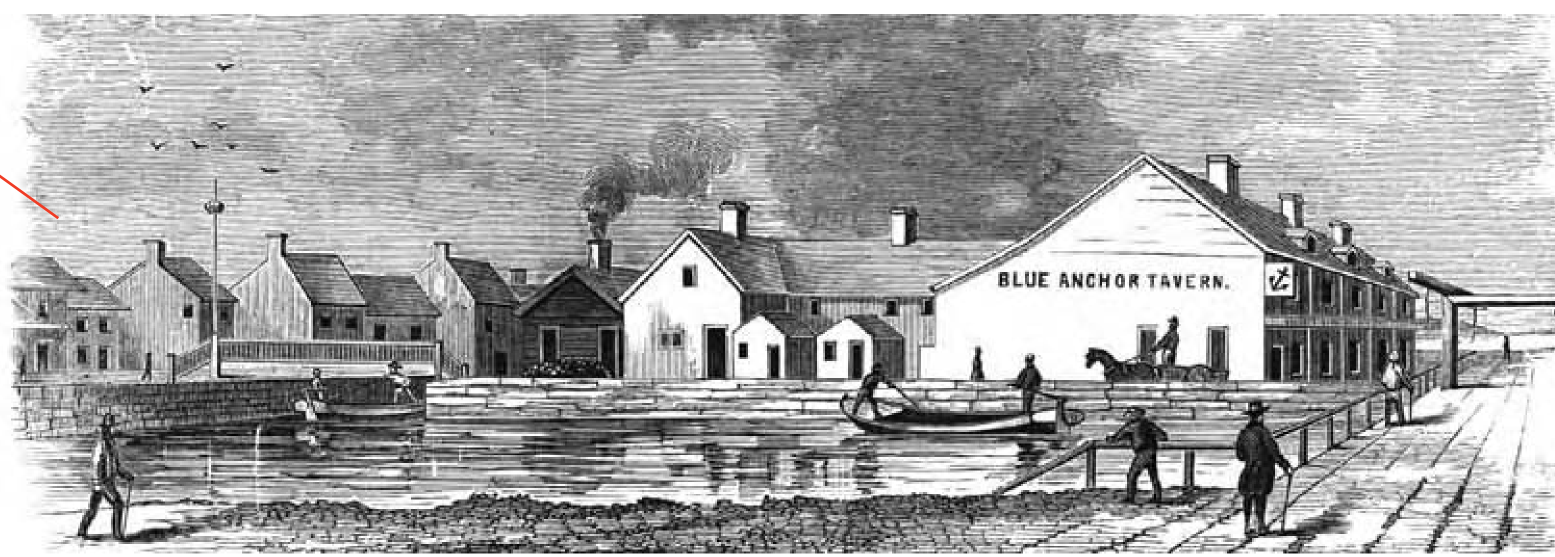
ANALYSIS

Natural Systems - larger ecological systems and their implications for creating a sustainable infrastructure.

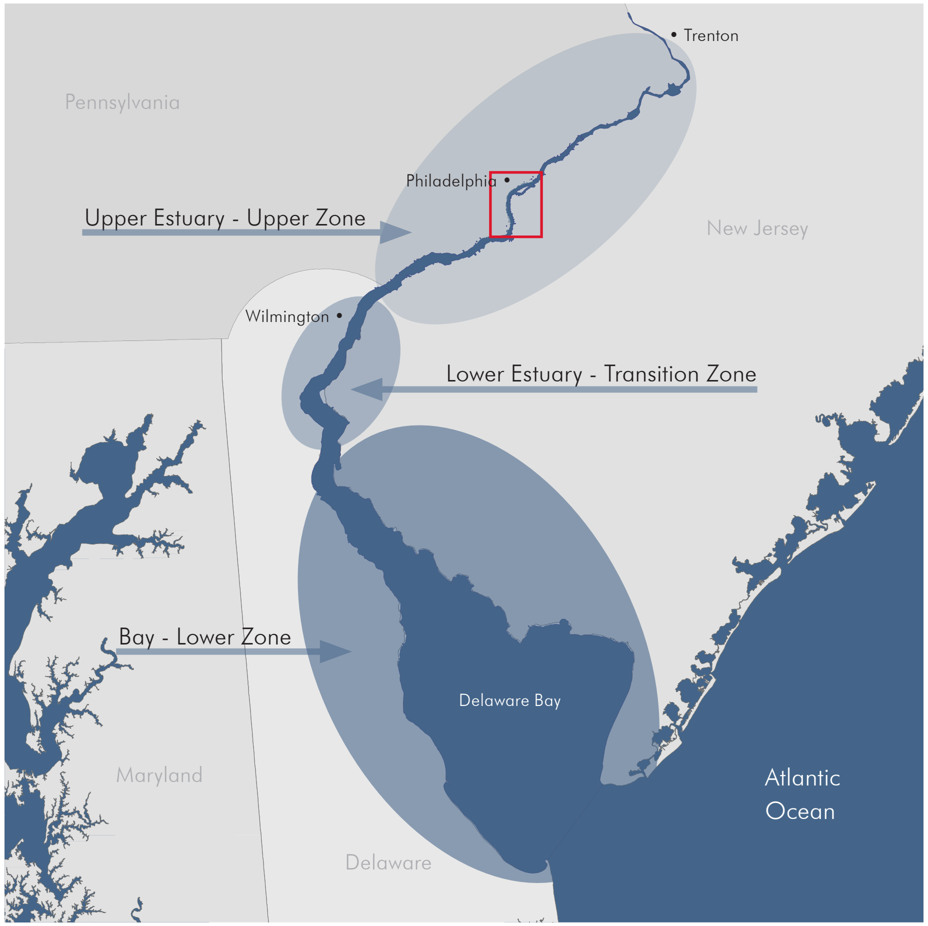
These natural systems are sets of relationships that, in order to be sustainable, we must strive to understand, integrate and support. By honoring and working within the framework these relationships provide, we may derive goods and services within our 7 mile stretch of downtown Philadelphia. It is important to be mindful however, that these intricate relationships have implications that extend well beyond the imposed limits of this study. This chapter contains a brief discussion of topics to consider when thinking about our unique waterfront.



