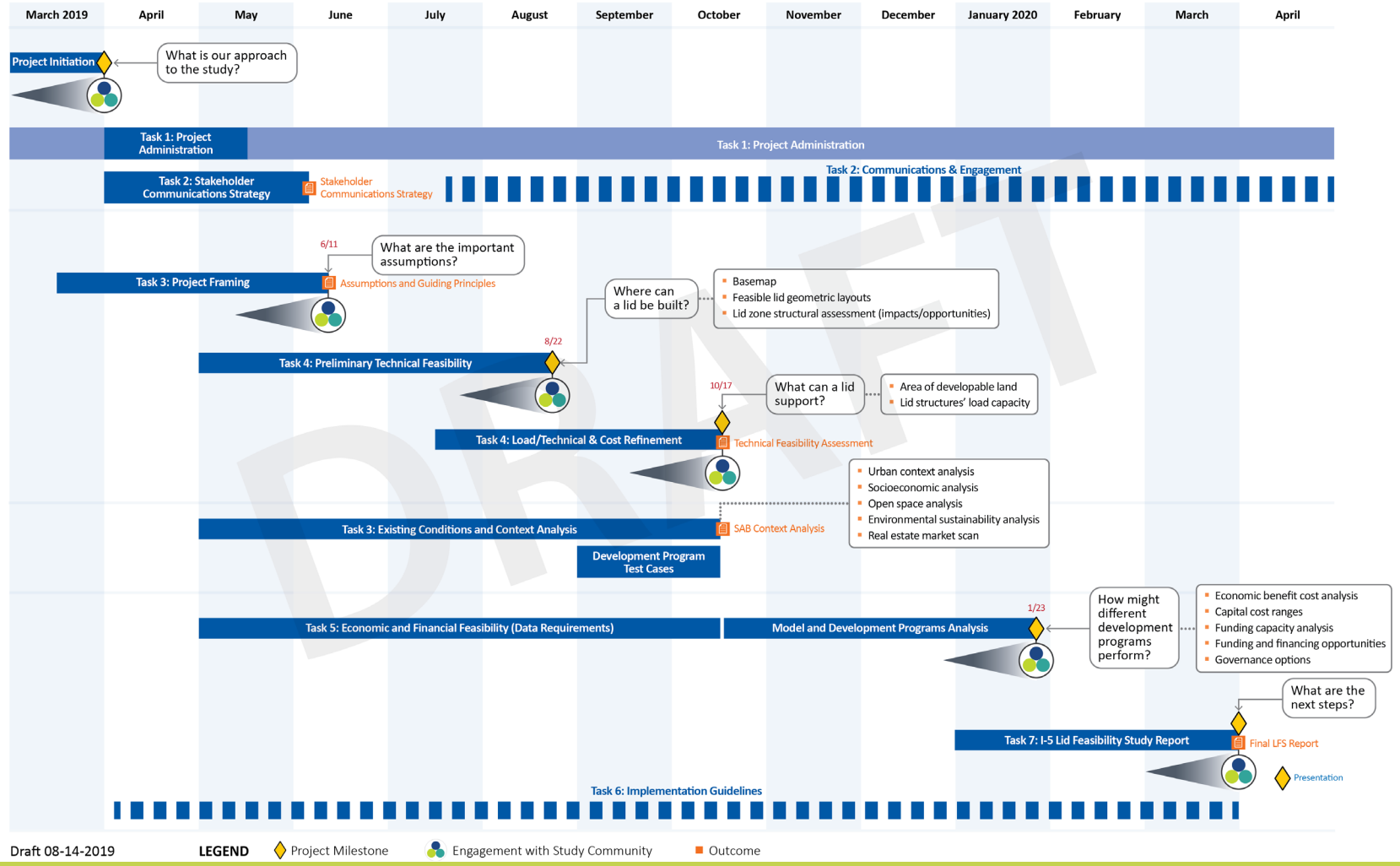
Preliminary Structural Feasibility

Presentation Overview

- General considerations and limitations
- Project approach
- Site overview
- Project technical assumptions
- Lid sub-area development
  - Features/geometrics
  - Structural assessment
- Considerations
- Next steps

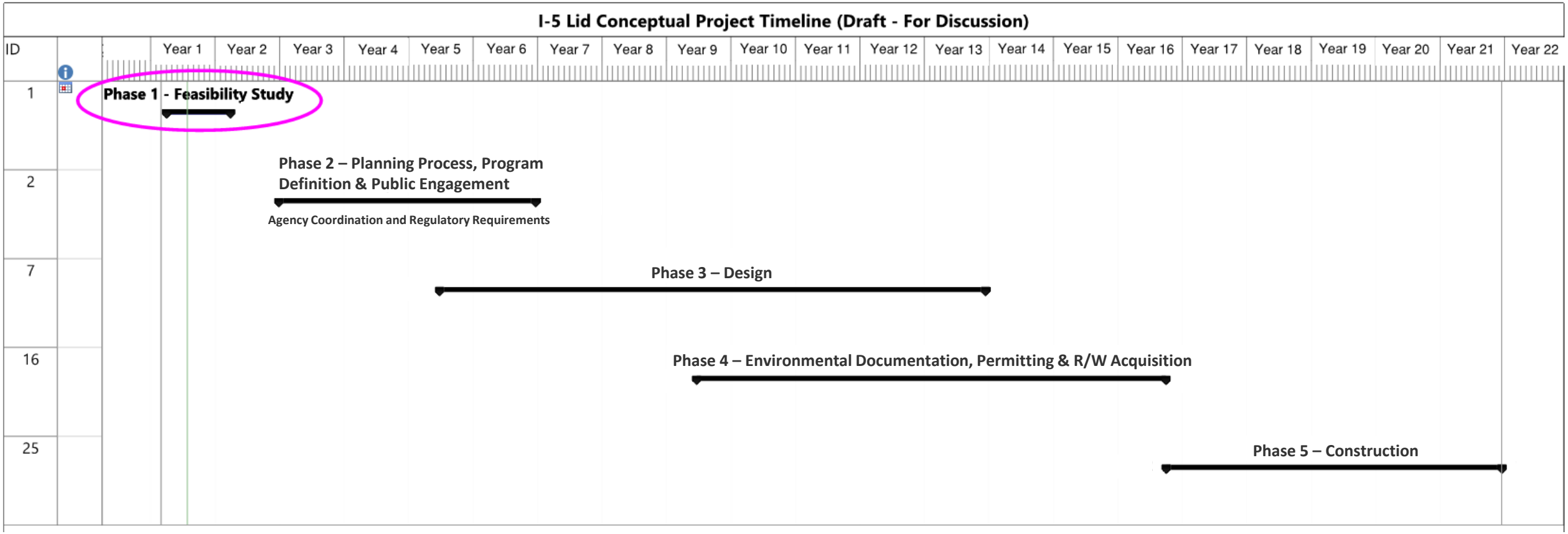
Project Schedule (This Phase)

General schedule for work being conducted under this study (phase of work)



Conceptual Project Schedule (Future)

General schedule for work being conducted in later (future) phases



Study Limitations – What's included?

List of items included in the study…

- Identification of potential impacts and capital cost ranges associated with various lid sub-areas for different levels of development
  - The study will provide the City and project stakeholders with credible information and resources to assess the economic feasibility of the project considering various land use ratios and associated potential infrastructure impacts.
- Concept level structural design suitable for establishing rough order of magnitude costs
  - Concept level structural design will not be what actually gets built
- Design decisions based on engineering judgement supported by limited analysis

Study Limitations – What's not included?

List of items NOT included in the study…

- Consultant Team recommendations, or identification of fatal flaws
  - The study will identify a tool set that can be used for planning future phases of work
- Development of design submittals for various engineering discipline review
  - This would need to be performed in future phases of work.
- Addressing traffic and utility impacts (temporary or permanent)
  - This would need to be performed in future phases of work.
- Mitigation of traffic impacts and associated costs
  - This would need to be addressed in future phases of work.

WSDOT Considerations

- WSDOT is working with the City of Seattle to understand the requirements and constraints that would affect freeway lid feasibility in this study area.
- WSDOT recognizes the need to identify long term plans for this segment of freeway, including consideration of its functional adequacy, asset management and seismic resilience.
- WSDOT identifies that we are a long way from knowing project feasibility or cost, and caution against drawing firm conclusions or estimates at this level of detail.
- Any changes in ramp locations would require detailed network analysis of effects on freeway and local street function.
- More work will be needed to determine the best approach to long-term preservation or replacement of existing structures and meeting future seismic resiliency needs.

Project Approach

Outlined below; will be an iterative process. Bolded items have commenced

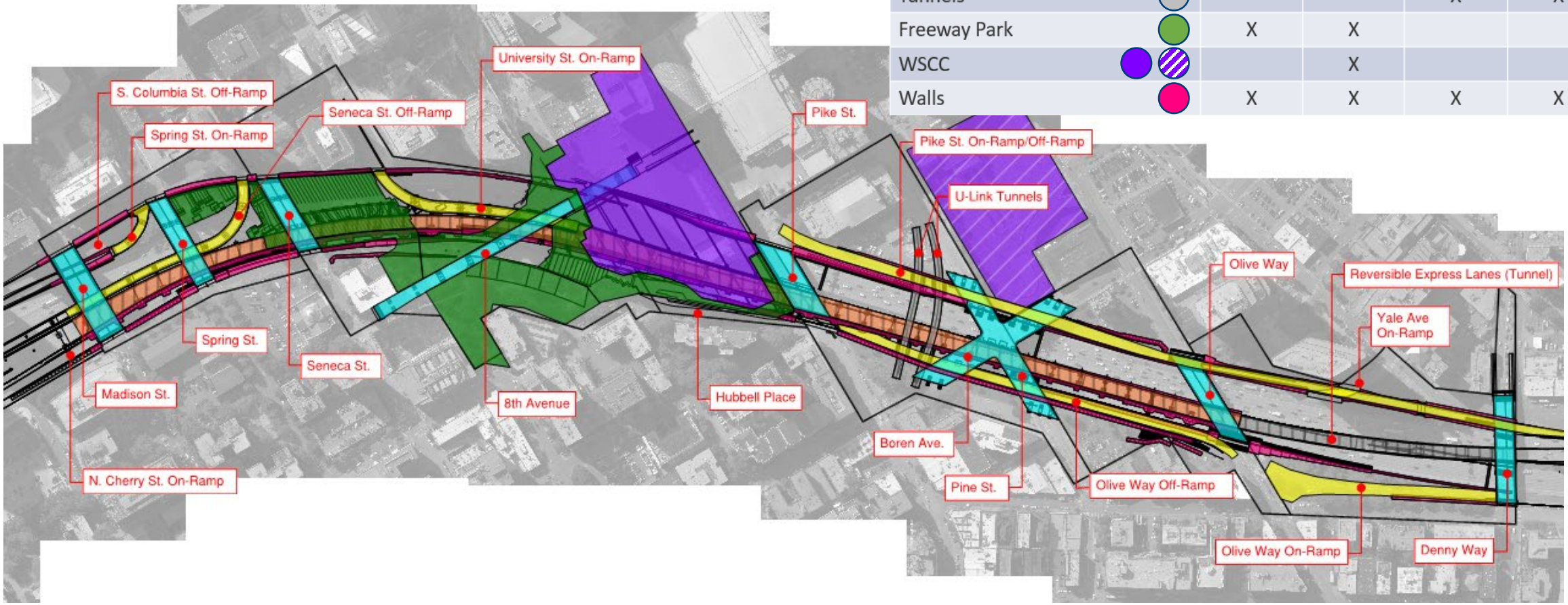
- **Basemap Development**
  - **Preliminary – built on documents received from information requests**
- **Lid Sub-Area Development (Geometric Layouts)**
  - **Definition of Impacts**
  - **Definition of Work Zones**
- **Lid Sub-Area Structural Assessment** ← Current Status
  - **Parametric study based on anticipated spans of the identified lid sub-areas**
  - **To consider different load conditions: open-space; low-rise, medium rise, and high-rise development**
- Interdisciplinary Coordination
  - Directed discipline specific task assignments to approximate costs and impacts

Site Overview

Structural Assessment Boundary (SAB) & Sub-areas

Site Overview - General

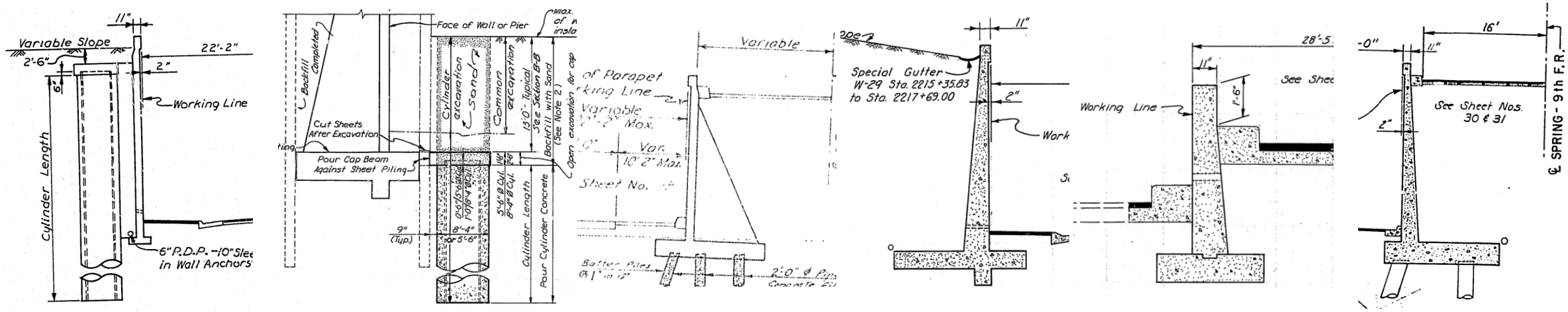
Component	Area 1	Area 2	Area 3	Area 4
NB I-5 (Elevated Structure)	X	X	X	X
Overpasses	X	X	X	X
Reversible Express Lanes	X	X	X	X
On/Off Ramps	X	X	X	X
Tunnels			X	X
Freeway Park	X	X		
WSCC		X		
Walls	X	X	X	X



Site Overview - Structures

Structure Type	Area 1	Area 2	Area 3	Area 4	Total
Quantity of Bridges	5	4	4	2	15
Quantity of Walls	8	7	9	9	33

- Bridge Types:
  - Cast-In-Place Box Girder
  - Cast-In-Place Slab
  - Cast-In-Place T-Beam
- Wall Types:
  - Cylinder Walls (5’-6’’ Dia., 8’-4’’ Dia., 10’-0’’ Dia.)
  - Cantilever Retaining Walls

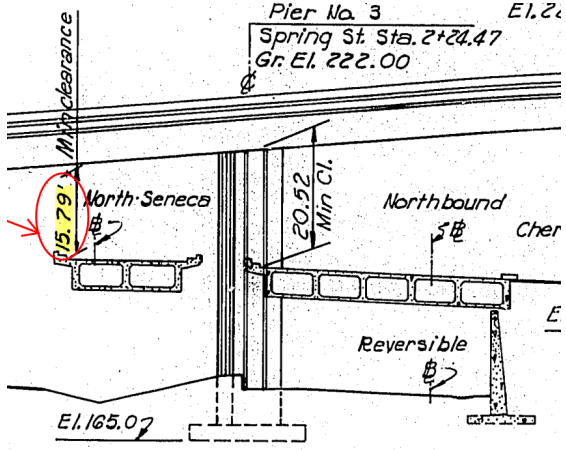


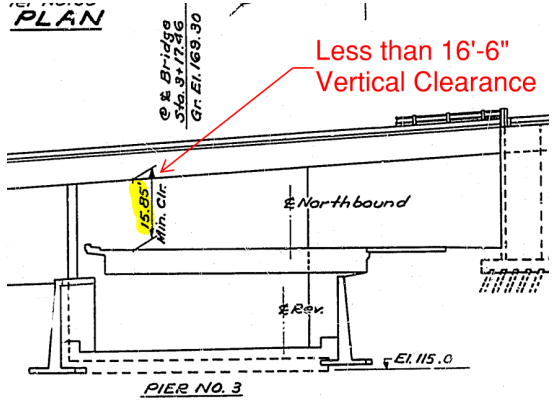
Cylinder Walls

Cantilever Retaining Walls

Site Overview – Vertical Clearances

Area	Location	Notes
1	Seneca Street Bridge	**Over Mainline NB I-5 (15.79-ft)** - left lanes
	Spring Street Bridge	Over Columbia Street (15.26-ft) **Over Seneca Street Off-Ramp (15.79-ft)**
	Madison Street Bridge	Over Columbia Street (16.32-ft)
2	7th Avenue Bridge	Over Columbia Street (16.00-ft)
	8th Avenue Bridge	Over University Street On-Ramp (15.17-ft)
	University Street On-Ramp	Over Columbia Street (15.35-ft)
3	Boren Avenue Bridge	Over Pike Street On/Off Ramp (16.00-ft)
	Pine Street Bridge	Over Pike Street On/Off Ramp (16.00-ft)
	Olive Way Bridge	**Over Mainline NB I-5 (15.1-ft)** - left lanes
4	Yale Avenue On-Ramp	Over Pike Street On/Off Ramp (14.75-ft)
	Denny Way Bridge	Over Pike Street On/Off Ramp (15.83-ft) **Over Mainline NB I-5 (15.08-ft)** - left lanes Over Olive Way On-Ramp (14.75-ft)

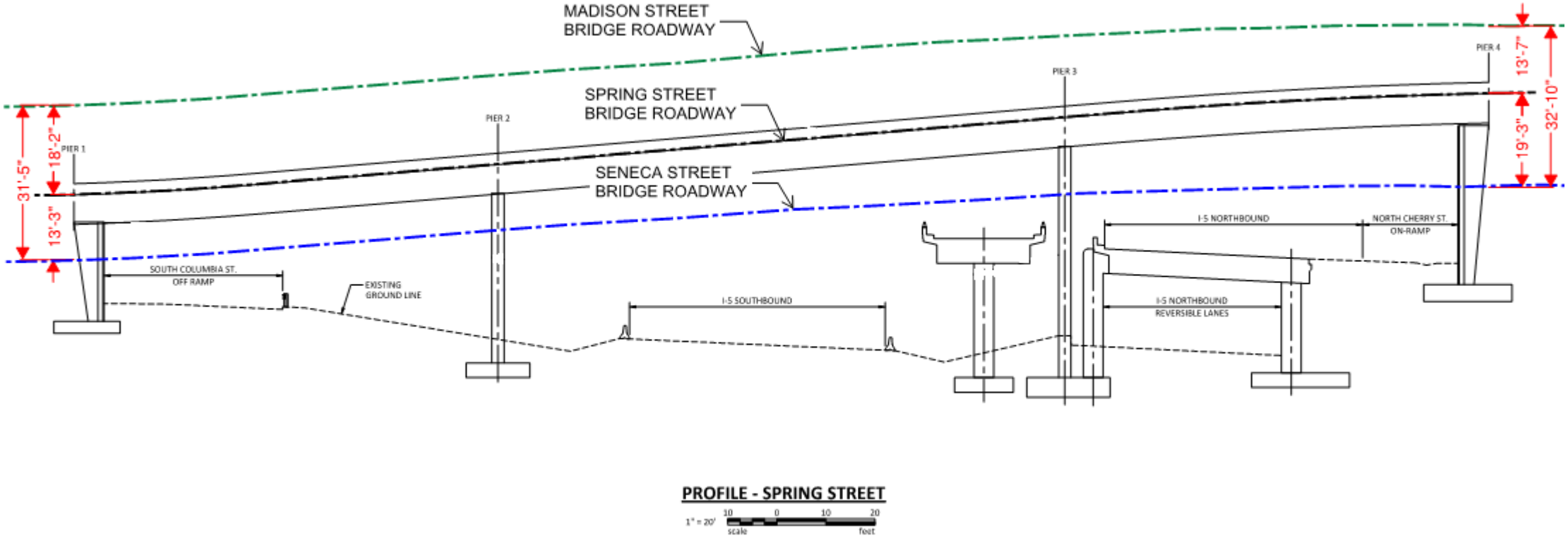




WSDOT Design Manual M22-01.16 720.03(5)(b)(1): **16.5-ft minimum clearance** for new bridge structures.

Site Overview - Grade Variation

Nothing is flat - generally sloping down to the west and fluctuating north/south



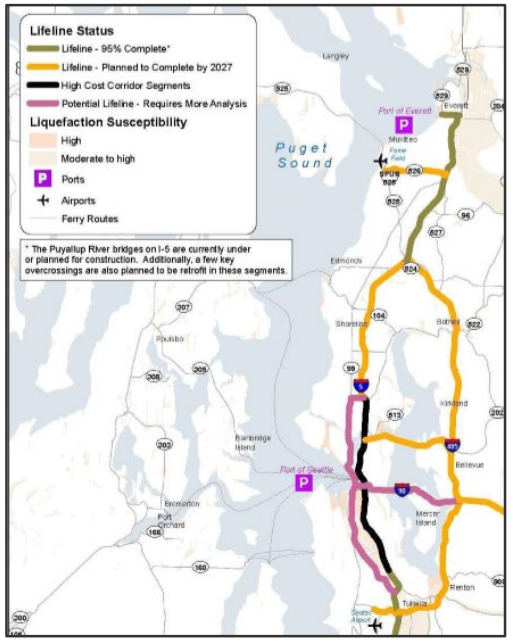
Other Lid Examples - Grade Variation

I-5 presents greater complexity and impacts in terms of connectivity and access to the lid area

E.g. Klyde Warren Park, Dallas (TX) over TX 366 downtown Dallas

Project Technical Assumptions

- The LFS will not make any decisions about the future of the I-5 corridor
- Projects constructed by April 2019 are included in the feasibility assessment, projects in planning are not considered to be built
- Existing structures are not being assessed for deficiencies; PSRC 2018 State Facilities Action Plan is the basis for the I-5 asset analysis
- Existing bridges, ramps, walls, or other structures (excluding buildings and tunnels) within the SAB can be removed, modified or replaced, for the purpose of the analysis
    - Removal of ramps (w/o replacement) would require additional analysis, beyond this study, to address potential implications
    - Removal of existing buildings is not permissible
- Geometrical layouts are conceptual and solely for the purpose of exploring the opportunities, constraints, and technical questions that will need to be examined in more detail if there are additional studies to lid I-5. This feasibility study is being conducted in collaboration with the asset owners and will not predetermine the use or function of public assets.



