Vegetated Roof Installations at O'Hare and Midway International Airports

Gene Peters, Ricondo & Associates, Inc.
On behalf of the Chicago Department of Aviation (CDA)
Integrated Transportation and Development Institute Congress
March 16, 2011

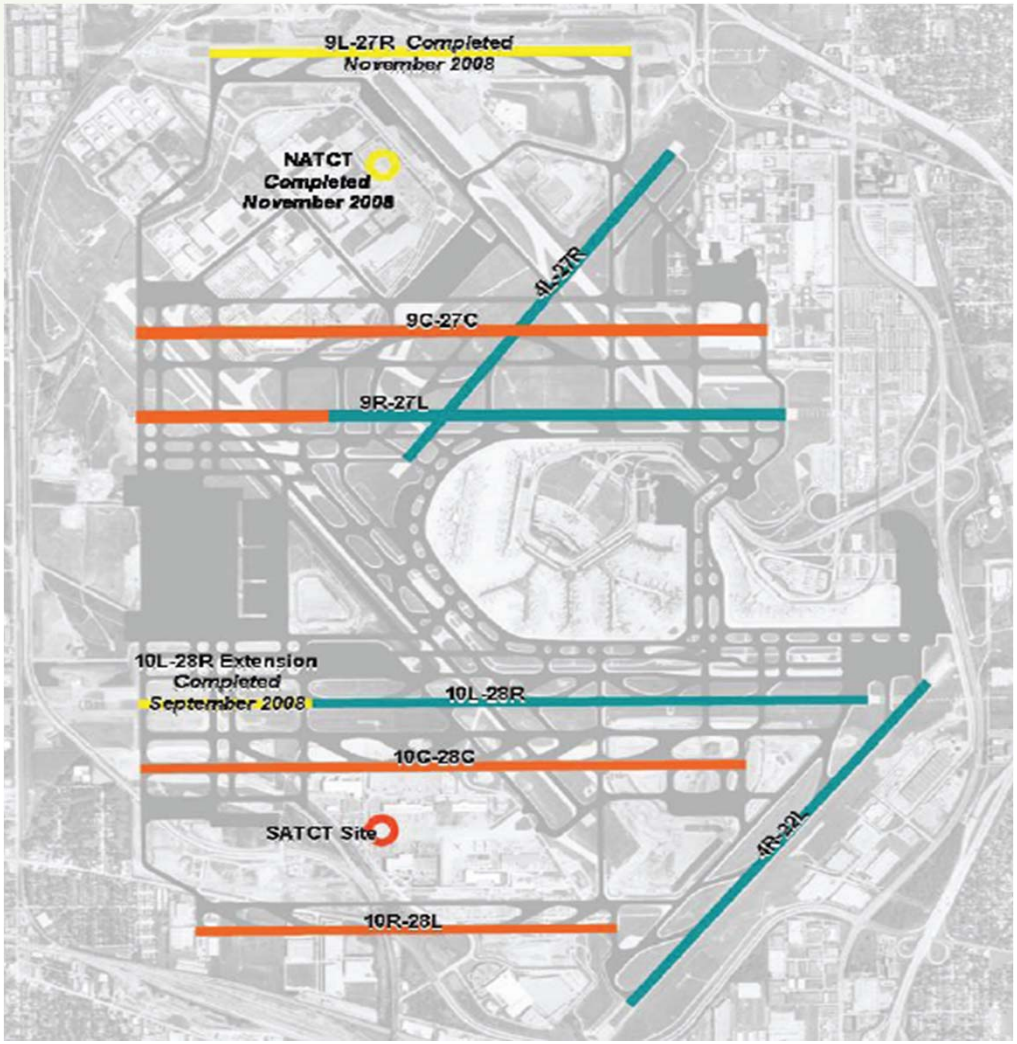
RICONDO & ASSOCIATES

Richard M. Daley
Mayor

CHICAGO CDA DEPARTMENT OF AVIATION
Rosemarie S. Andolino
Commissioner

Agenda

- O'Hare Modernization Program and Sustainability
- Why Vegetated Roofs?
- Green Roofs at an Airport - Considerations
- ORD & MDW Green Roof Inventory
- FedEx Vegetated Roof Case Study
- Benefits
- Lessons Learned