Dock Creek and Drawbridge at Front Street from *Watsons Annals V1*

The historic streams mapped to the left were buried in sewers in the early 1900s. The above etching depicts Dock Creek (present day Dock Street) in its transition from free flowing waterbody to sewer.

Historic Streams



Delaware Estuary

- The Philadelphia Central Delaware Waterfront is part of the Upper Estuary of the Delaware River.
    - This section is tidal, with free-flowing waters between Delaware Bay and river sections north of Trenton.
    - The 7-mile stretch is bounded by the confluence of Darby Creek to the south and Poquessing Creek to the north.
    - This section has a daily tidal flux of 6 to 8 feet on average.
    - Tides combined with storm events exacerbate flooding.
- The Upper Estuary is characterized by intertidal wetlands, fed by freshwater streams.
- The salt line fluctuates and has generally remained below Wilmington.
- The optimal shoreline from an ecological perspective is a gradual transition from subtidal areas (aquatic zone), through intertidal areas (marshes) and swamps, to uplands (floodplain forest)[1]
    - Submerged, aquatic communities occur at depths of 6+ feet and are typically dominated by eel grass.
    - Intertidal marshes are characterized by emergent vegetation at depths of 4 to 5 feet.
    - Wet Meadow-Shrub Swamp communities occur within the frequently-inundated zone.
    - Sycamore-river birch–cottonwood floodplain forest is characteristic of the upland zone.

Submergent Aquatic Vegetation

Valisneria americana (Eelgrass)
Elodea canadensis (Waterweed)
Potamogeton pectinatus. (Sago Pondweed)
Ceratophyllum demersum (Coontail)
Potamogeton perfoliatus (Redhead Grass)

Emergent Vegetation

Caltha palustris (Marsh Marigold)
Carex crinita (Fringed Sedge)
Carex lurida (Bladder Sedge)
Iris versicolor (Blue Flag)
Nuphar lutea (Spatterdock)
Pontederia cordata (Pickerelweed)

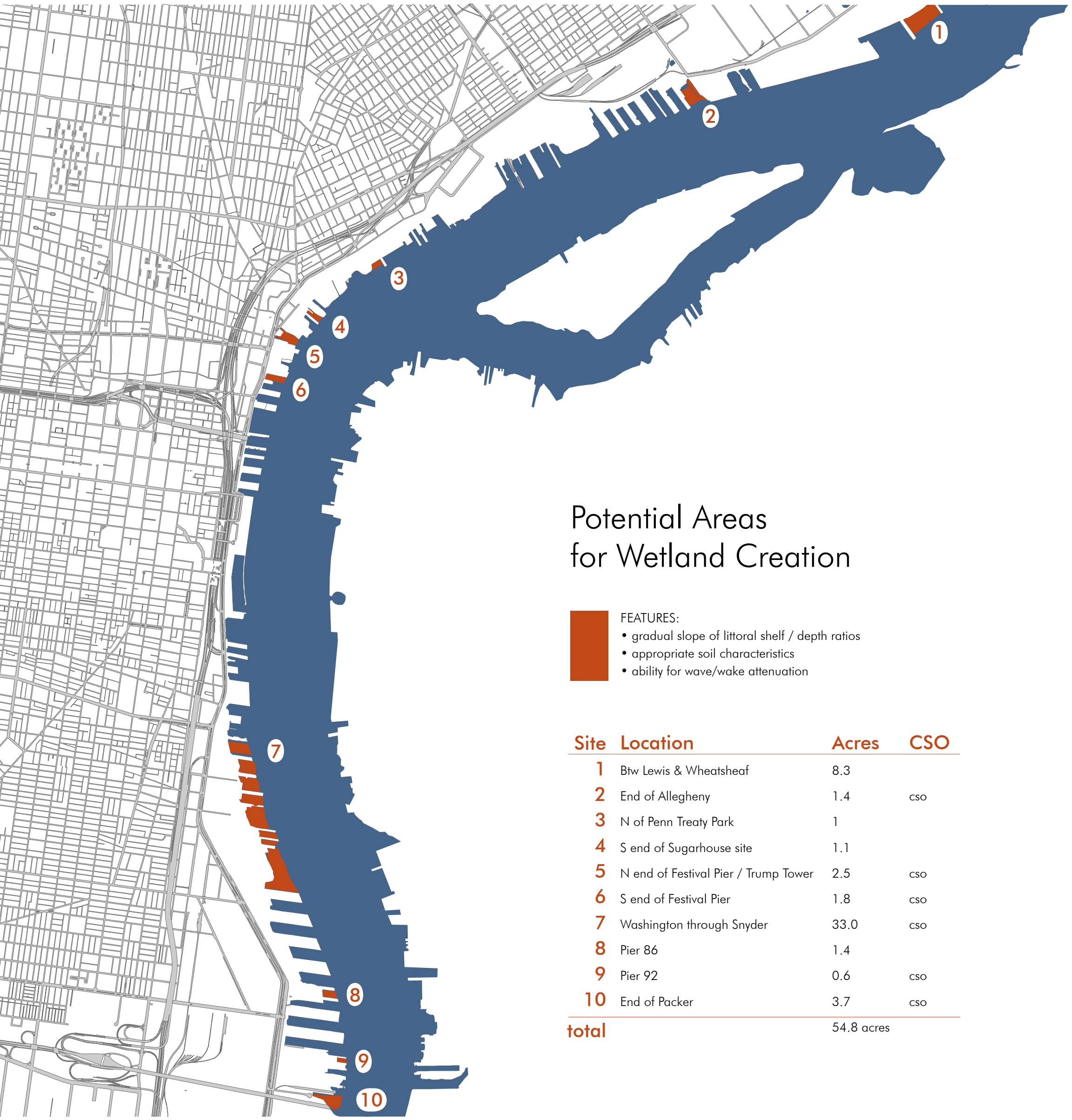
Wet-Meadow Shrub Swamp

Spiraea alba (White Meadowsweet)
Spiraea tomentosa (Steeplebush)
Cephalanthus occidentalis (Buttonbush)
Alnus serrulata (Smooth Alder)
Calamagrostis canadensis (Bluejoint)
Dulichium arundinaceum (Threeway Sedge)