Project Technical Assumptions

- The study will only assess structural modifications to the existing lids at Freeway Park and the Convention Center necessary for potential edge integration with a future lid
- The existing capacity of I-5 will not be reduced
- Permanent I-5 lane configuration modifications may be considered
  - Creates space for lid structure intermediate piers
  - May create island between on/off ramp and mainline lanes or between HOV and mainline lanes
- Temporary I-5 Impacts may be permissible
  - Long duration lane closures; construct piers in the median of I-5
  - Short duration multiple lane closures; demolition of overpasses and off ramps

Project Technical Assumptions

- Deliverables – preliminary in nature and for scoping level purposes only.
- Costs can be developed without performing construction engineering or studying potential modifications to I-5 (based on sound engineering judgement and regional project experience)
- Four loading levels:
  - Open space – landscaping and pavilions (up to 3 stories)
  - Low-rise Residential – 7 story (5 over 2) structures
  - Mid-rise Residential/Commercial – 15 to 20 story structures
  - High-rise Residential/Commercial – 45 story structures
- No new subsurface explorations will be performed.
- Existing road network has adequate capacity to support the proposed lid development.
- Existing utility (i.e. storm drain, sanitary sewer, water, electrical, etc.) systems have adequate capacity to support the proposed lid development

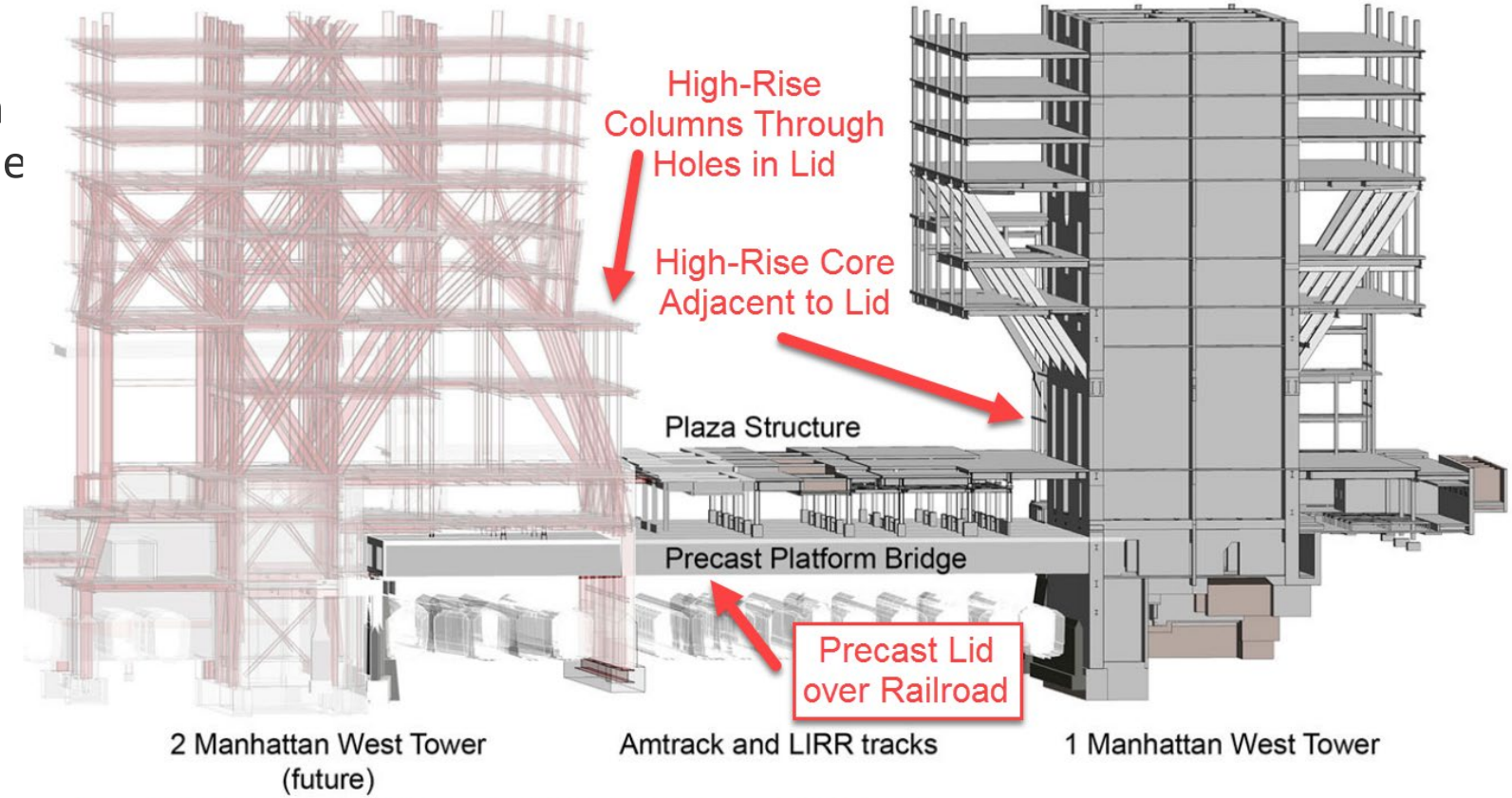
Project Technical Assumptions

- Existing utility infrastructure challenges and opportunities that have been identified by utility purveyors have been disclosed to team
- EIS may be required to complete the SEPA and NEPA process
  - Complexity of the project and dense urban context may generate significant environmental impacts and/or a high level of controversy.
- Lid sub-areas will require:
  - Lighting
  - Emergency Ventilation System
  - Fixed Fire Fighting System
  - Structure Fire Durability Protection
  - Power and Controls: for lighting and emergency ventilation systems
    - Climate controlled room to house switchgear, switchboards, and related appurtenances
    - Emergency Generator

Project Assumptions

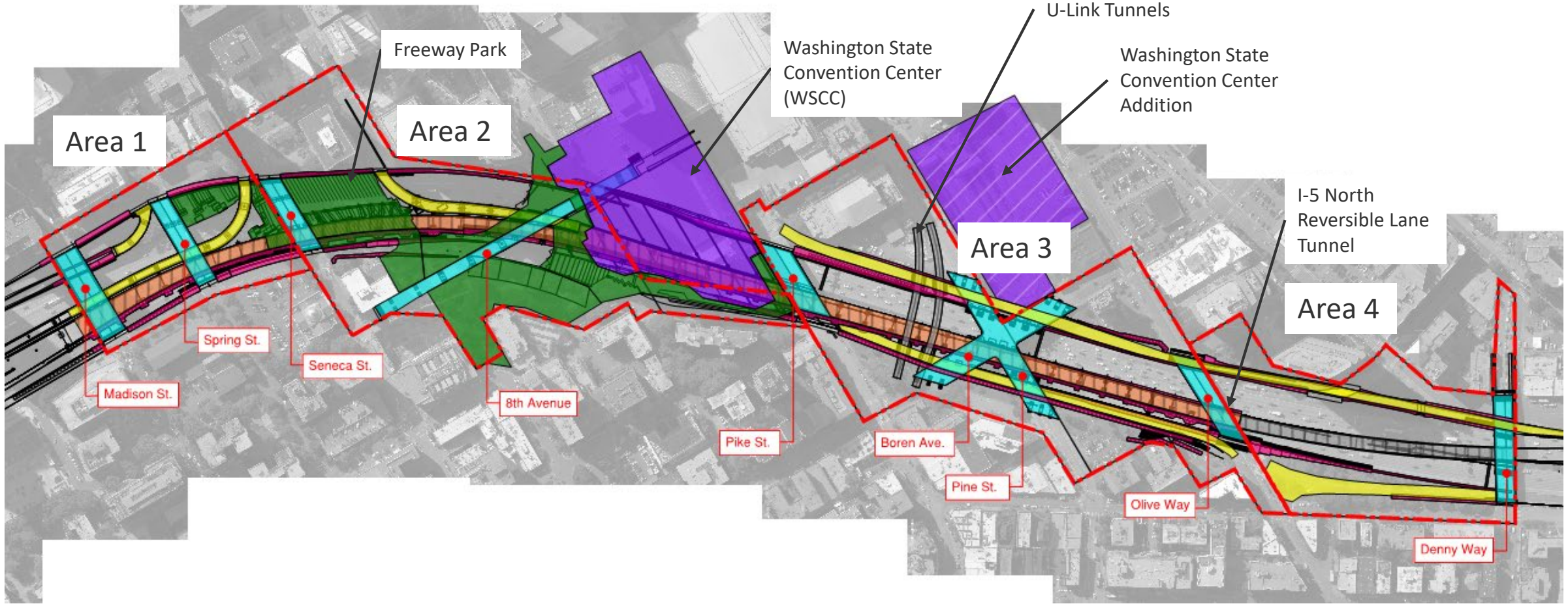
- For high-rise load level, only locations where a structure can be conventionally framed will be considered.

EXAMPLE: 1 & 2 Manhattan West Over 240 ft Span Lid

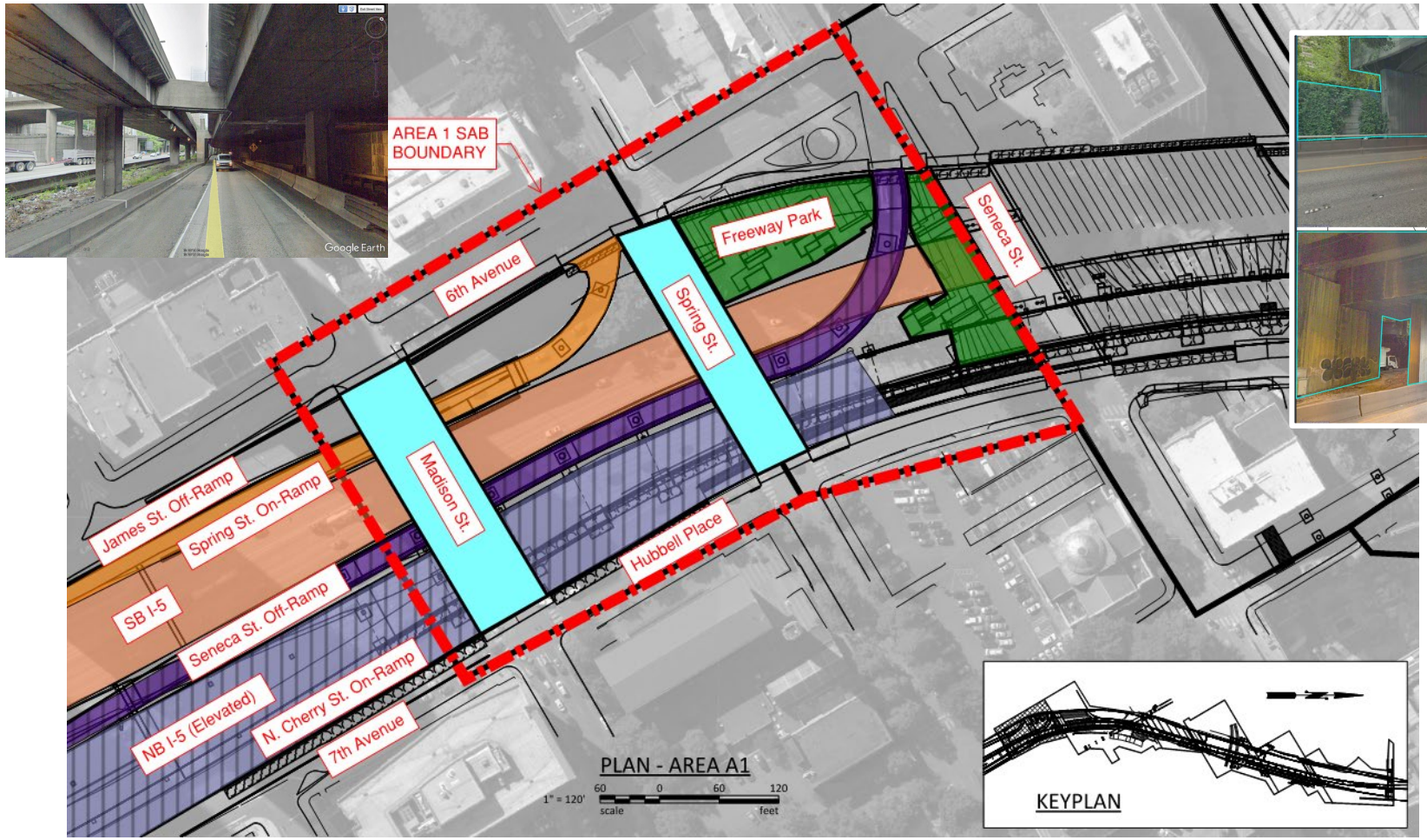


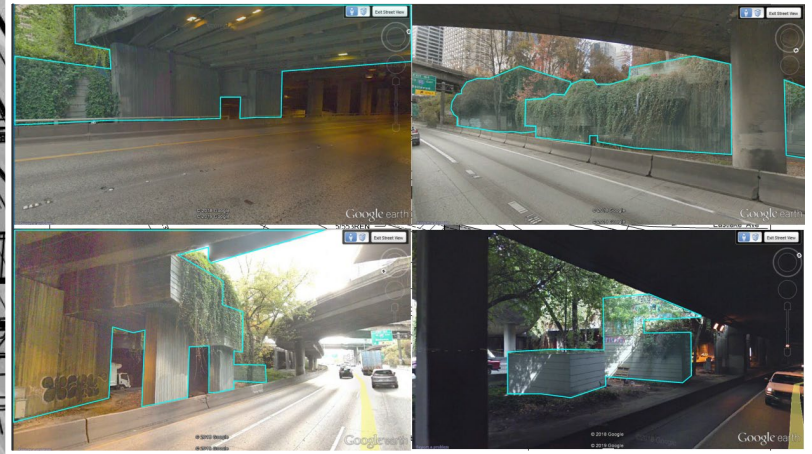
Georgi I. Petrov, Preetam Biswas, Ronald B. Johnson, Aurelie Seblani & Charles Besjak (2018): Supertall Over the Train Tracks - One Manhattan West Tower, Structural Engineering International, DOI: 10.1080/10168664.2018.1516125

Lid Sub-area Development



Lid Sub-area Development - Area 1

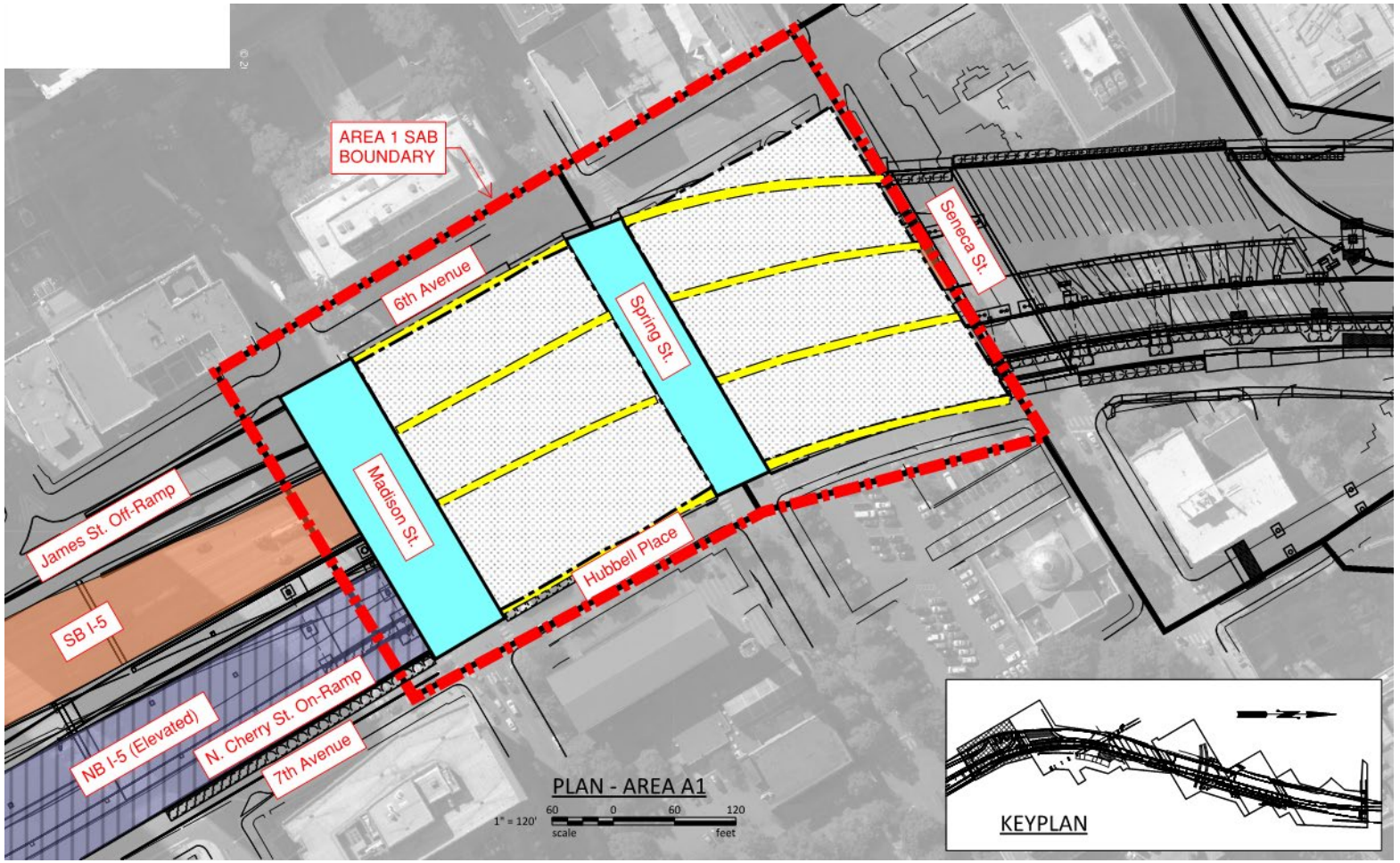




Lid Sub-area Development - Area 1

- Freeway Park is eligible and has been nominated to be included in the National Register of Historic Places

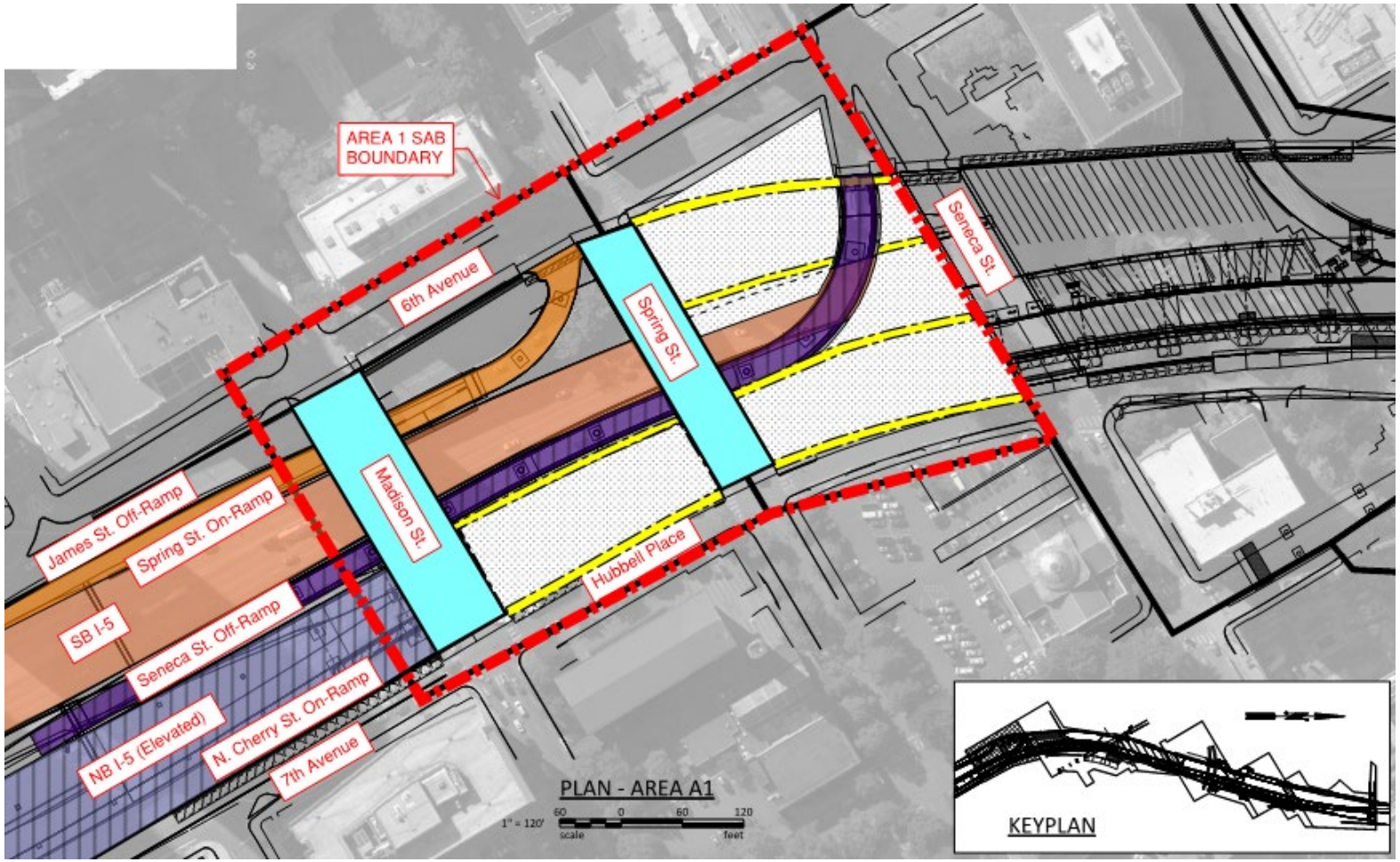
Lid Sub-area Development - Area 1



Span	Length (feet)
Over James St. Exit	80 - 90
Over SB I-5	80 - 90
Over NB I-5	90 - 120

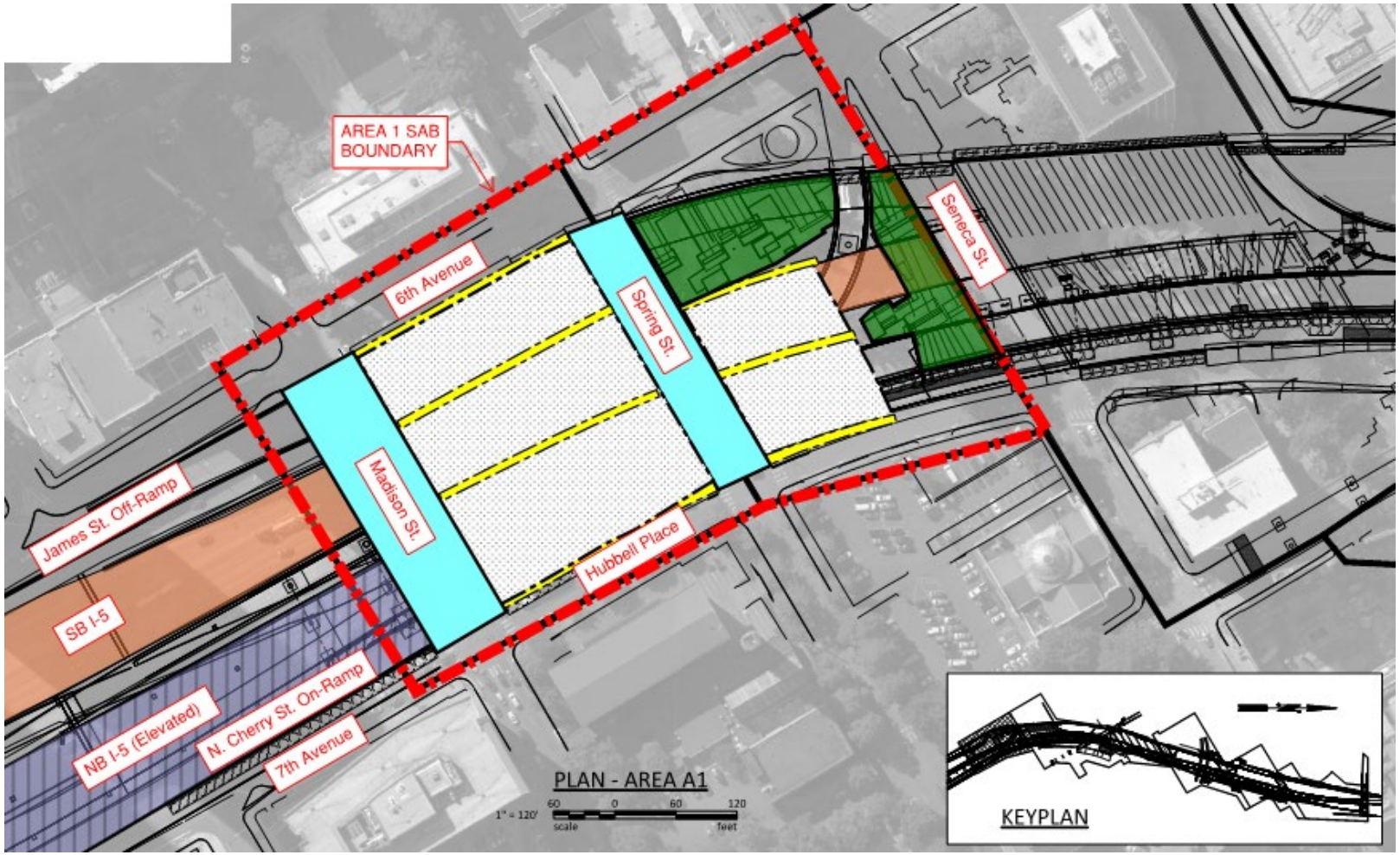
- Considerations:
  - Demolition of Freeway Park Box Gardens & South Edging
  - Demolition of Ramps
  - Modification of Existing Walls
  - Temporary I-5 Traffic Impacts
- Benefits:
  - Maximized Lid Area
  - Simplified intersections with potential road safety benefits

Lid Sub-area Development - Area 1



- Considerations:
  - Partial Demolition of Freeway Park Box Gardens & South Edging
  - Modification of Existing Walls
  - Temporary I-5 Traffic Impacts
- Benefits:
  - No changes in I-5 asset configuration (ie. maintains existing ramps)
- Drawbacks:
  - Minimal and discontinuous lid area
  - Seneca St. off-ramp splits area
  - Complex intersections with potential road safety impacts remain

Lid Sub-area Development - Area 1



Considerations:

- No Demolition of Freeway Park Box Gardens & South Edging
- Demolition of Ramps
- Modification of Existing Walls
- Temporary I-5 Traffic Impacts

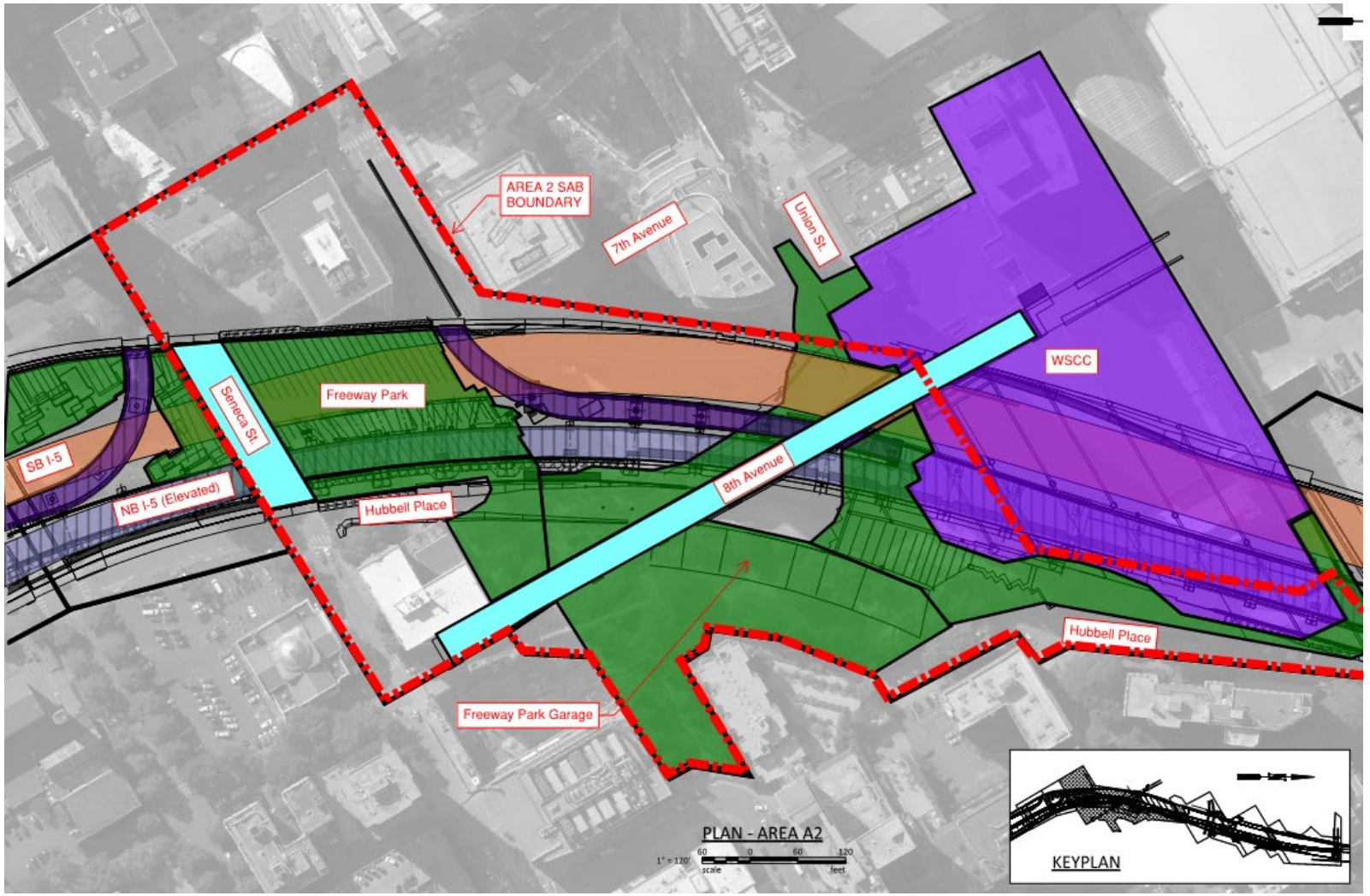
Benefits:

- Does not touch Freeway Park Box Gardens & South Edging

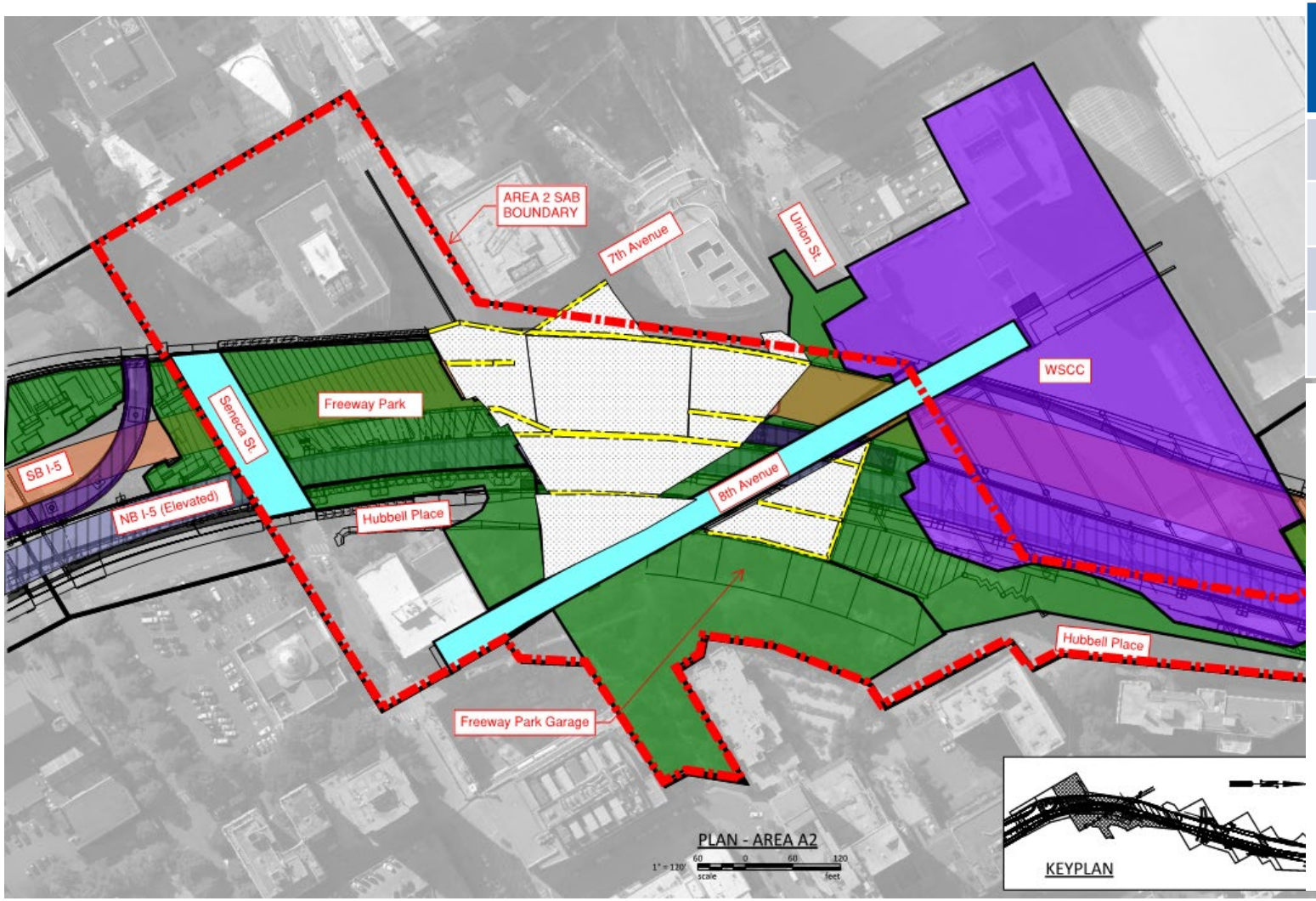
Drawbacks:

- Does not maximize lid area
- Constrained construction methods and staging of equipment

Lid Sub-area Development - Area 2



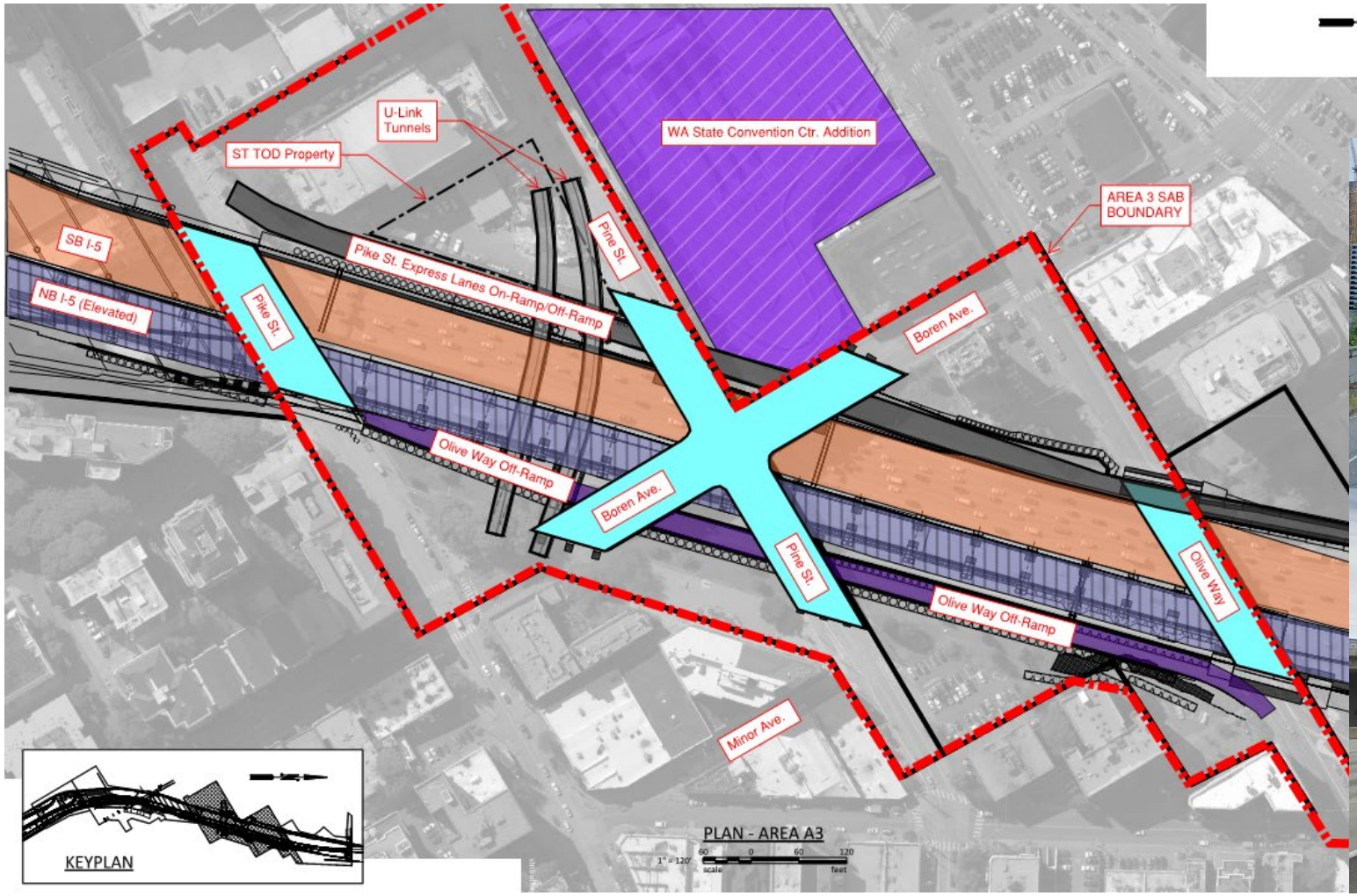
Lid Sub-area Development - Area 2



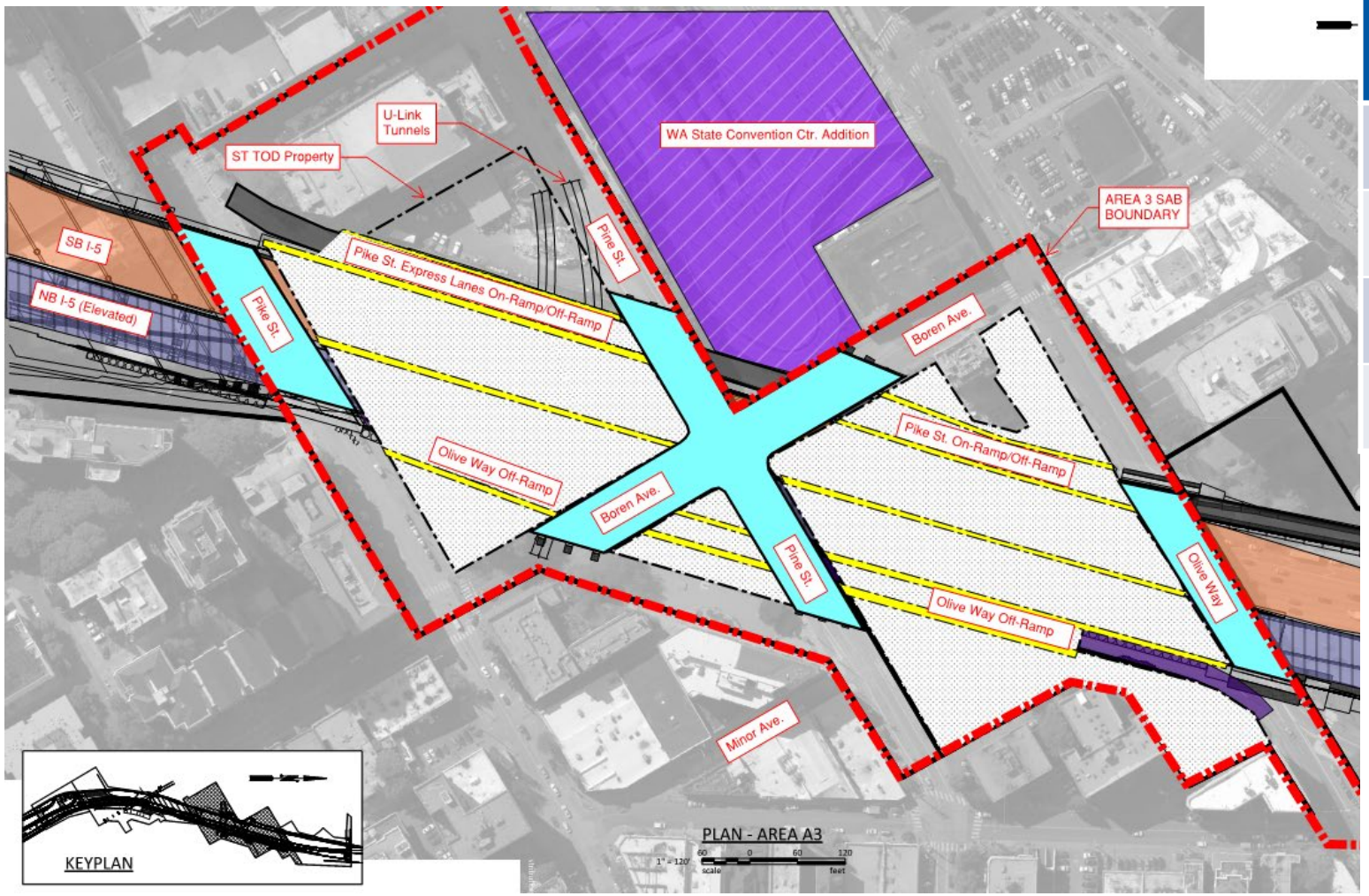
Span	Length (feet)
Over University	40 – 100
Over SB I-5	80 – 125
Over NB I-5	80 - 120
Over Hubbell	40 - 65

- Considerations:
  - Partial Demolition of Freeway Park Edges
  - Modification of Existing Walls
  - Temporary I-5 Traffic Impacts
  - Partial Demolition/Replacement of Overhangs
- Benefits:
  - Noise Reduction
  - Increases connections
  - Increases area for active uses on Freeway Park