Floodplain Forest

Platanus occidentalis (American Sycamore)
Populus deltoides (Eastern Cottonwood)
Betula nigra (River Birch)
Acer negundo (Box Elder)
Acer saccharinum (Silver Maple)
Salix nigra (Black Willow)

permanent inundation | daily tidal inundation | periodic flooding



PWD OOW projections

Potential Areas for Wetland Creation

FEATURES:
- gradual slope of littoral shelf / depth ratios
- appropriate soil characteristics
- ability for wave/wake attenuation

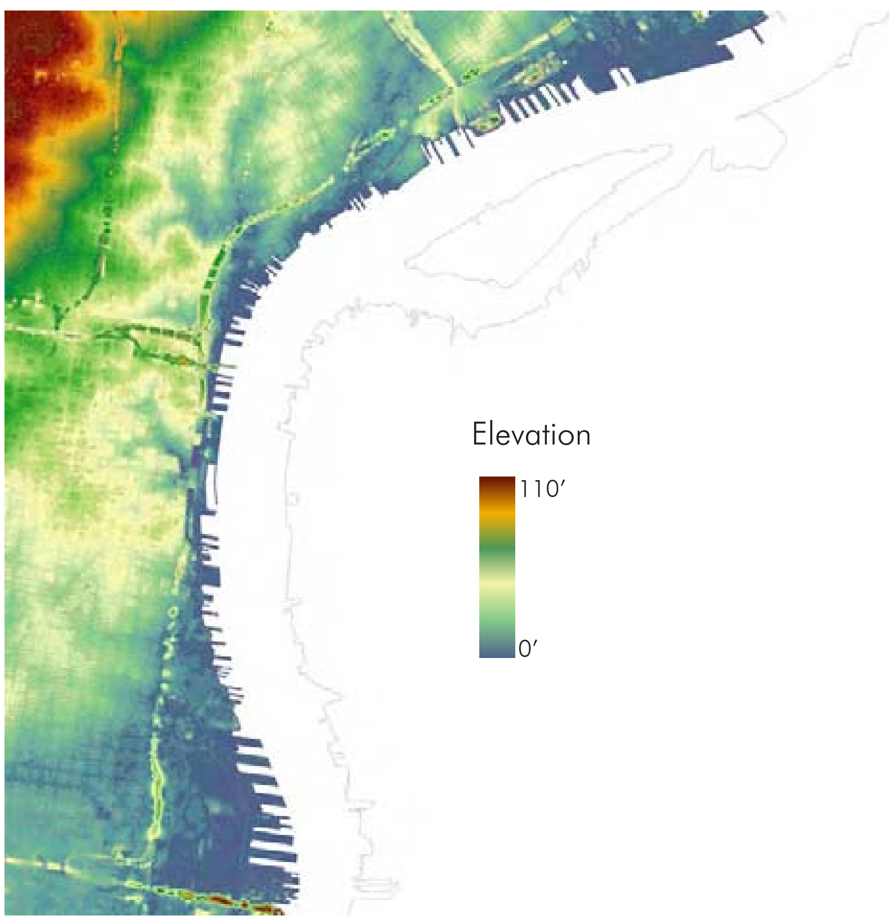
Site	Location	Acres	CSO
1	Btw Lewis & Wheatsheaf	8.3	
2	End of Allegheny	1.4	cso
3	N of Penn Treaty Park	1	
4	S end of Sugarhouse site	1.1	
5	N end of Festival Pier / Trump Tower	2.5	cso
6	S end of Festival Pier	1.8	cso
7	Washington through Snyder	33.0	cso
8	Pier 86	1.4	
9	Pier 92	0.6	cso
10	End of Packer	3.7	cso
total		54.8 acres	

Delaware River Habitat

- The Upper Delaware Estuary is an extremely complex ecosystem marked by high productivity, internationally recognized habitat, and a large range of biodiversity.[2]
- Daily tidal flux creates conditions for both aerobic and anaerobic communities to thrive.[3]
  - Breakdown and cycling of nutrients is more rapid with both conditions present.
  - Additional nutrients are brought in and distributed by tidal action.
- Historic Biogeomorphology - process-morphology dynamics, (or the relationships between the tide, sedimentation/deposition, base substrate, and plant and animal communities) create islands of habitat in the Delaware Estuary tidal freshwater marsh under natural conditions.
- Edge conditions and depth fluctuation, coupled with orientation, create micro-habitat conditions that allow for many different species to thrive in close proximity. Philadelphia's piers, though not designed for habitat, are better than a straight line of bulkhead along the waterfront.
- The Upper Estuary is part of a larger habitat corridor and is important for different species at different times of the yearly cycle.
  - Atlantic flyway for migratory birds – song birds, water fowl, raptors
  - Anadromous fish spawning migrations
- Existing "natural" areas are highly disturbed with remnant communities.
  - Remnant floodplain forests at Pennypack Creek and Petty's Island
  - Bald eagle nesting pair reported in Philadelphia spring 2007. First nest in Philadelphia County in more than 200 years.
- The potential for restoring/creating intertidal marshes exists when the following three factors are addressed [4]
  1. Gradual slope of littoral shelf, and appropriate depth range
  2. Appropriate sediment character
  3. Wave/wakes can be attenuated