Lid Sub-area Development - Area 3



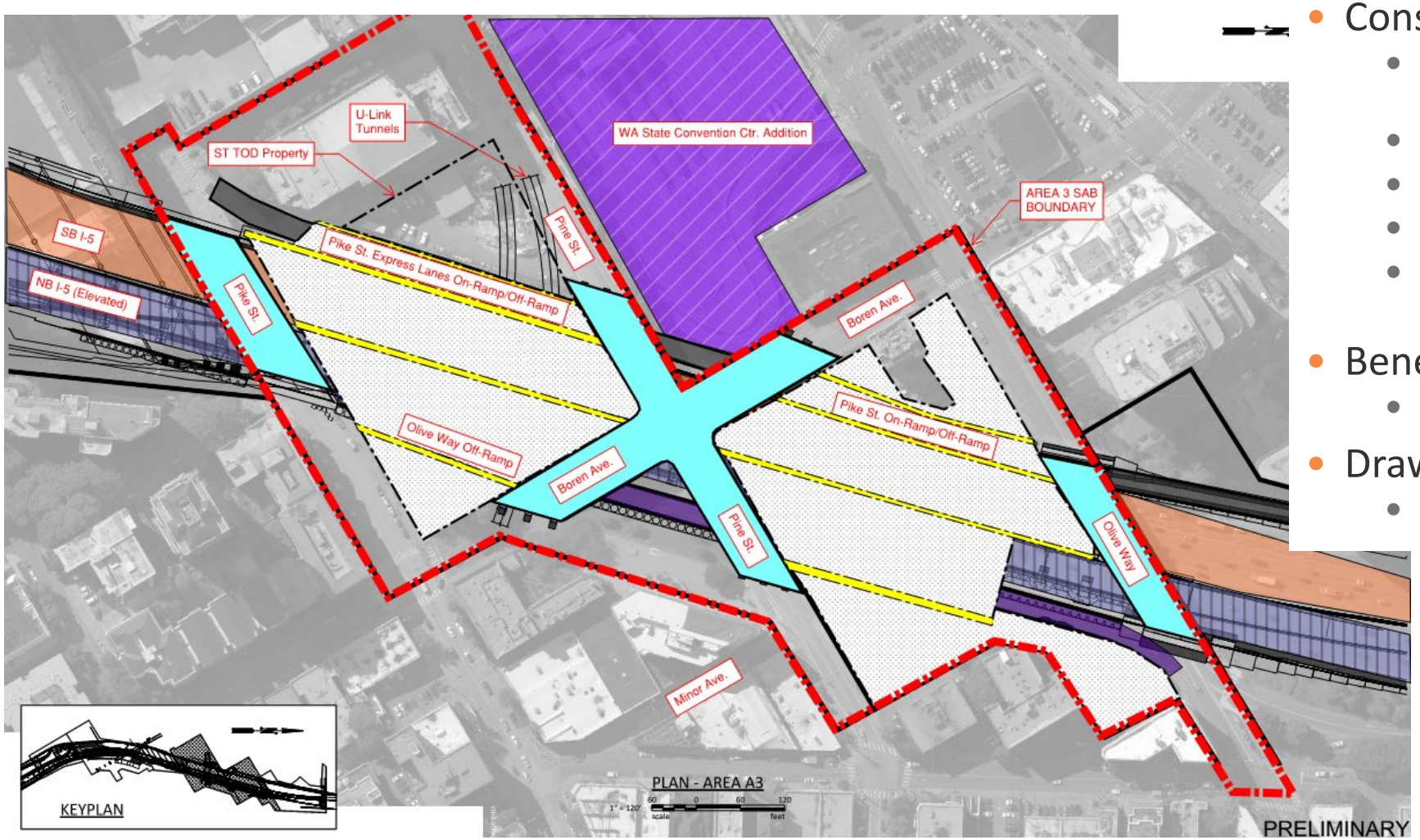
Lid Sub-area Development – Area 3



Span	Length (feet)
Pike St. Express Lanes Ramp	50 - 60
Over SB I-5	95 - 145
Over NB I-5	75 - 130
Olive Way Off-Ramp	50 - 70

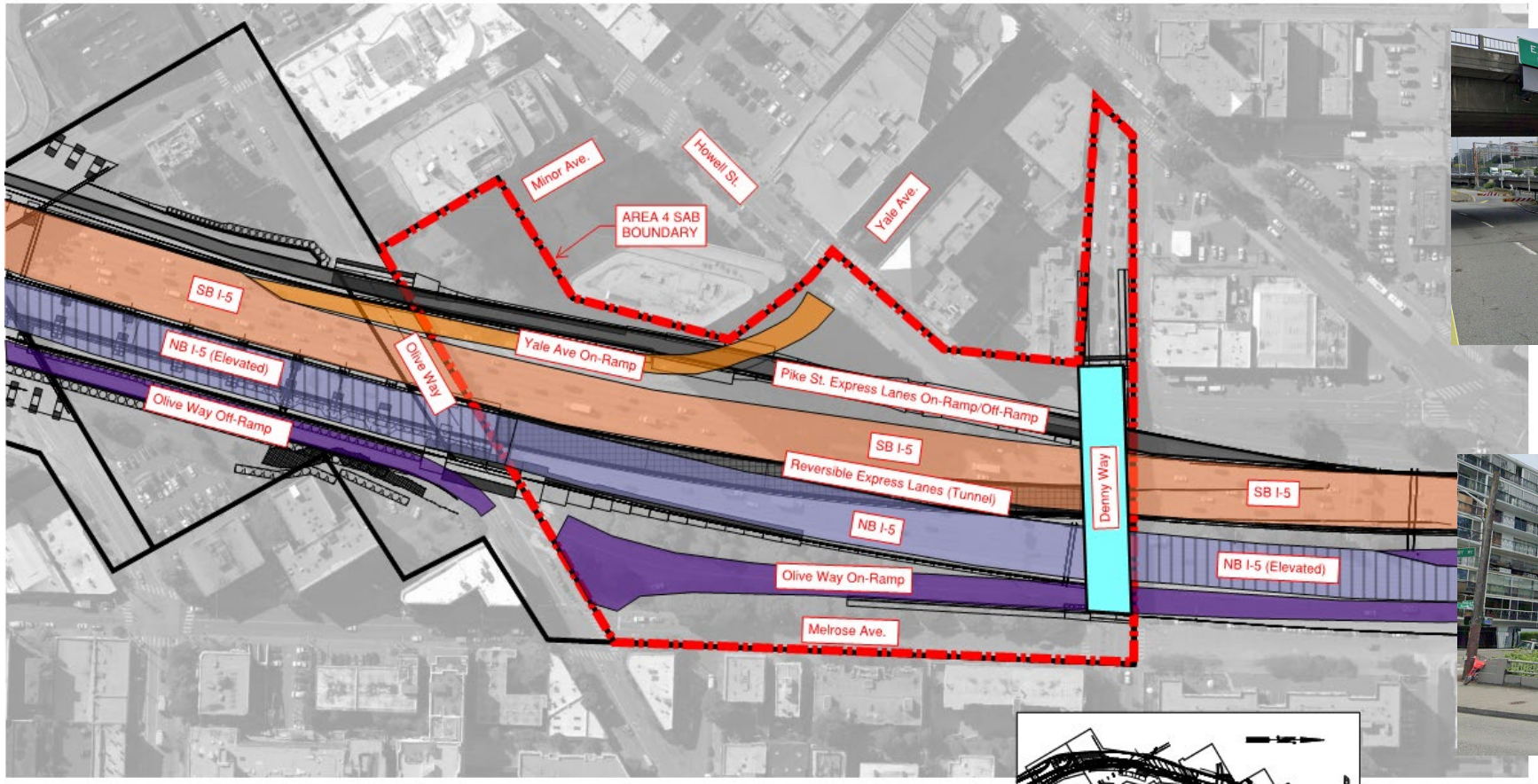
- Considerations:
  - Partial Demolition/Replacement of Overhangs
  - Modification of Existing Walls
  - Temporary I-5 Traffic Impacts
  - Modification of Ramps
  - Permanent I-5 Lane Reconfiguration
- Benefits:
  - Maintains existing ramps

Lid Sub-area Development – Area 3



- Considerations:
  - Partial Demolition/Replacement of Overhangs
  - Modification of Existing Walls
  - Temporary I-5 Traffic Impacts
  - Temporary Ramp Impacts
  - Permanent I-5 Lane Reconfiguration
- Benefits:
  - Maintains existing ramps
- Drawbacks:
  - Minimal Lid Area

Lid Sub-area Development - Area 4

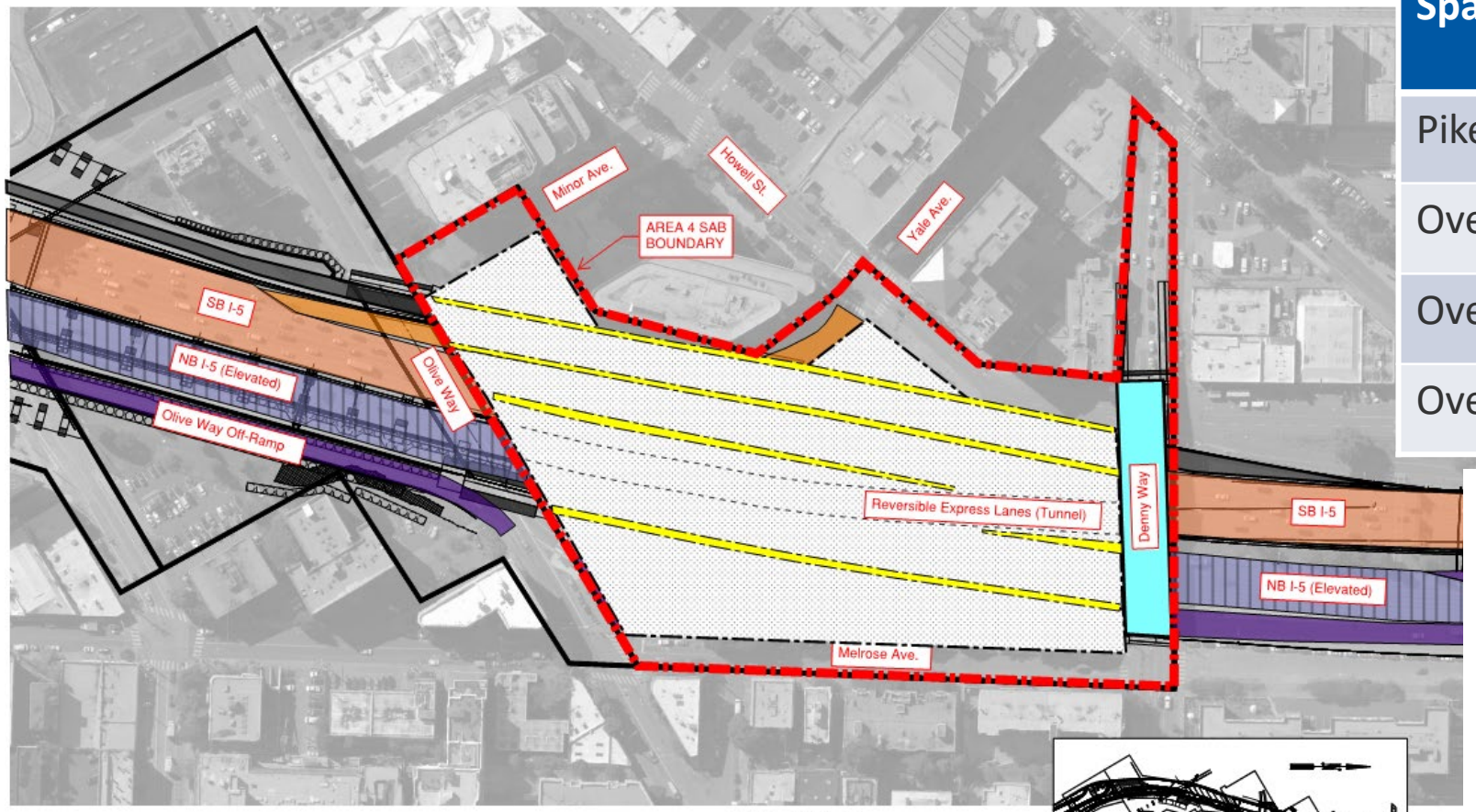


PLAN - AREA A4

1" = 120' 60 0 60 120 scale feet

PRELIMINARY

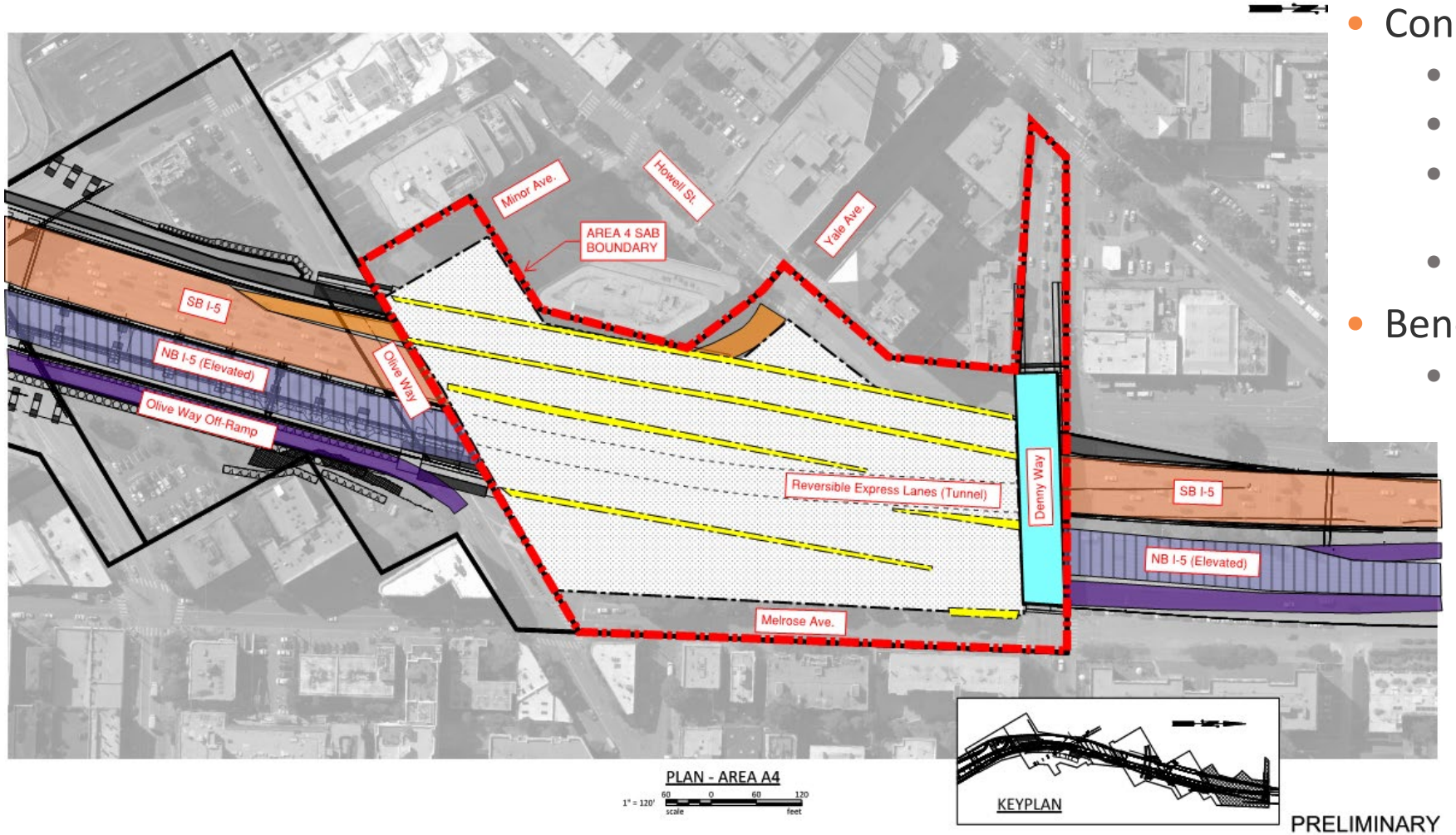
Lid Sub-area Development - Area 4



Span	Length (feet)
Pike St. Express Lanes Ramp	50 - 60
Over SB I-5	80 - 105
Over NB I-5	160 - 170
Over Olive Way On-Ramp	60 - 160

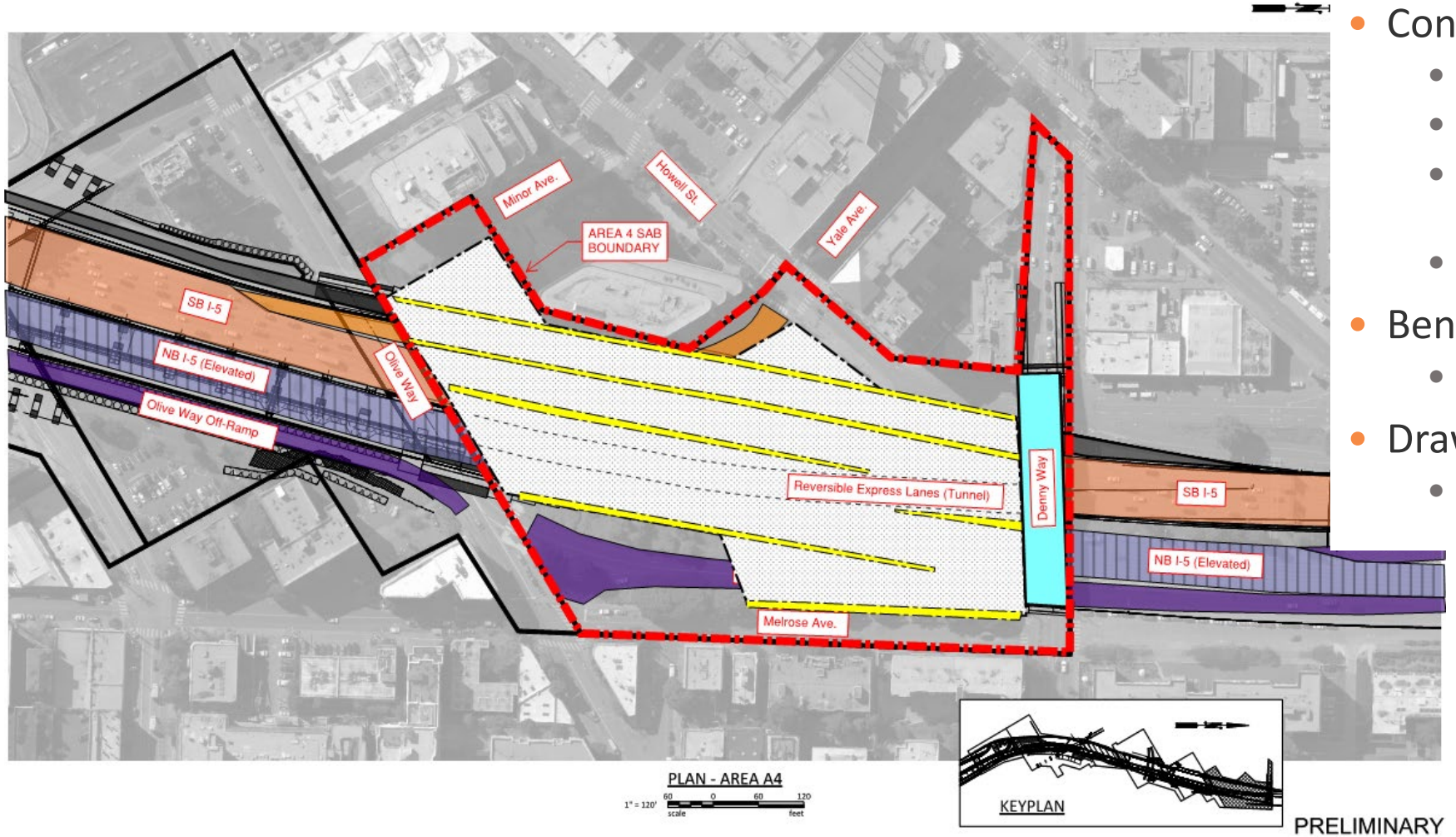
- Considerations:
  - Demolition of Ramps
  - Modification Existing Walls
  - Temporary I-5 Traffic Impacts
  - Permanent I-5 Lane Reconfiguration
  - Temporary Ramp Impacts

Lid Sub-area Development - Area 4



- Considerations:
  - Modification Existing Walls
  - Temporary I-5 Traffic Impacts
  - Permanent I-5 Lane Reconfiguration
  - Modification of Ramps
- Benefits:
  - Maintains existing ramps

Lid Sub-area Development - Area 4

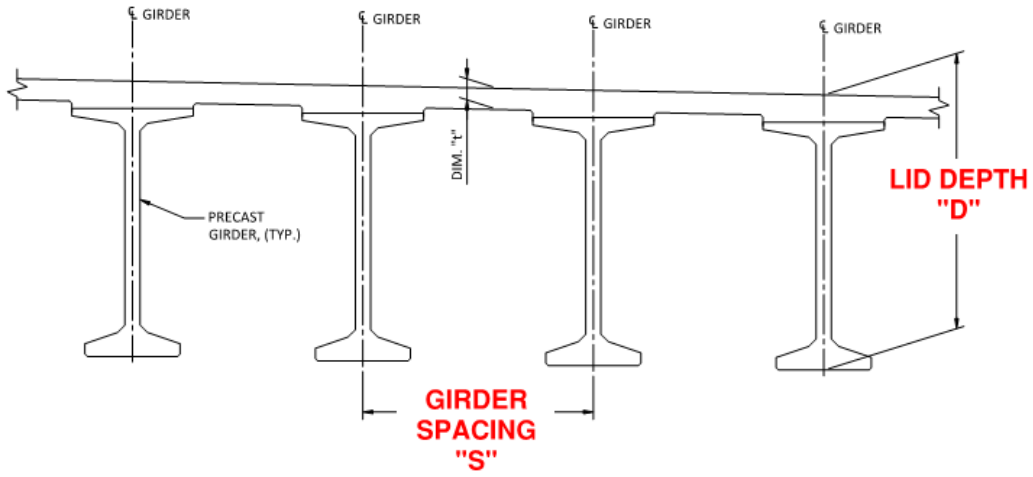


- Considerations:
  - Modification Existing Walls
  - Temporary I-5 Traffic Impacts
  - Permanent I-5 Lane Reconfiguration
  - Temporary Ramp Impacts
- Benefits:
  - Maintains existing ramps
- Drawbacks:
  - Minimum Lid Area

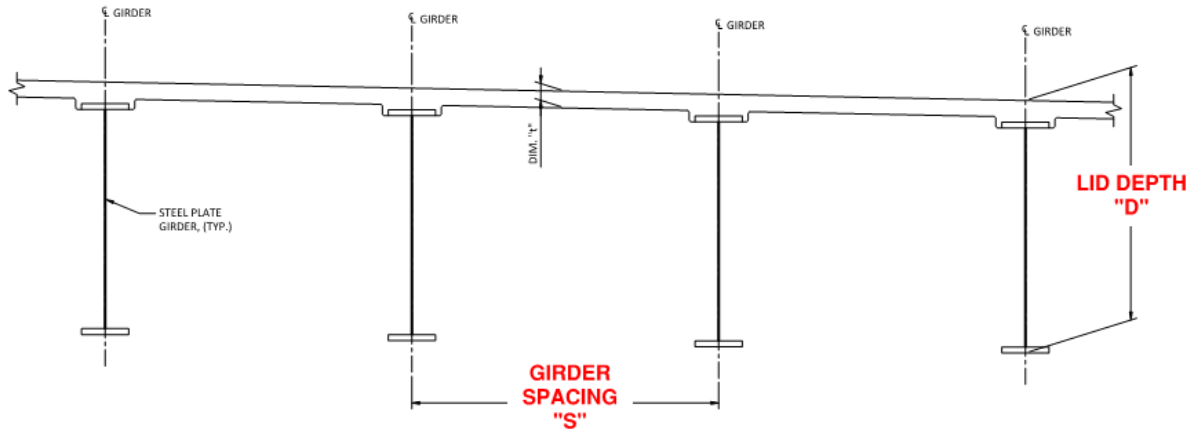
Lid Sub-area Development - Structural

Load Level	Dead Load (psf)	Live Load (psf)
Open space	1000	100 or 250
Low-rise	600	430
Medium-rise	2,650	1,150
High-rise	6,815	2,100

Lid Sub-area Development - Structural



Typical Section – Precast Girder



Typical Section – Steel Plate Girder

Lid Sub-area Development - Structural

Table: Precast Girder Span Lengths

Lid Depth "D" (feet)	Girder Spacing "S" (feet)	Load Level (--)	Max Span Length (feet)
4	5	Open space	75
		Low-rise	65
		Mid-rise	-
		High-rise	-
	12	Open space	55
		Low-rise	45
		Mid-rise	-
		High-rise	-
9.33	5	Open space	160
		Low-rise	130
		Mid-rise	-
		High-rise	-
	12	Open space	115
		Low-rise	85
		Mid-rise	-
		High-rise	-

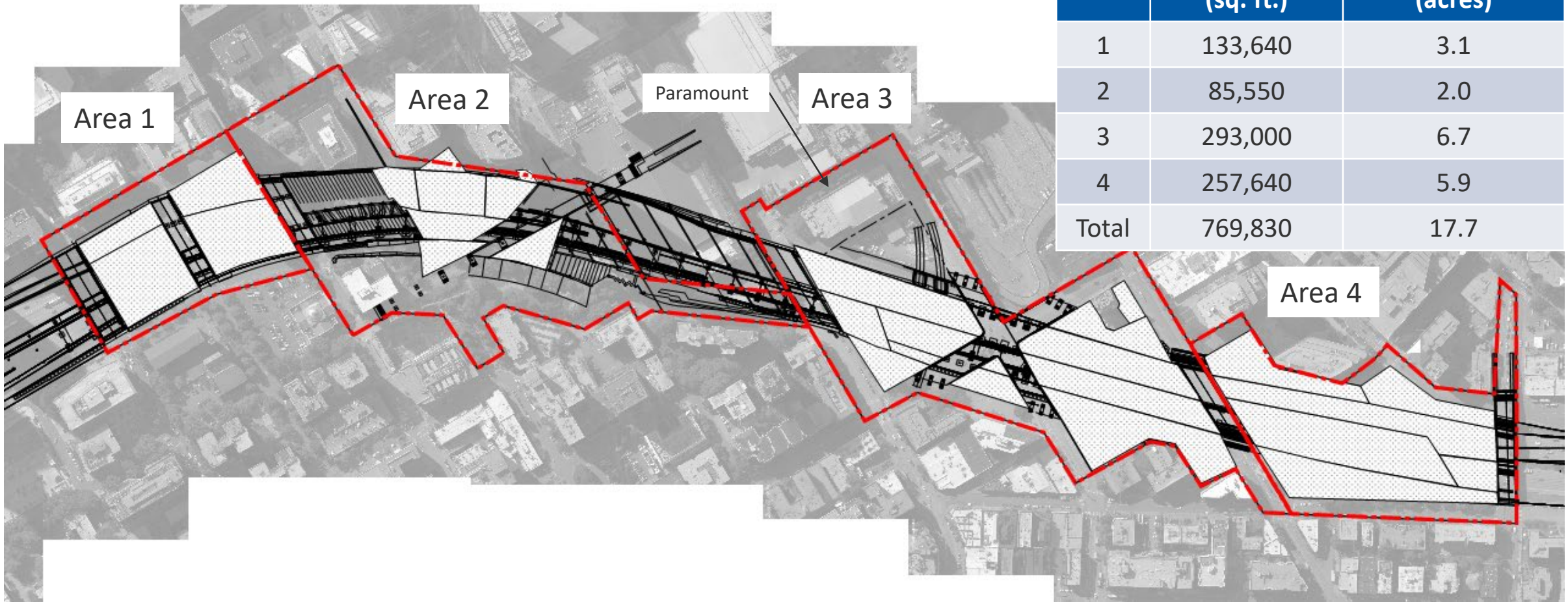
Table: Steel Plate Girder Span Lengths

Lid Depth "D" (feet)	Girder Spacing "S" (feet)	Load Level (--)	Max Span Length (feet)
4	5	Open space	88
		Low-rise	76
		Mid-rise	42
		High-rise	32
	12	Open space	55
		Low-rise	42
		Mid-rise	-
		High-rise	-
13	5	Open space	185
		Low-rise	168
		Mid-rise	120
		High-rise	105
	12	Open space	175
		Low-rise	152
		Mid-rise	104
		High-rise	82

Lid Sub-area Development - Structural

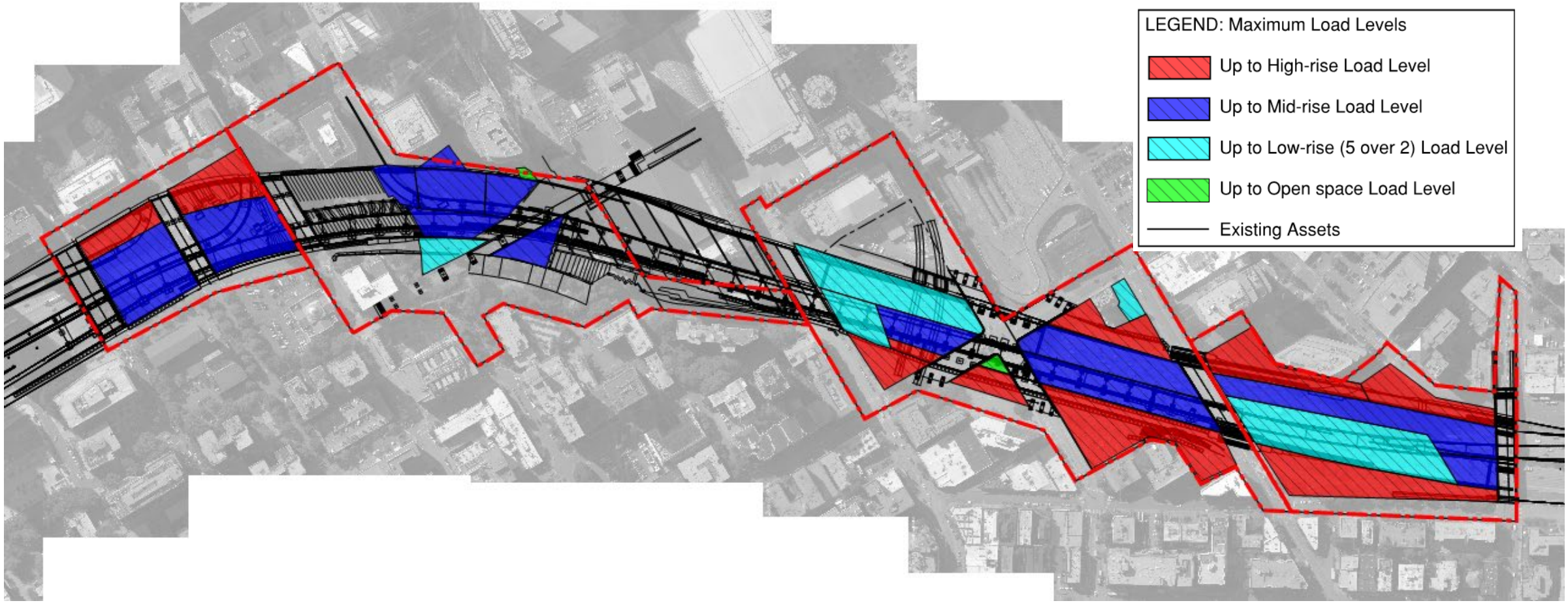
Total new potential lid area…

Area	Potential New Lid Area	
	(sq. ft.)	(acres)
1	133,640	3.1
2	85,550	2.0
3	293,000	6.7
4	257,640	5.9
Total	769,830	17.7



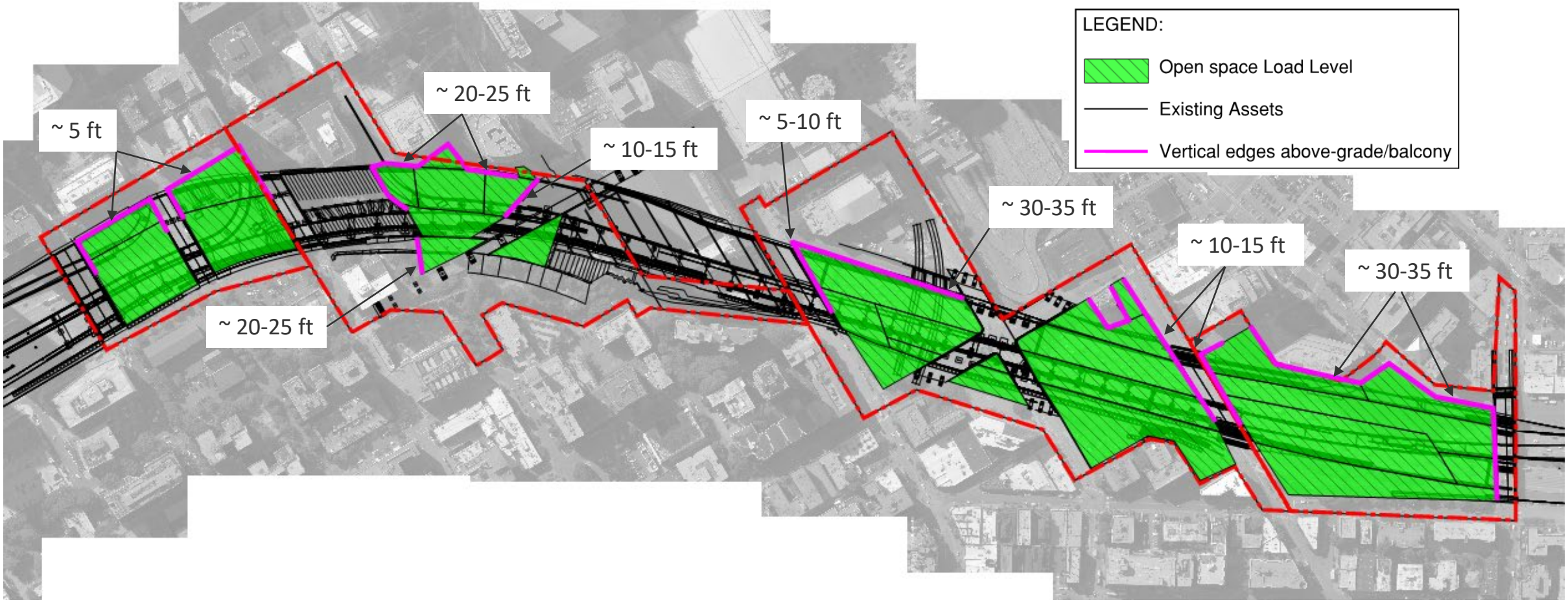
Lid Sub-area Development - Structural

Maximum load levels based on conventional girder framing and anticipated span arrangements…



Lid Sub-area Development - Structural

Maximum load levels do not preclude lid areas from being considered for open space use…

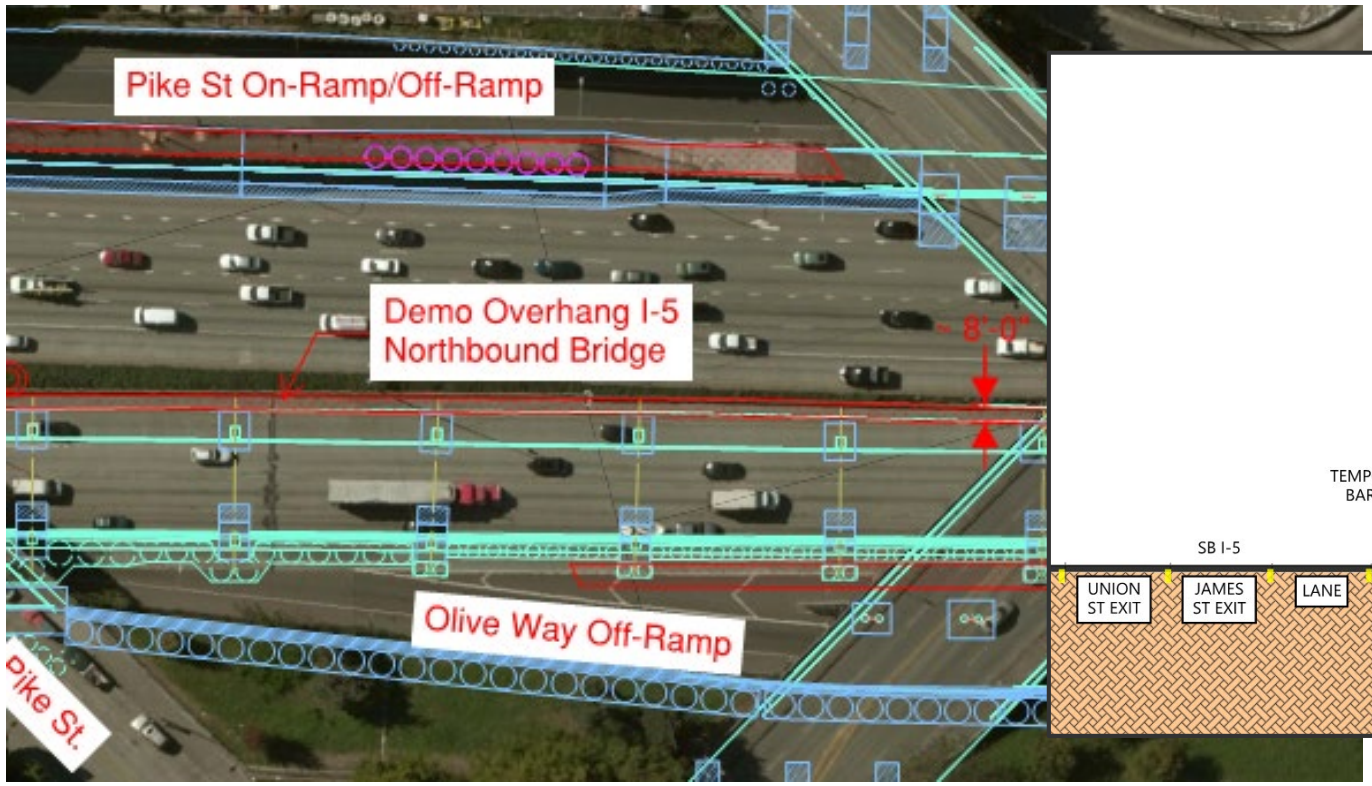


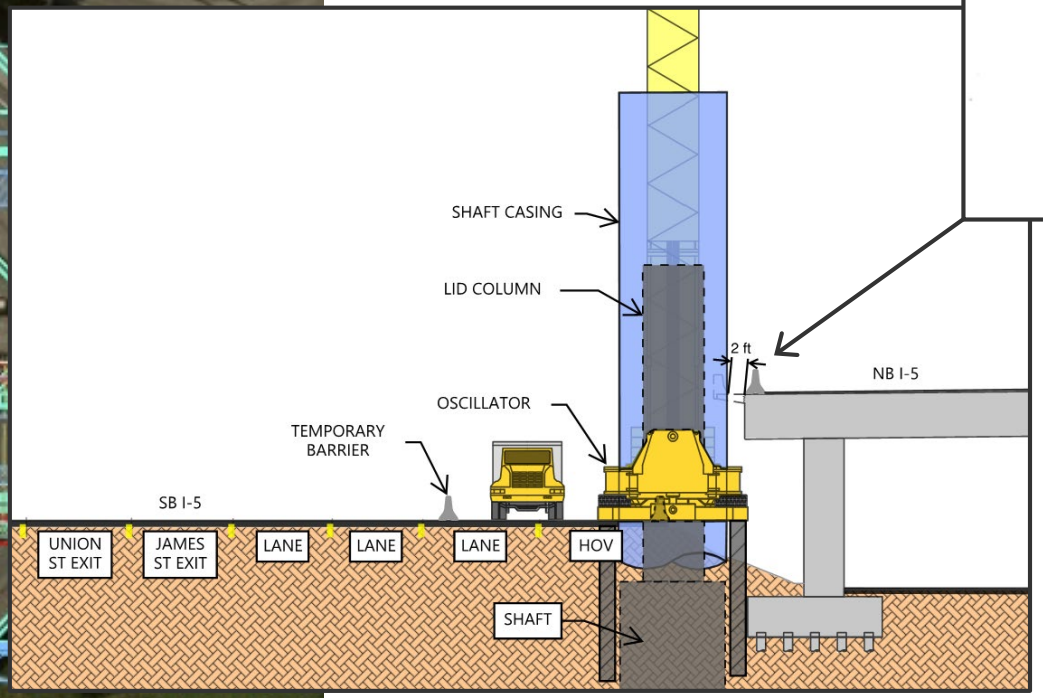
Considerations

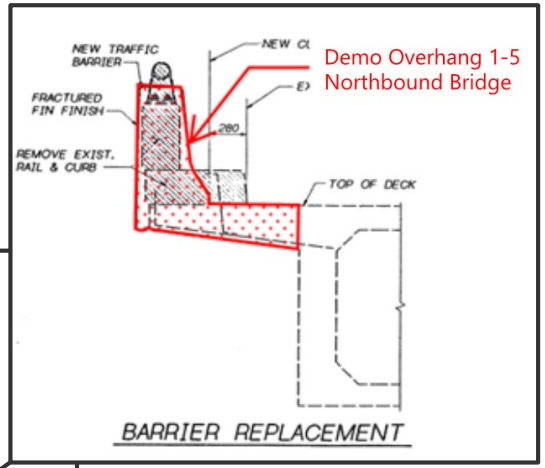
Consideration	Area 1	Area 2	Area 3	Area 4
Demolition/Replacement Elevated of I-5 Overhangs	X	X	X	
Demolition/Replacement of Overpasses	X		X	X
On/Off Ramp Modification	X		X	X
On/Off Ramp Removal	X		X	X
Wall Removal/Modifications	X	X	X	X
Freeway Park/WSCC Modifications	X	X		
I-5 Channelization Reconfiguration			X	X
Utilities	X	X	X	X

Consideration – Replace Elevated I-5 Overhangs

- **Mainline I-5**: May need to close the shoulder and some lanes along mainline I-5, and demolish and replace existing overhangs, in order to construct the intermediate pier.
  - Long stretches of I-5 (Largest impact on Southbound)
  - Will impact sign bridges and illumination too

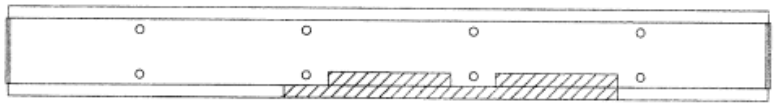


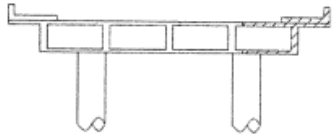




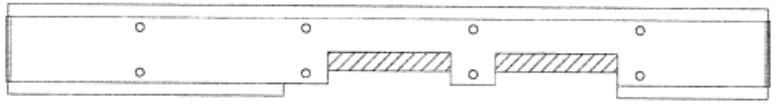
Consideration – Overpass Demolition/Replacement