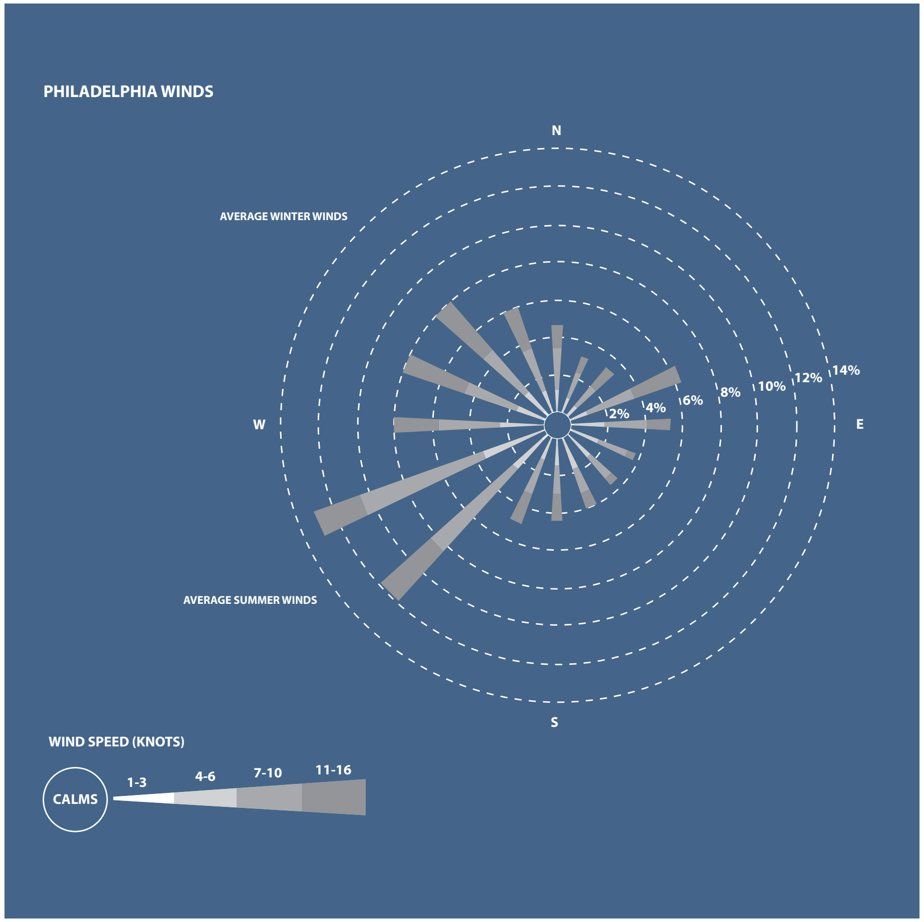
Physiography

- Remnants of natural topography exist within this immediate watershed.
    - Old streambeds may have hydrologic soils and exhibit drainage patterns that have implications for habitat type and stormwater function, especially in upland parcels.
- Sub-watersheds have been modified and follow combined sewer drainage pattern and are known as sewersheds.
    - Combined sewers (CS) are for the most part, gravity-based and loosely follow natural/historic topography.
- Parts of the waterfront lie within the 100 year floodplain.
    - Significant recent floods have occurred in 2004, 2005, and 2006 – all have exceeded flood stage by over nine feet, as recorded at Philadelphia/Mt Holly monitoring station (NOAA/NWS).



Weather Patterns

- Wind direction
    - NW in November – March
    - SW in April – October
    - Strongest winds in September & December
- Sun Angles
    - Philadelphia latitude = 40°00′ North
    - Sun positions on solstices
        - Dec. 21, 9am and 3pm: Altitude = 14°, Azimuth = ±42°
        - June 21, 9am and 3pm: Altitude = 49°, Azimuth = ±80°
- Storm Events
    - Occur year round
    - Snow melt contributes to flooding in early spring
    - Tropical system storms have caused significant flooding in Delaware Valley, most recently in September 2004 post-Hurricane Ivan.



Major sewer lines

ANALYSIS

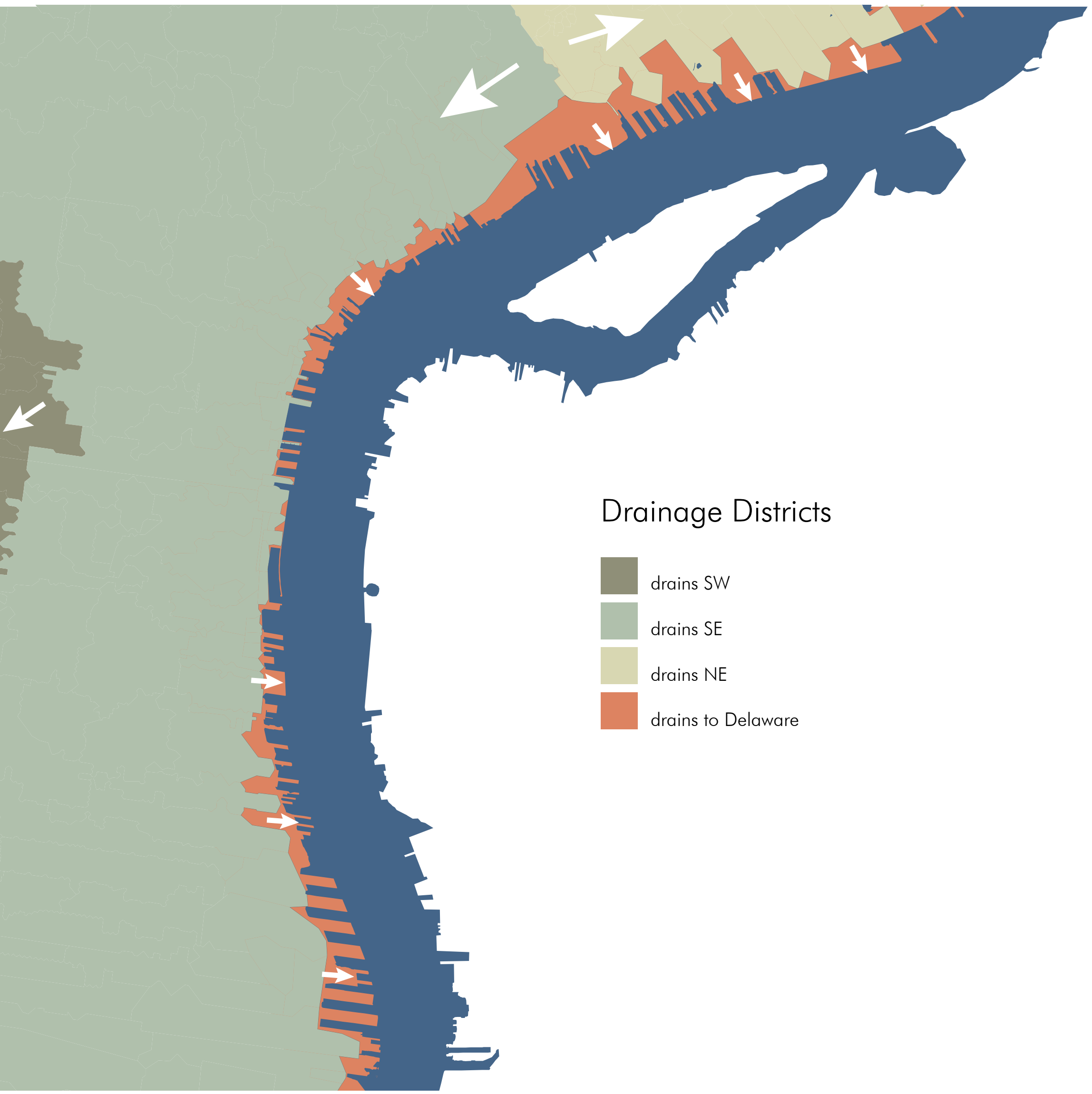
Man Made Infrastructure – constraints and opportunities for converting existing infrastructure into green infrastructure.

Throughout our history, Philadelphia has been a hub of innovative thinking and the forerunner of instituting cutting edge ideas aimed to enhance the quality of life for its inhabitants. As we continue to build upon our collective knowledge, it is with this Philadelphian zeal we should approach the opportunity our waterfront holds. This section looks at the implications of our prior land use decisions with a critical eye toward the future. All of the areas below should be considered opportunities for innovation and improvement.

Wingohocking Creek Sewer under construction, 1909
City Archives of Philadelphia

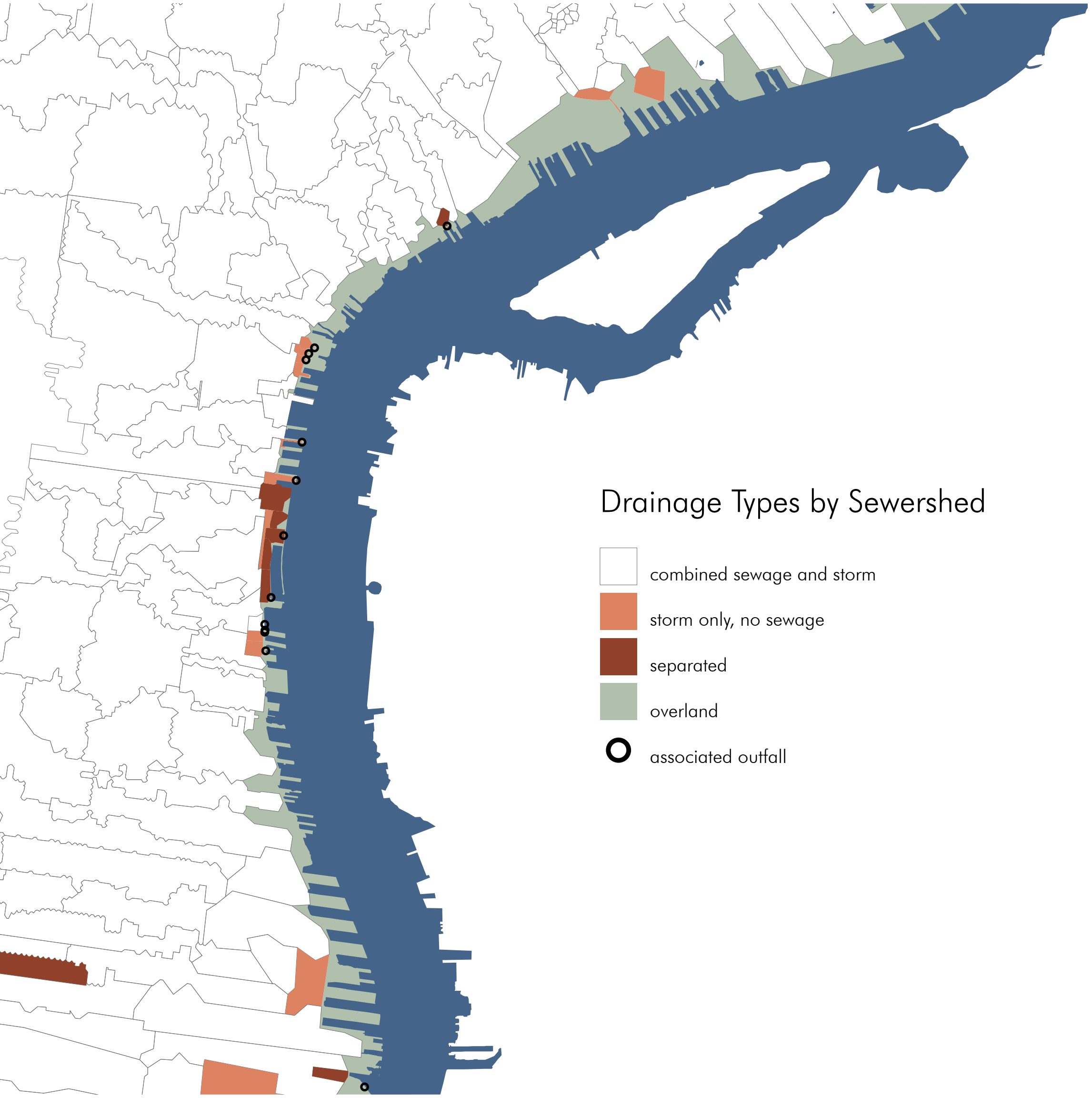
Aramingo Canal during its conversion into a sewer, April 1, 1901
PWD Historical Collection