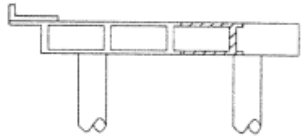
STEP 1



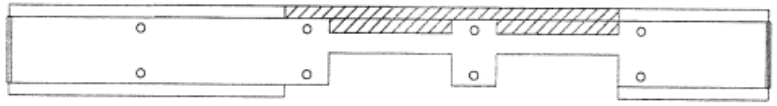


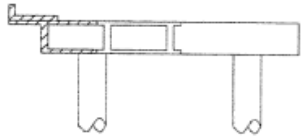
STEP 2



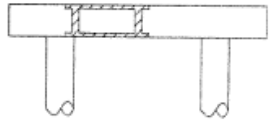


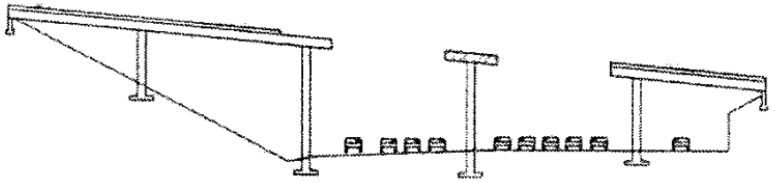
STEP 3



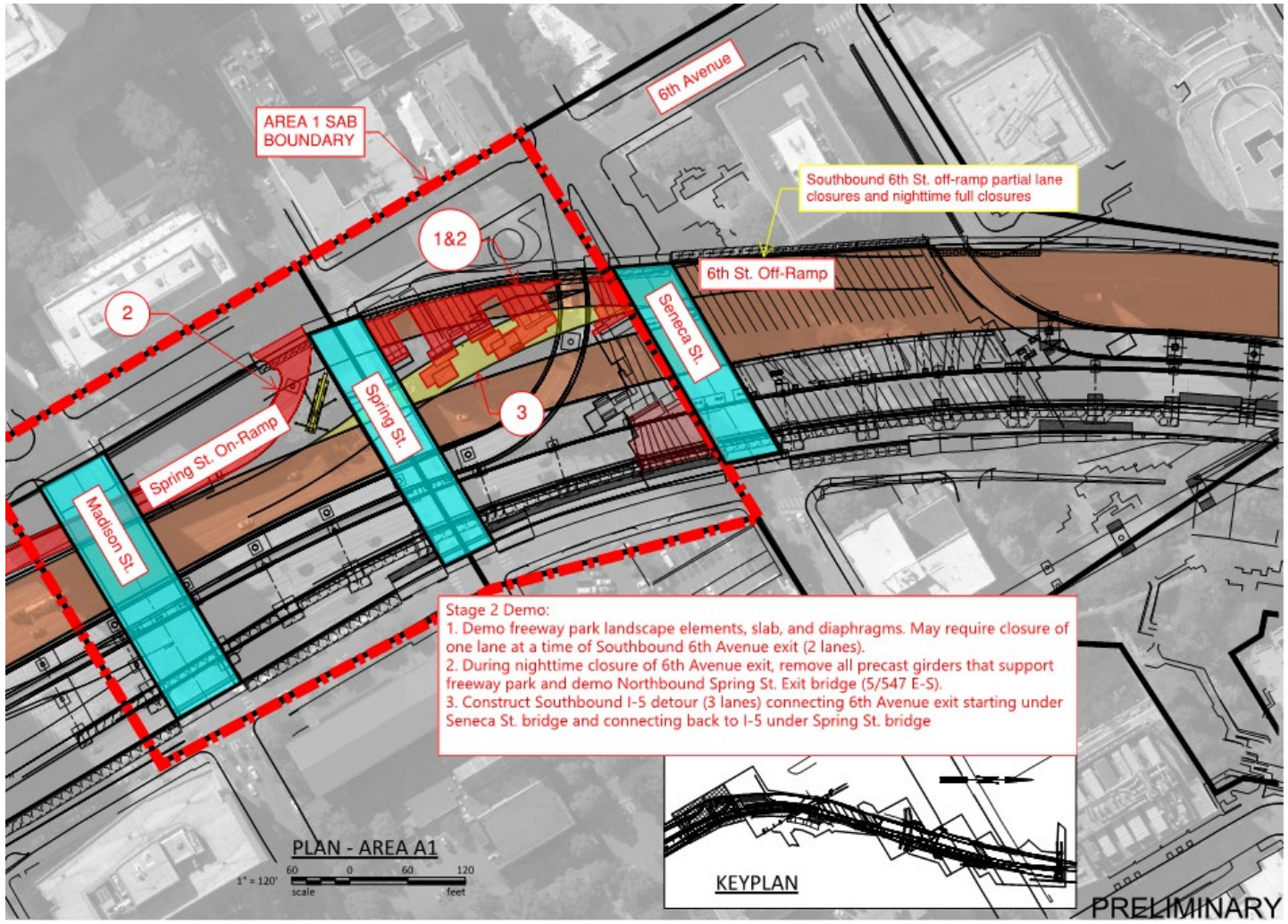


STEP 4



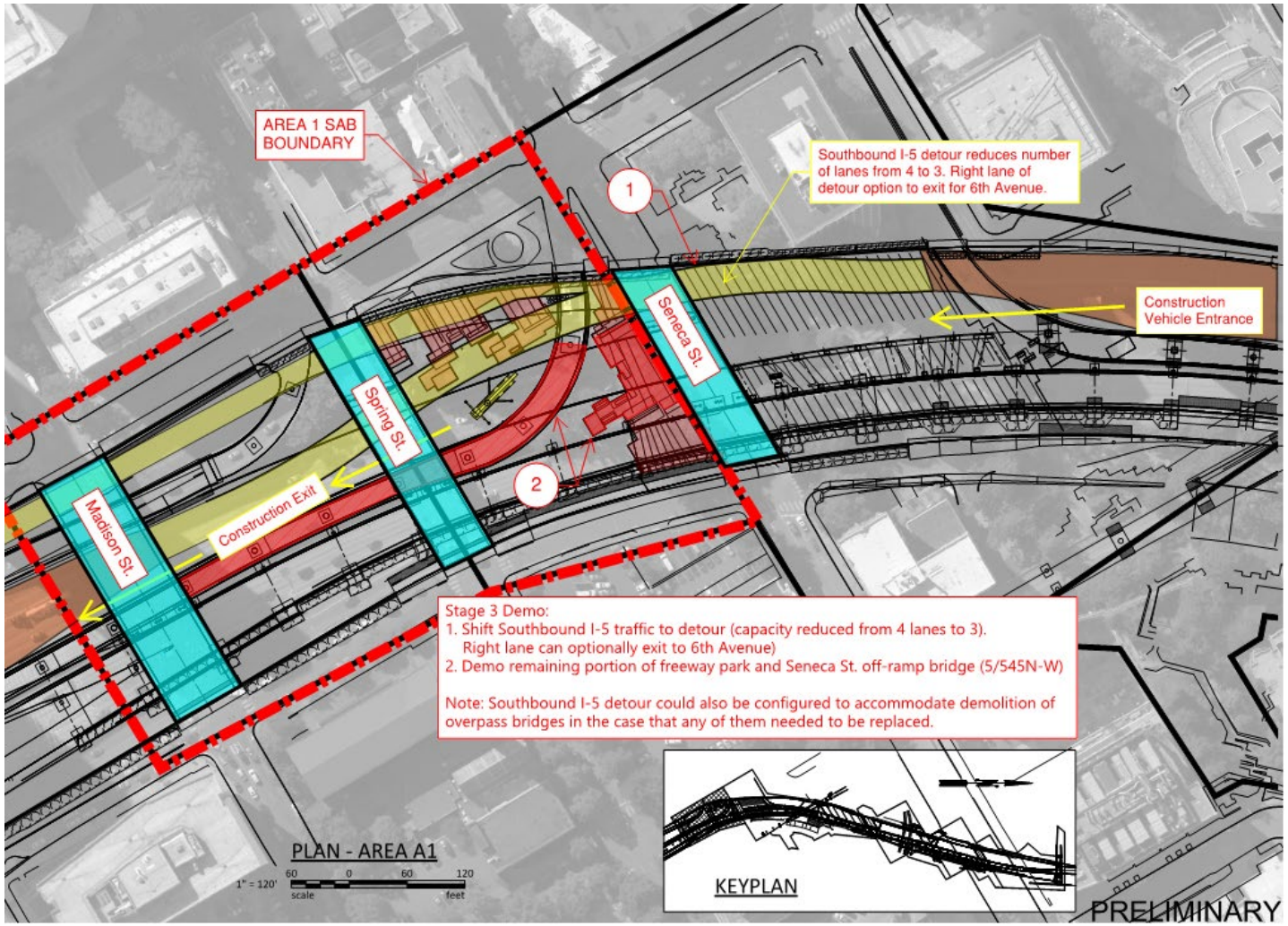


Consideration – On/Off Ramp Removal

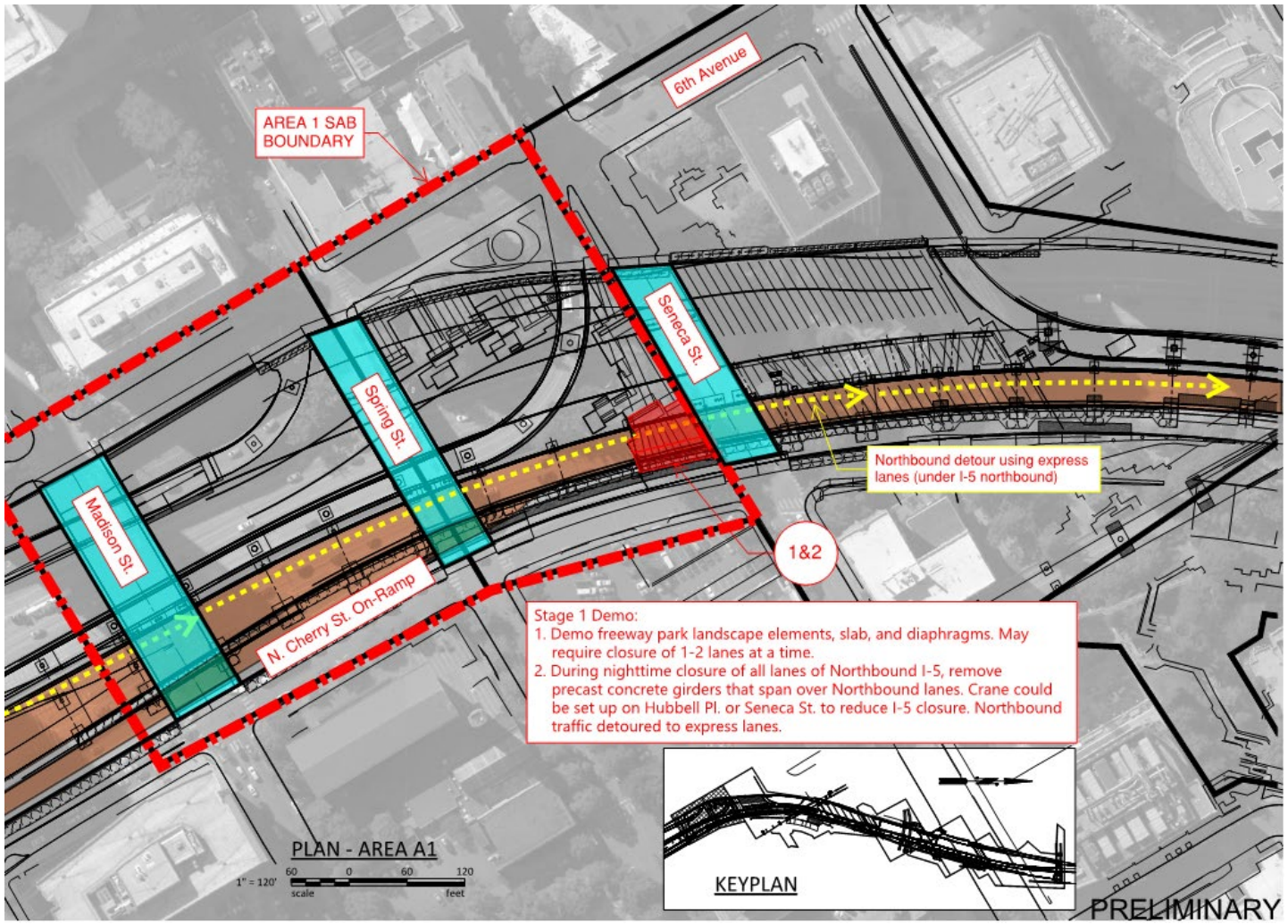


I-5 Lid Feasibility Study

Consideration – On/Off Ramp Removal

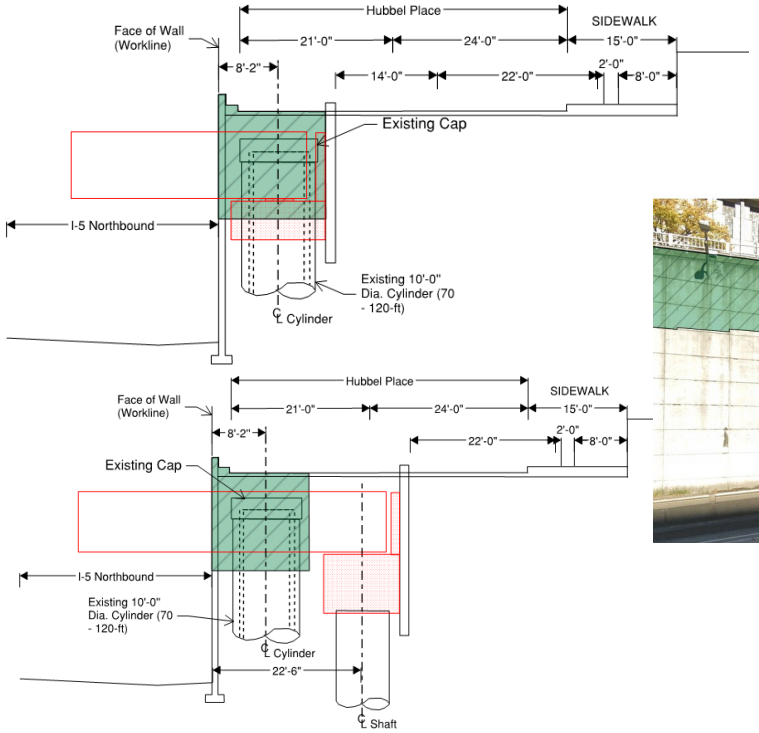


Consideration – On/Off Ramp Removal



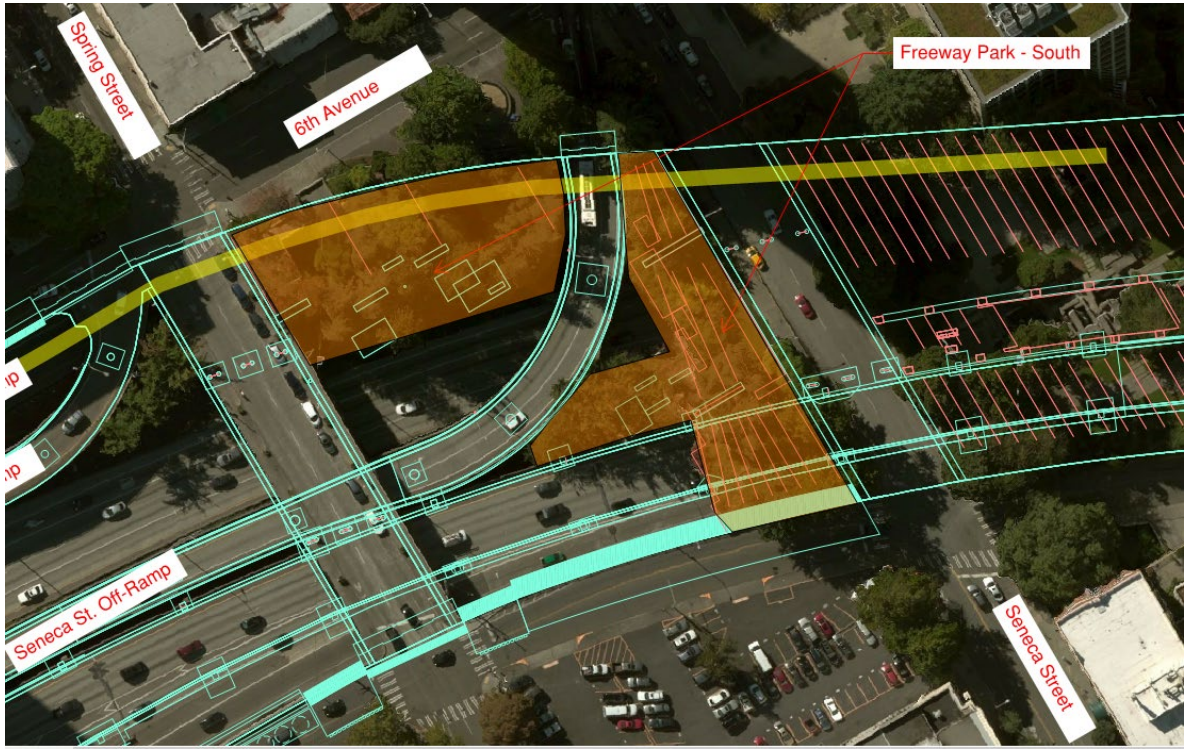
Consideration – Wall Removal/Modifications

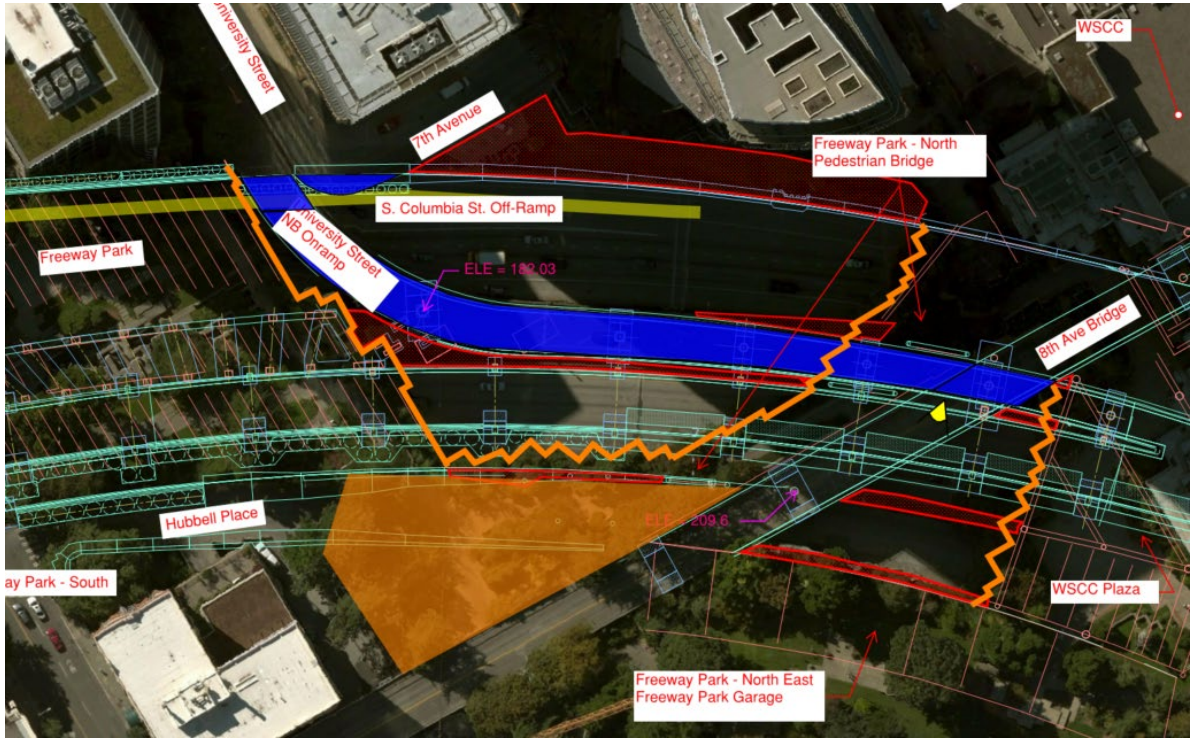
- **Existing Walls**: the abutments may need to be supported on driven piles or drilled shafts in order to not load the existing walls. This requires the abutments to be located behind the walls (within City streets)
  - Disruption to local City streets (traffic; utilities; businesses; residential; etc.) during construction



Consideration – Freeway Park/WSCC Modifications

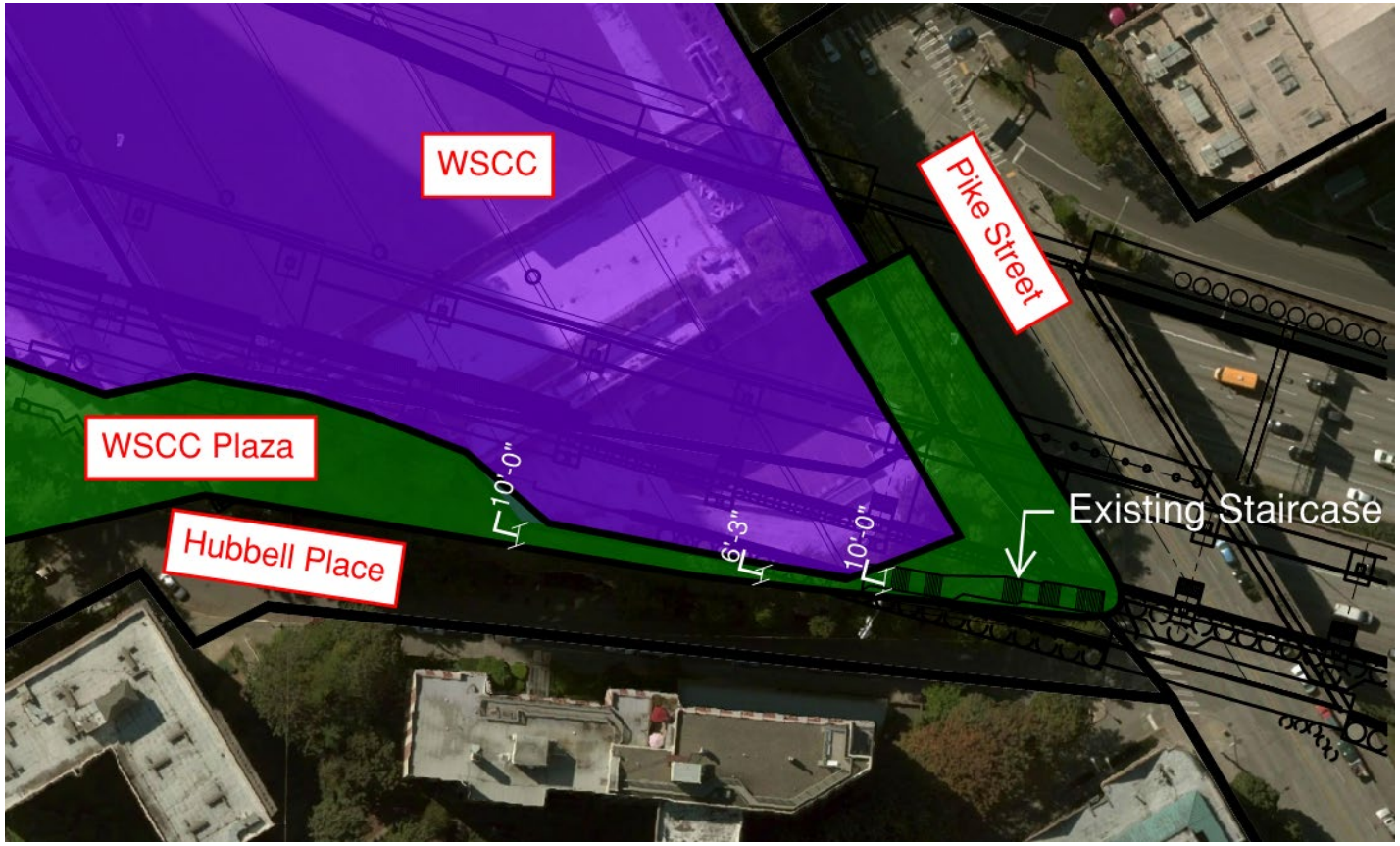
- Would require to demolish up to Seneca Street in order to cleanly frame between Seneca and Spring.
- Would require to demolish façade to form clean edges for sub-area 2
- Would require to demolish and reconstruct a portion of Freeway Park to tie in with 8th Avenue