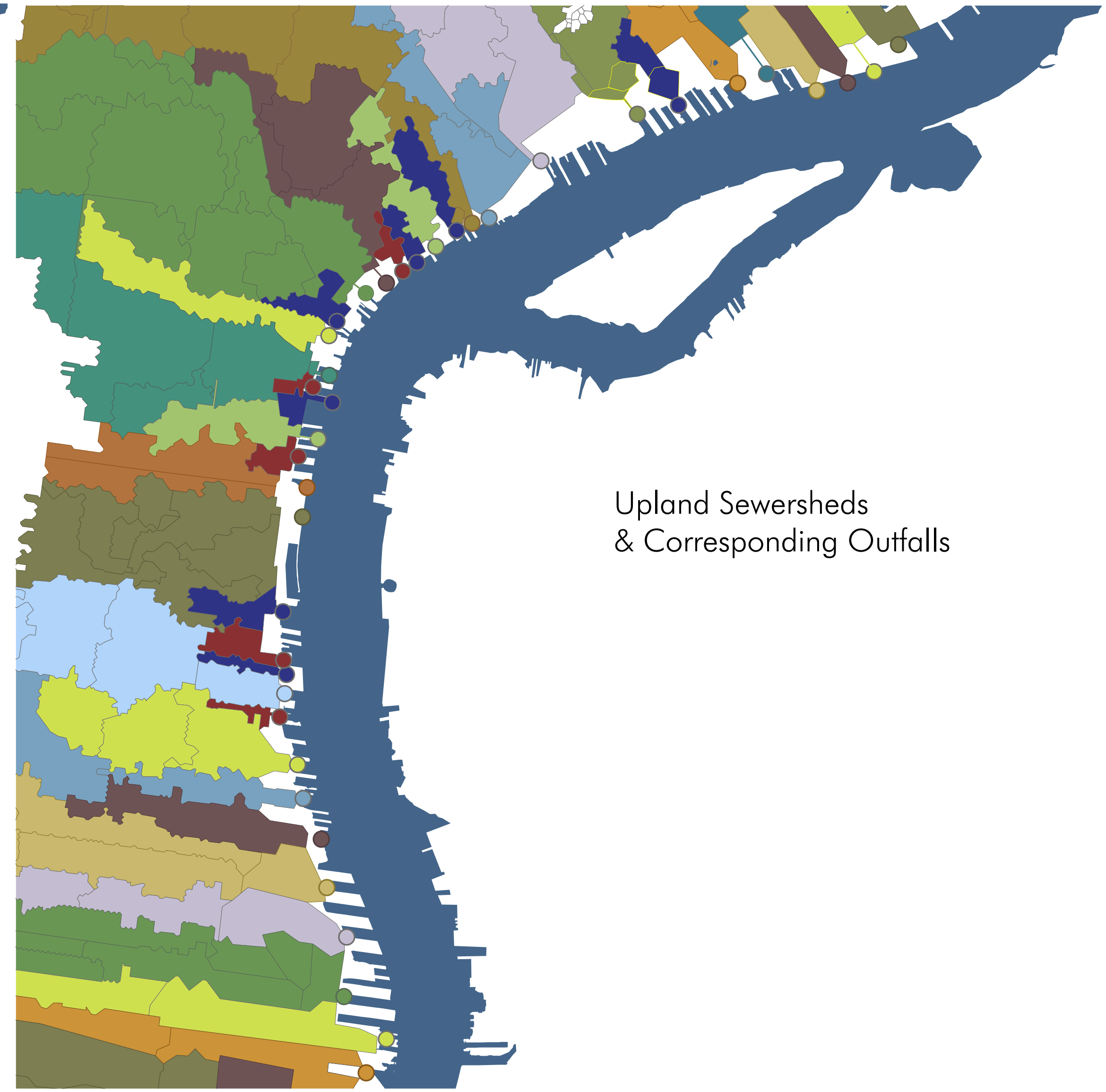
Mill Creek Sewer under construction, 1883
PWD Historical Collection