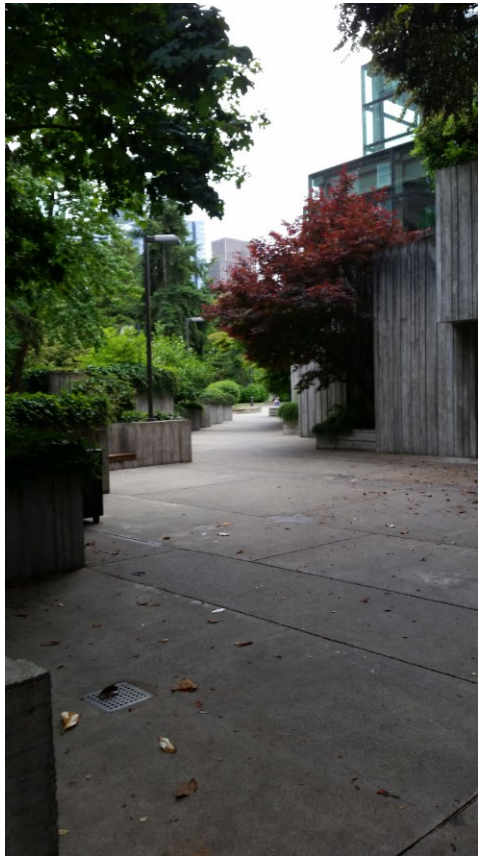
Consideration – Freeway Park/WSCC Modifications

- Existing N-S Walkway and Stair between WSCC Plaza and Pike – Varies from 6.25’ to 10’ wide



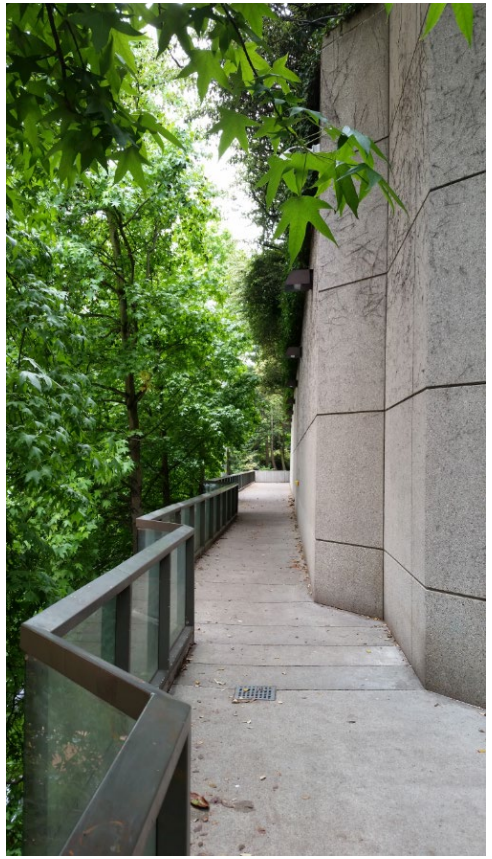
Consideration – Freeway Park/WSCC Modifications

- Existing N-S Pedestrian Route

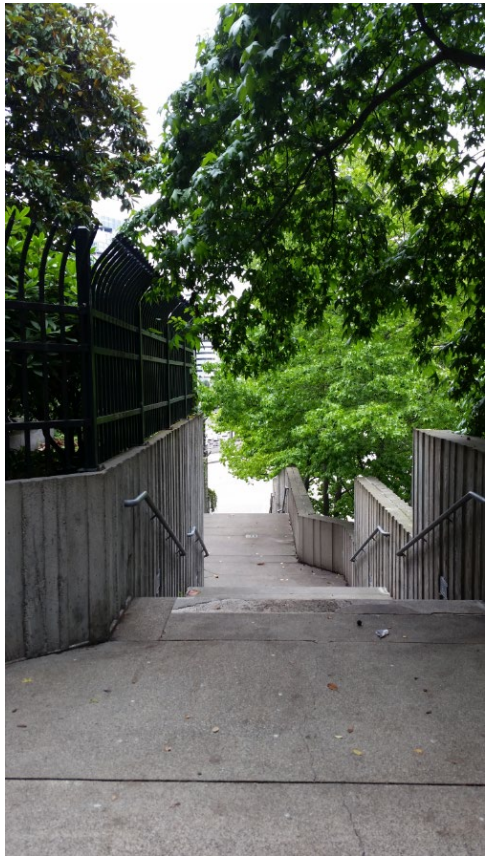


(Looking South)

(Looking South)



(Looking South)

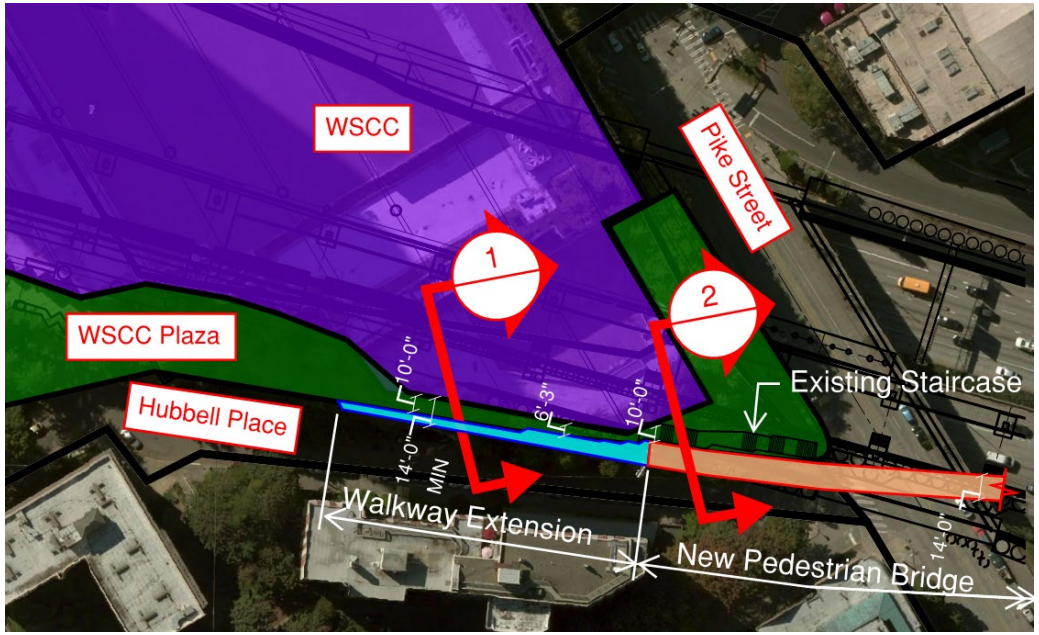


(Looking North at Pike)

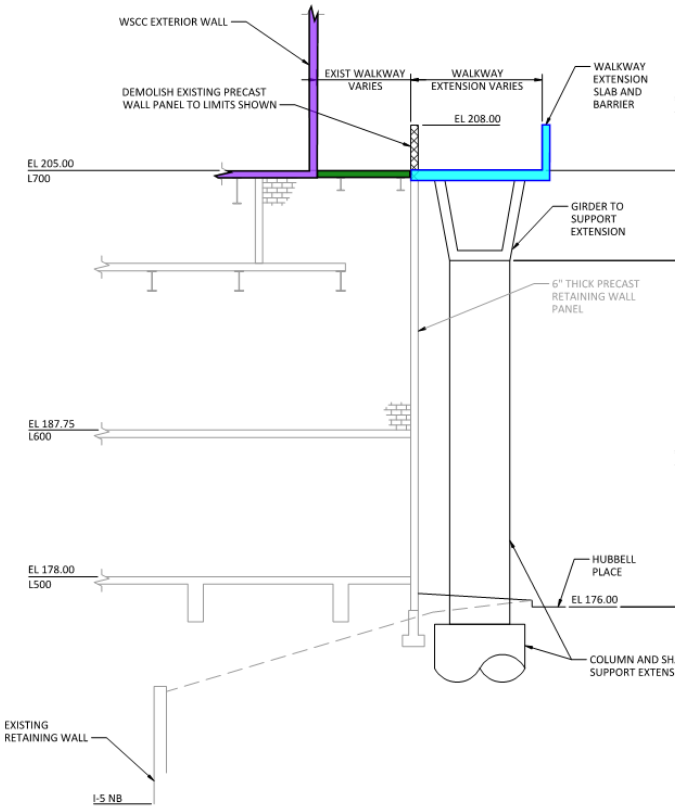
(Walking South)

Consideration - Freeway Park/WSCC Modifications

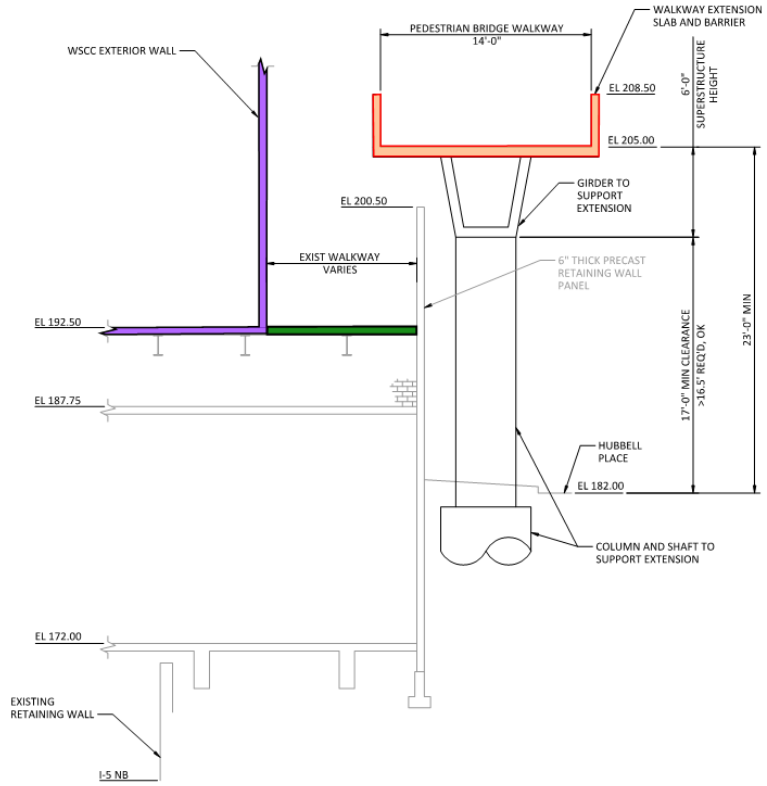
- Walkway Extension and Pedestrian Bridge Concept to provide N-S Pedestrian Route



- Considerations:
  - Removal of trees adjacent to retaining wall along Hubbell
  - Permanent lane configuration modification of Hubbell. May require removal of on-street parking

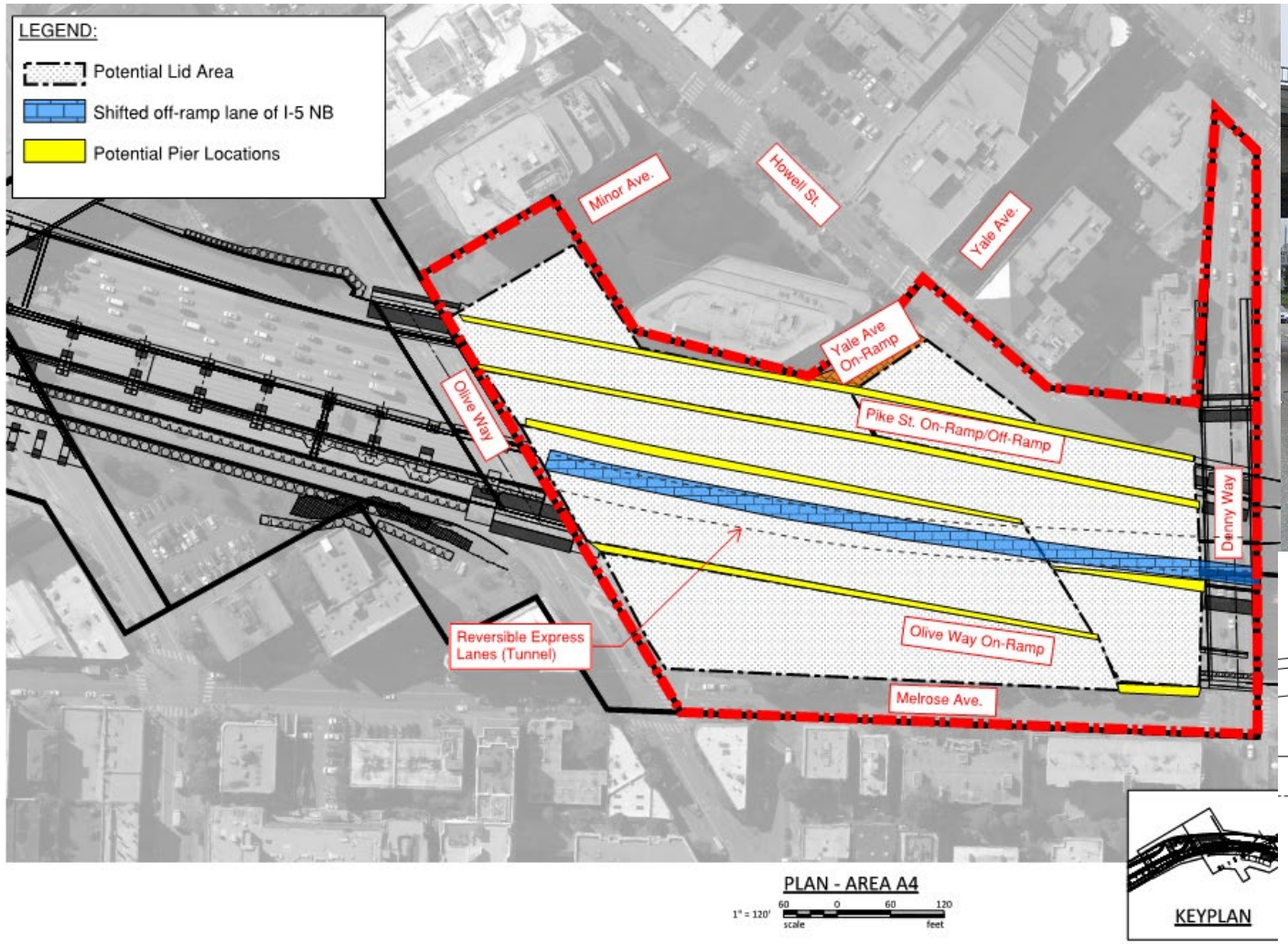


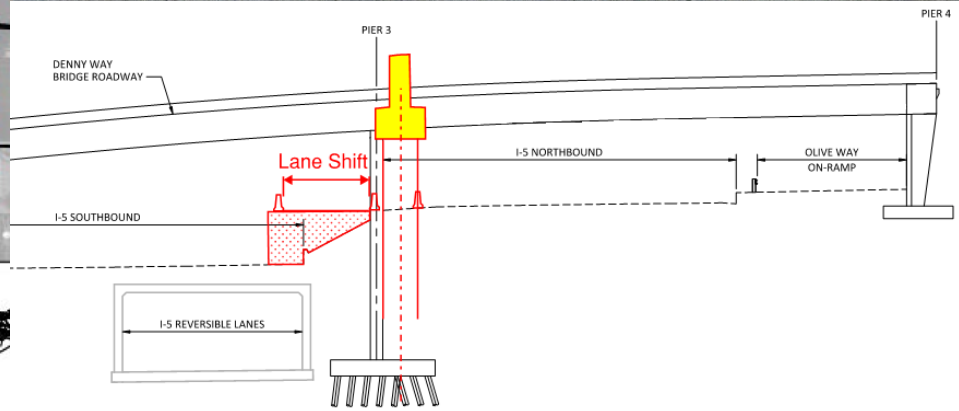
Section 1 – Walkway Extension



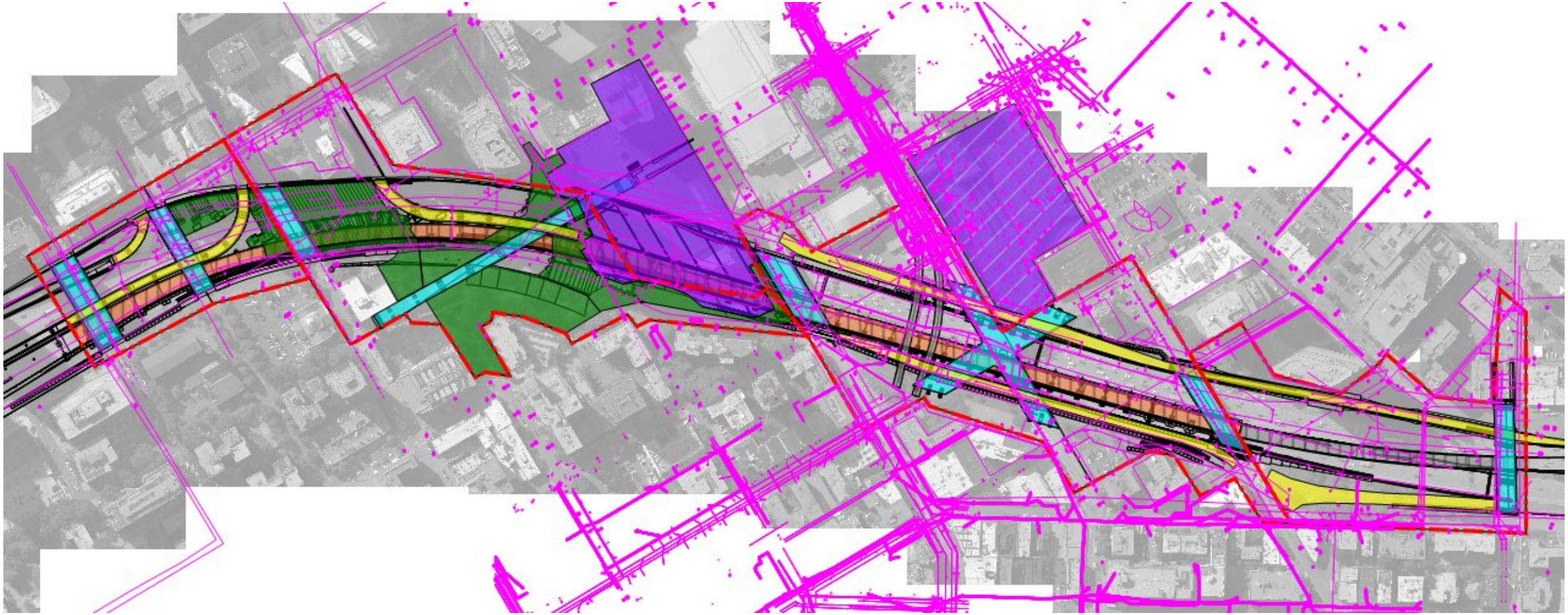
Section 2 – New Pedestrian Bridge

Consideration – I-5 Channelization Reconfiguration





Consideration – Utilities



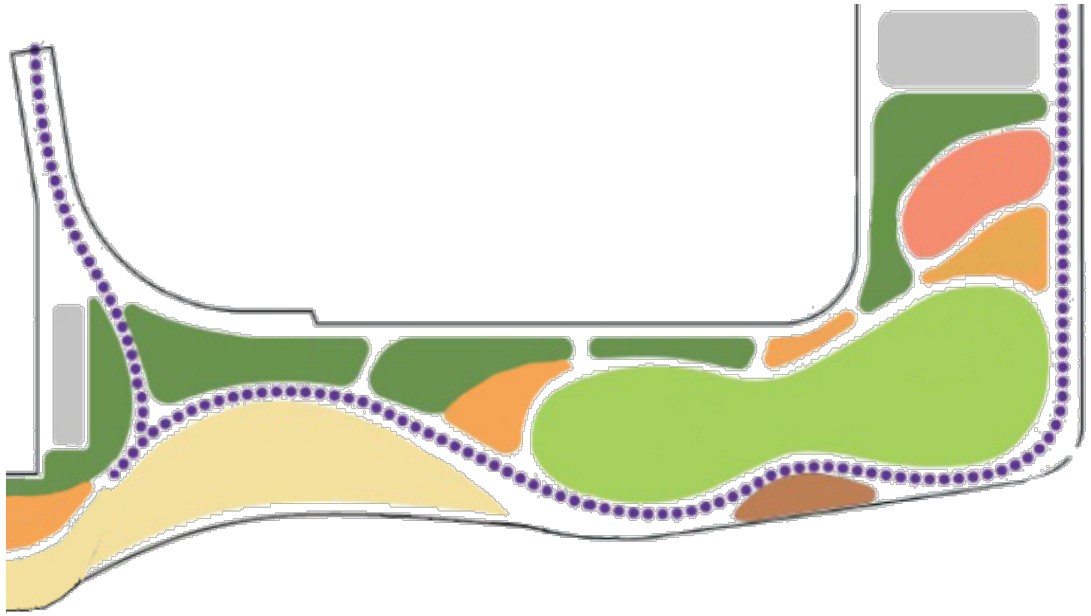
Next Steps

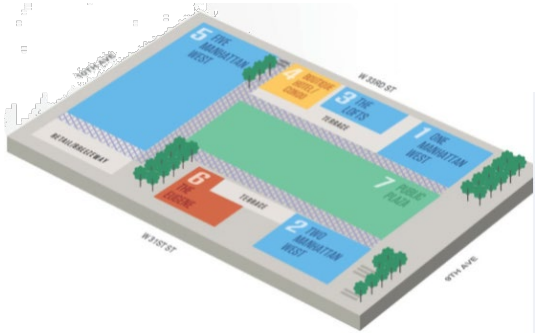
Outlined below; will be an iterative process. Bolded items have commenced

- Basemap Development
  - Preliminary – built on documents received from information requests
- Lid Sub-area Development (Geometric Layouts)
  - Definition of Impacts
  - Definition of Work Zones
- **Lid Sub-area Structural Assessment**
  - **Additional Framing Options (i.e. trusses)**
  - **Substructure and foundation design – consideration of seismic loads**
  - **Lid-to-Building structural interface assessment**
- **Interdisciplinary Coordination**
  - **Directed discipline specific task assignments to approximate costs and impacts**
    - **Technical Team Disciplines - E.g. Look at utility impacts, life safety requirements, etc.**
    - **Urban Design and Economics Teams – massing and edging**

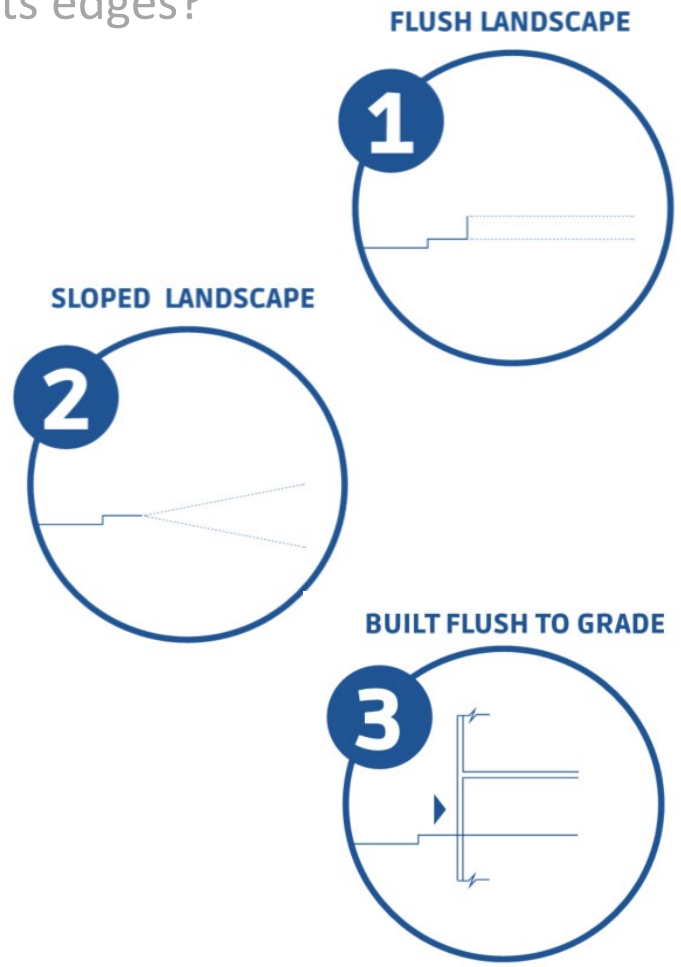
Next Steps - Massing & Edging

How will the lid structure be used and tie into the existing conditions along its edges?



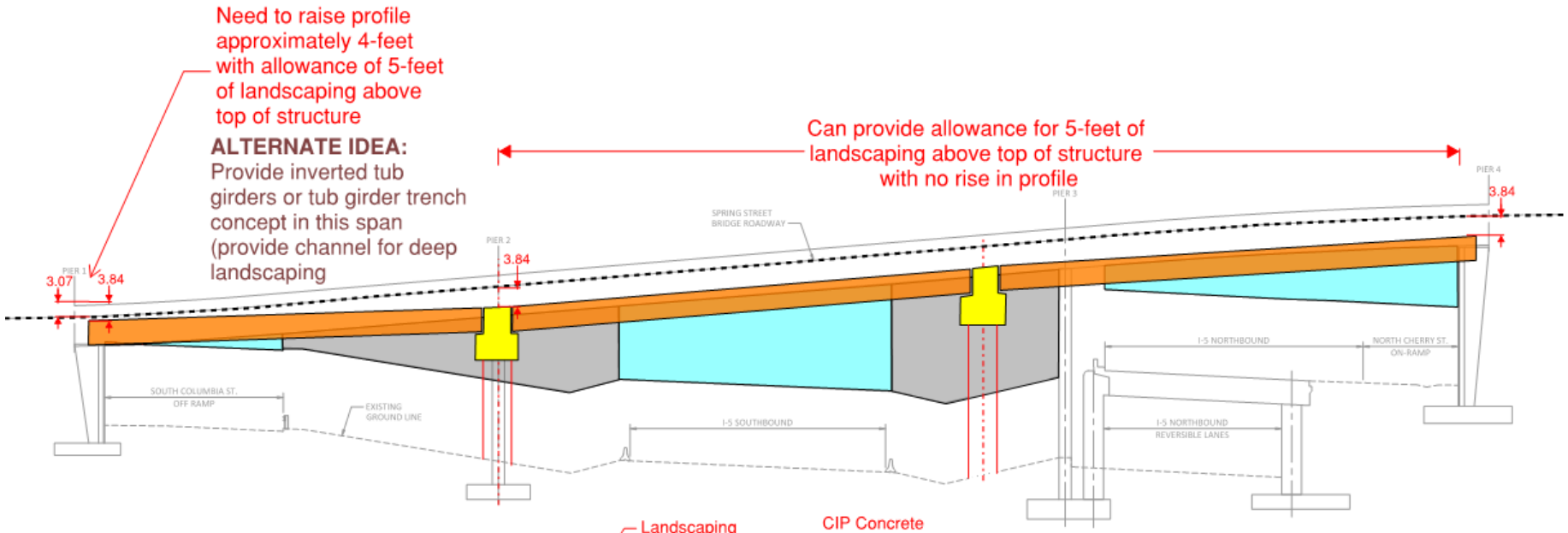


Representative examples



NOTE: Study will not program the lid; it will only provide representative massing concepts.

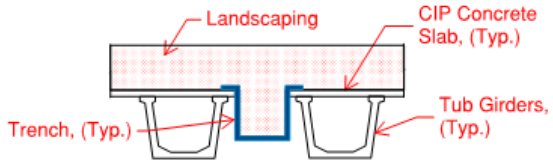
Next Steps - Edging (Landscape)



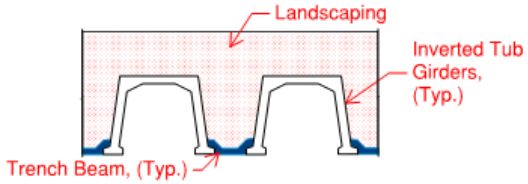
1" = 10' 10 0 10 20 scale feet

LEGEND:

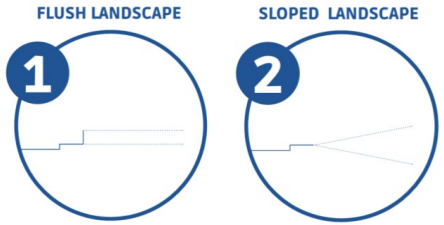
- Seneca Off-Ramp (Assumed to be Removed)
- Inadequate Clearance
- Adequate Clearance over roadway
- Adequate Clearance between roadway
- 3 Span Option



TUB GIRDER TRENCH CONCEPT

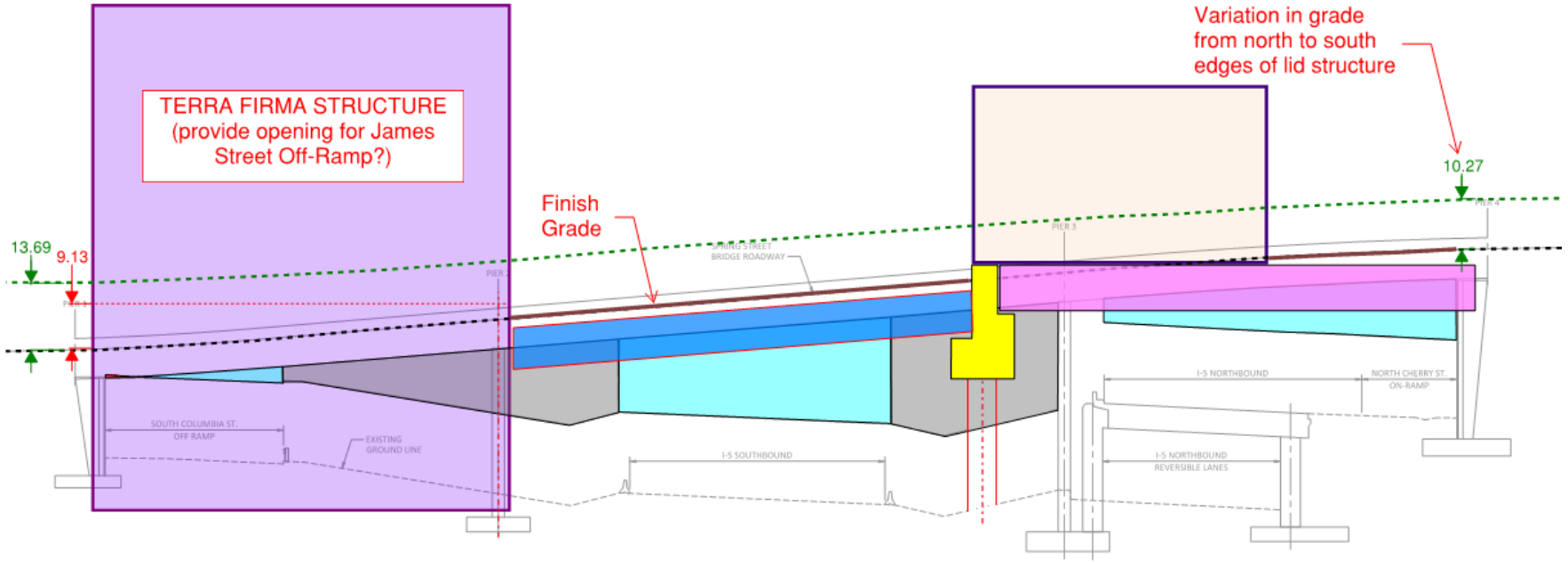


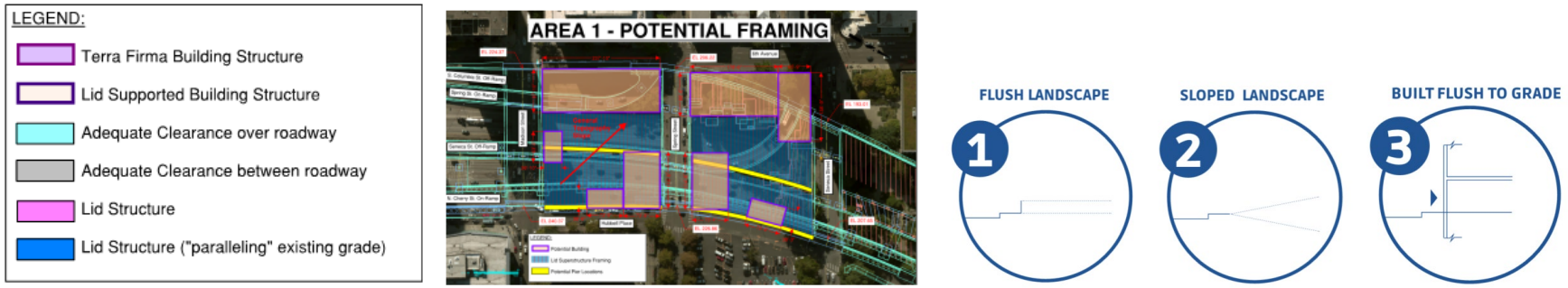
INVERTED TUB GIRDER CONCEPT



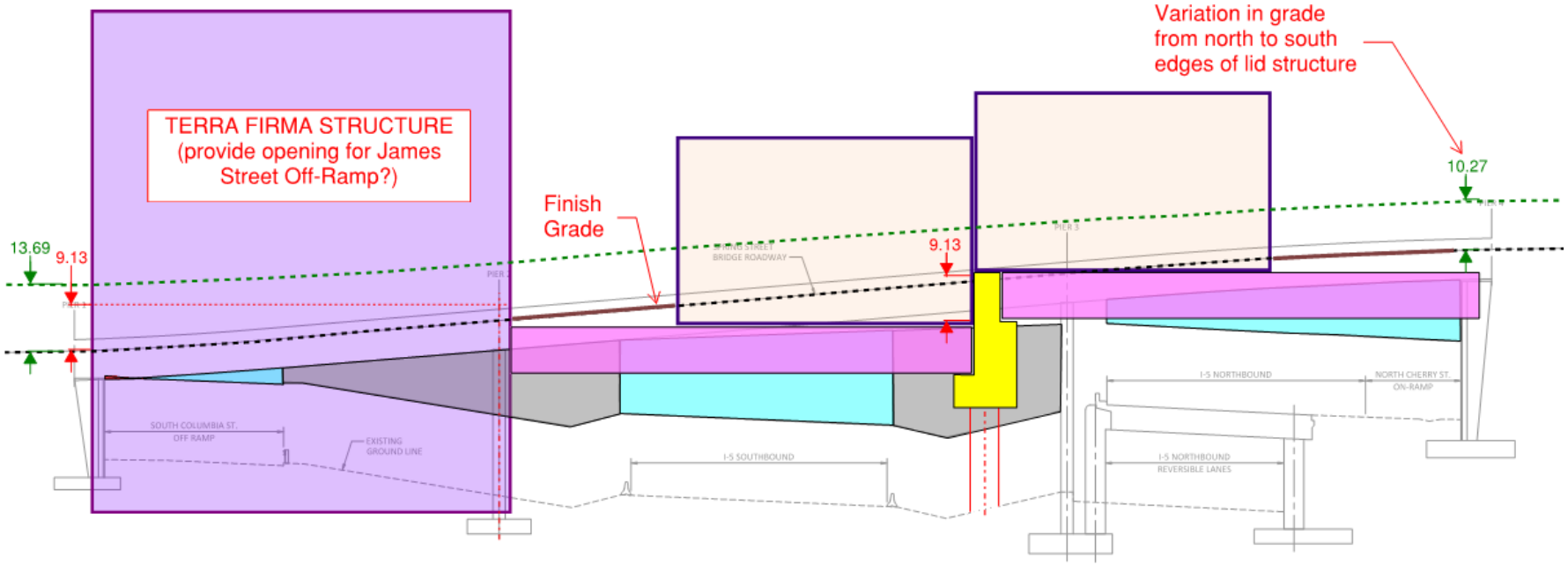
NOTE:
1.Superstructure development concepts shown are based on the low load level (i.e. landscaping/open space).

Next Steps - Edging (On-Lid Development)





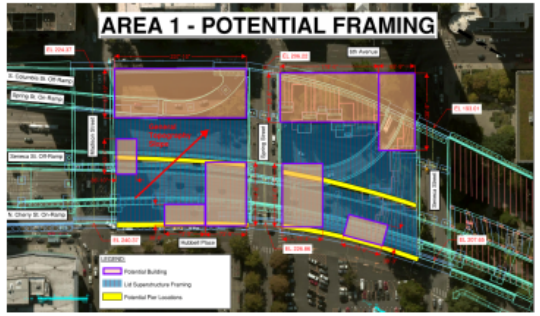
Next Steps - Edging (On-Lid Development)

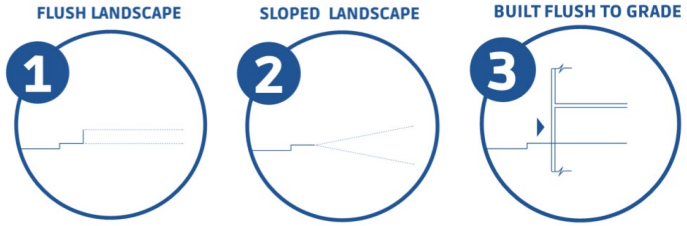


1" = 10' scale 10 0 10 20 feet

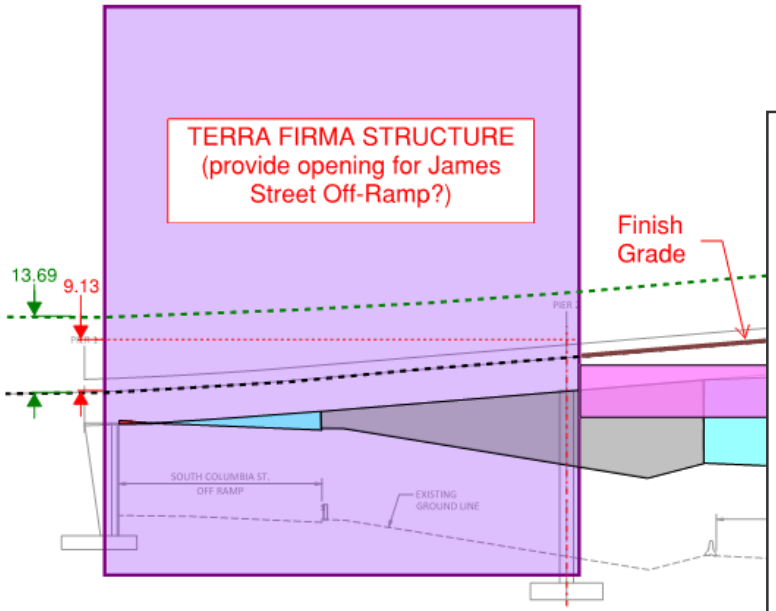
LEGEND:

- Terra Firma Building Structure
- Lid Supported Building Structure
- Adequate Clearance over roadway
- Adequate Clearance between roadway
- Lid Structure





Next Steps - Lid-to-Building Interface



LEGEND:

- Terra Firma Building Structure
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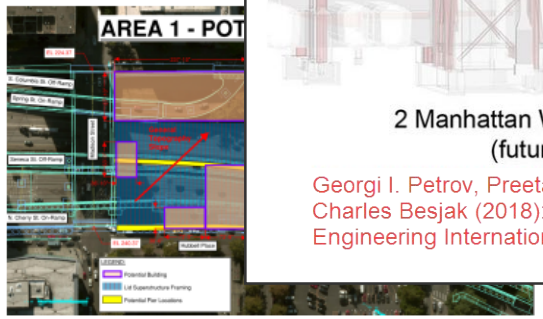
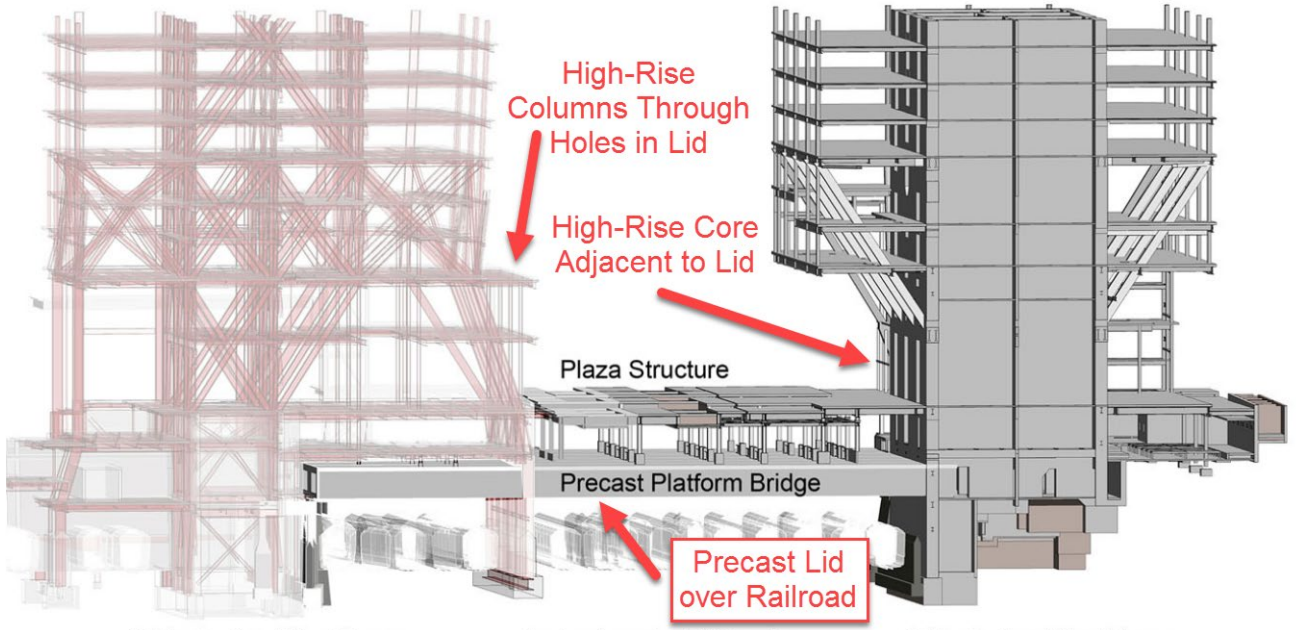


Variation in grade from north to south edges of lid structure

EXAMPLE: 1 & 2 Manhattan West Over 240 ft Span Lid



Georgi I. Petrov, Preetam Biswas, Ronald B. Johnson, Aurelie Seblani & Charles Besjak (2018): Supertall Over the Train Tracks - One Manhattan West Tower, Structural Engineering International, DOI: 10.1080/10168664.2018.1516125

Future Additional Technical Studies

Below is a list of future studies to be conducted under potential future phases of work…

- Traffic Network (transportation) Study
- Fire & Life Safety/Ventilation Study
- Construction Staging & Phasing Study
- Field Explorations (Geotechnical, surveying, etc.)
- Etc…

Closing Remarks

- **Indication** that it is **technically feasible** to construct a lid over Interstate-5 through downtown Seattle.
  - Additional in-depth technical studies, beyond the scope of this feasibility analysis will be necessary
- **Work-to-date is preliminary**.
  - Iterative process with refinements/updates through the course of the study
  - Other considerations required to address overall feasibility, informed by:
    - Urban context
    - Economic & financial feasibility
    - Governance assessment
    - Agency alignment
- Costs (capital, O&M) will be developed and shared by the 1/23 committee meeting

10 Minute Break

Sub-area Analysis and Small Group Discussion

Small Group Discussion

- Work in 3-4 groups of 5 people
- Use the discussion questions and materials at your table
- Each table will have a facilitator
- Technical resource staff will float between groups
- 65 minutes for small-groups and 40 minutes for report-out and discussion

Public Comment

Meeting Close

- Closing remarks
- Next steps and action items