Sewer Infrastructure

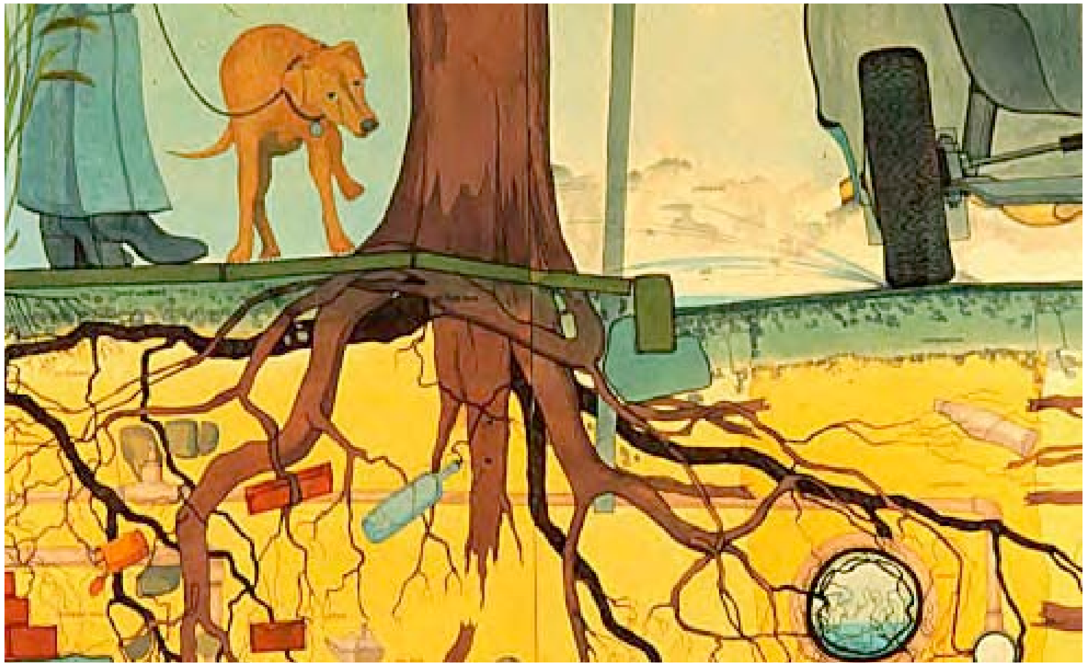
- The majority of sewers in the study area are combined and route wastewater to a treatment facility to the south. The area from the Conrail overpass and north drains to another treatment facility.
    - Aggregates of upland sewersheds contribute sum runoff and sewage to specific combined sewer outfalls (CSOs) at corresponding points along the river.
    - Trunk sewers follow existing E/W street grid pattern while the main interceptor sewer runs parallel to the waterfront.
    - Some historic streams have been converted to trunk sewers and cannot be daylighted within this watershed as they are now combined sewers connecting directly to outfalls.
    - Discharge velocity, nutrient and pollution loads are a concern at all outfall locations.
    - Effluent contribution to the Delaware is greatest in big storm events when sewers run full, discharging more than once a week on average. (yearly)
    - Upstream stormwater separation and infiltration reduces the contribution of effluent from sewersheds.
    - Delaware waterfront land is not able to mitigate the stormwater volumes coming from upland sources.
- A sliver of riverfront area drains directly to Delaware River, some through separated storm sewer systems, others via overland flow.
    - All of these small sewersheds can be studied for local infiltration and stormwater mitigation opportunities.
    - A shoreline buffer could ideally mitigate water quality for a one-inch storm for the immediately adjacent upland site.


Drainage Types by Sewershed
combined sewage and storm
storm only, no sewage
separated
overland
associated outfall


Upland Sewersheds
& Corresponding Outfalls

Soil Compaction, Loss/Deposition and Pollution

- The majority of soils in the study area can be classified as urban and are anthropogenic, meaning they have been altered by humans.
    - Pore space within soil structure has been compressed by heavy material and equipment. This reduces ability of the soil to infiltrate water and prevents root penetration.
    - Fill materials like concrete and dredge change the chemical make-up and alter the chemical interaction of soil biota.
    - As a result of industrial activities, soils may also contain heavy metals and hydrocarbons, as well as other toxic substances.
    - Many times top soil has been removed by construction activities and not replaced and/or allowed to erode away.
- Altered soil properties result in a reduced ability to perform the critical functions or activities of natural soil.
- Soil-building processes can be designed and managed for, however the timeframe for rebuilding healthy soil is not overnight.

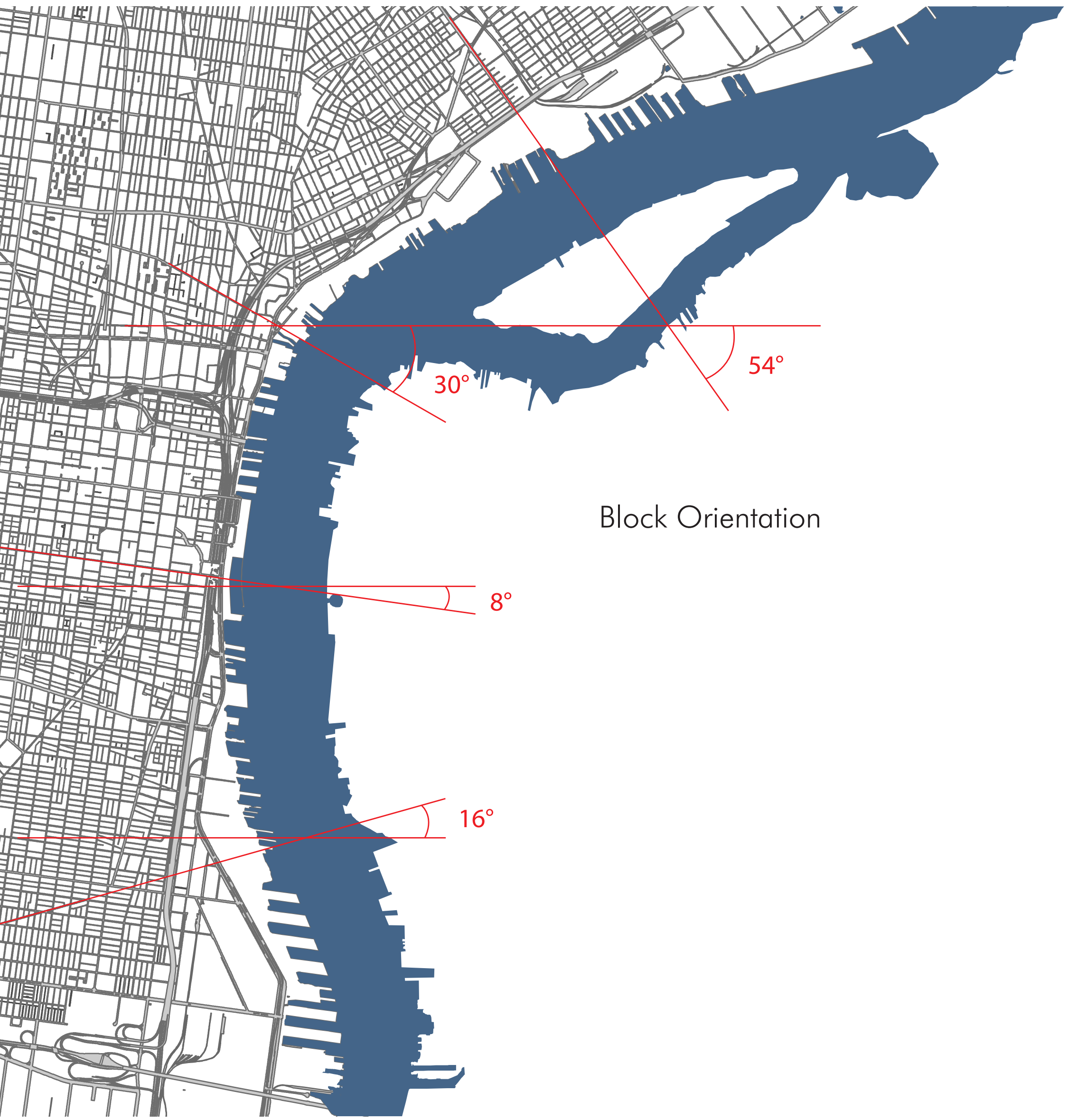


Urban surfaces: Permeability and Albedo

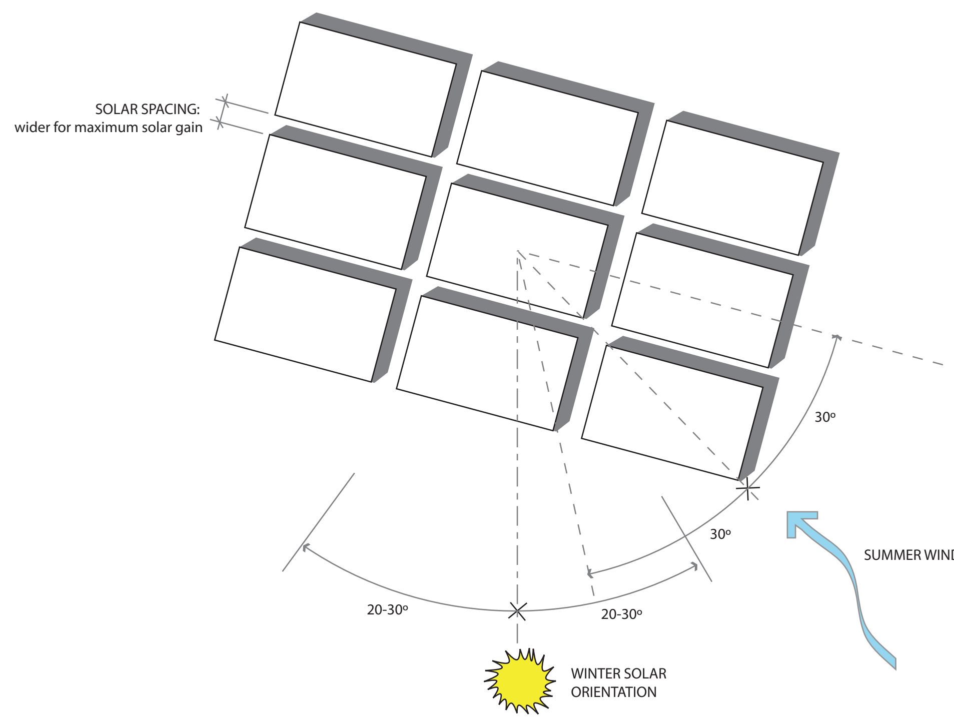
- Urbanization along the waterfront will further increase the amount of impervious surface and therefore contribute to runoff into the Delaware River.
    - Impervious pavements (asphalt, concrete, mortared brick, stone, etc.) seal surfaces, repel water, and prevent precipitation from infiltrating soils.
    - Intense storms quickly generate large volumes of runoff.
    - Impervious surfaces cause non-point water pollution problems.
    - Impervious surfaces have higher thermal conductivities than do vegetated, pervious surfaces.
- Urbanization also has the potential to increase the “urban heat island effect.”[5]
    - In urban areas, buildings and paved surfaces have gradually replaced preexisting natural landscapes. As a result, solar energy is absorbed into roads and rooftops, causing the surface temperature of urban structures to become 50 - 70 °F higher than the ambient air temperatures.
    - As surfaces throughout an entire community or city become hotter, overall ambient air temperature increases. This phenomenon, known as an “urban heat island,” can raise air temperature in a city by 2 - 8 °F.
- Increased albedo (solar reflectivity) of urban surfaces, vegetated surfaces, and permeable surfaces are effective ways to combat the heat-island effect.

Streets and Building Orientation

- Original North-South-East-West block orientation laid out by Penn does not take full advantage of solar orientation strategies.
    - Due to the bend in the Delaware River, streets perpendicular to the waterfront on both the northern and southern end of the study area maintain desirable solar orientation.
    - In temperate climates, those streets offset from the cardinal directions at an angle between 20-30 degrees achieve optimal orientation for solar gain, daylighting, and passive heating.



Block Orientation



Optimal Grid Orientation for Solar Gain

Pier on pilings

Concrete bulkhead

Rip-rap with backfill

Pier with concrete bulkhead and rubble fill

Remnant wooden pier

Pier with wooden bulkhead and soil fill

Bulkhead - Seawall

- Much of the Central Delaware River edge is concrete seawall, however other types of bulkhead exist.
  - Different types of bulkheads in conjunction with the various types of backfill create distinctive conditions and therefore support particular types of biota.
  - Bulkheads were designed, and function to this day to resist routine flooding events and erosion from wake of passing ships.
  - All bulkheads in central portion will be overtopped by 100 year flood events
  - The abrupt edge acts as a barrier to habitat, disrupting smooth transitions between aquatic and terrestrial systems and the exchange needed for healthy habitats.
- Bulkheads should be evaluated for repair.
  - Failing bulkheads may present opportunities for vegetated seawalls that work with habitat or other innovations.
  - Example: artificial reef, Lake Ontario, Toronto

Existing Openspace

- Current openspace does not relate to the river
  - Existing waterfront parks do not engage the river
- Openspace within the immediate downtown is not connected, or networked
- These spaces proved marginal ecosystem services, and could be utilized to a greater extent.