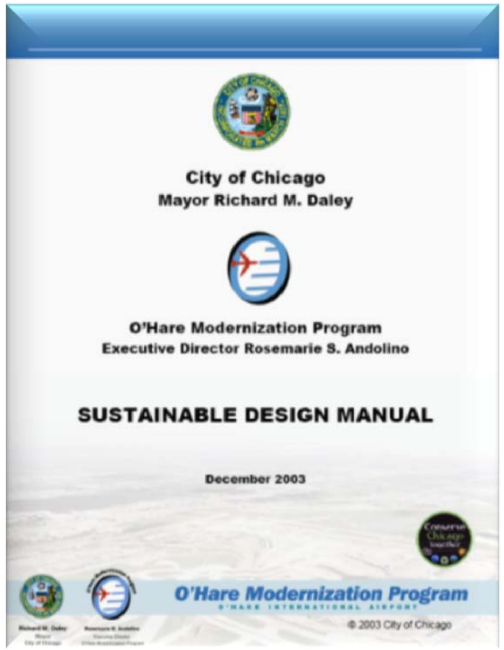


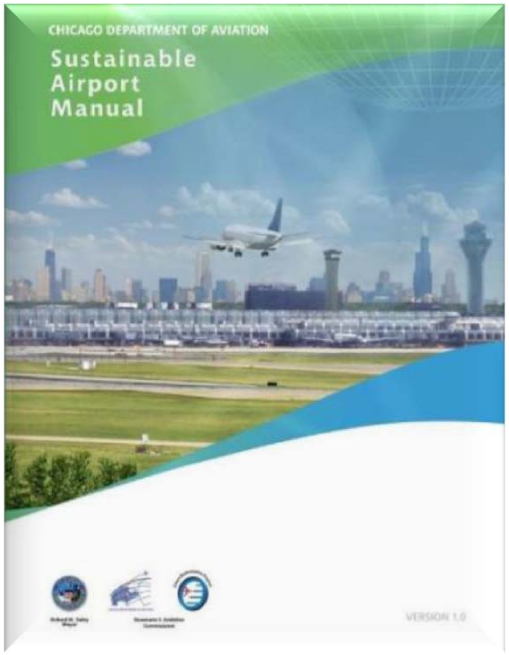
The O'Hare Modernization Program

- A $6.6 billion project to extend existing runways, develop a new runway & associated airfield components, terminal facilities & landside improvements
- Reconfigures intersecting runways into a parallel layout, reducing delays and increasing airfield capacity

CDA Sustainability Guidance

- Sustainable Design Manual (SDM) (2003), Sustainable Airport Manual (SAM) (2009)
  - Established contractual requirements to incorporate sustainability in design and construction of all CDA projects
  - Established standards & specs, checklists, rating/ranking program & award recognition





The Sustainable Airport Manual (SAM)

- SAM (2009)
  - Incorporates lessons learned and input from > 200 contributors, airport case studies, and LEED® 2009 guidance
- SAM 2.0 (2010)
  - New chapters on: Planning; O&M; Concessions & Tenants
- Over 55 projects have been reviewed under SDM/SAM
  - Facilitated NEPA approval
  - $$ and GHG savings
- Green Airplane Certifications
  - Recognizes those who meet or exceed contractual obligations to incorporate sustainable design initiatives into projects

World Map of SAM Contributors

Green Airplane Certification

Applicable SAM Credits

- Vegetated roofs are a strategy to accomplish the following SAM Credits:

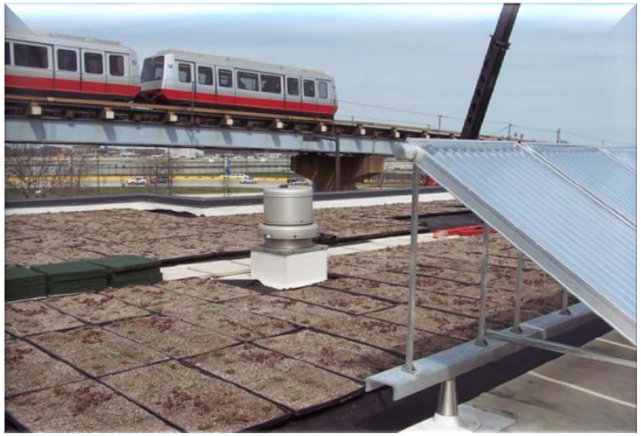
SAM 2.5.1:	**Sustainable Sites – Stormwater Design, Quantity Control**
1 Point	Limit disruption of natural water hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff, and eliminating contaminants.
SAM 2.5.2:	Sustainable Sites – Stormwater Design, Quality Control
1 Point	Limit disruption and pollution of natural water flows by managing stormwater runoff.
SAM 2.6.2:	Sustainable Sites – Landscape & Exterior Design to Reduce Heat Islands, Roof
1 Point	Reduce heat islands to minimize impact on microclimate and human and wildlife habitat.
SAM 4.4:	Energy & Atmosphere – Optimize Energy Performance
19 Points	Achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

SAM Checklists

Design & Construction Sustainable Airport Manual Credits		Design Checklist				Construction Checklist				LEED 2009 Reference
		Civil-Airside	Civil-Landside	Occupied Buildings	Unoccupied Buildings	Civil-Airside	Civil-Landside	Occupied Buildings	Unoccupied Buildings	
1.0	**Administrative Procedures**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	
AP.1	*Prerequisite 1 Green Meetings*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	
AP.2	*Prerequisite 2 Document Reduction and Recycling Initiative (DRRI)*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	
AP.3	Corporate Sustainability Policy	1	1	1	1	1	1	1	1	
AP.4	Green Procurement Policy	4	4	4	4	4	4	4	4	
AP.5.1	Recycled Content Paper, 30%	1	1	1	1	1	1	1	1	
AP.5.2	Recycled Content Paper, 50%	1	1	1	1	1	1	1	1	
AP.5.3	Recycled Content Paper, 100%	1	1	1	1	1	1	1	1	
2.0	**Sustainable Sites**	**3**	**5**	**18**	**6**	**3**	**5**	**18**	**6**	**SS**
2.1	*Prerequisite 1 Construction Activity Pollution Prevention*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*SS pr1*
2.2	*Prerequisite 2 Adopt CDA Best Management Practices*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	*Required*	
2.3	Brownfield Redevelopment	1	1	1	1	1	1	1	1	SS cr3
2.4.1	Alternative Transportation: Public Transportation Access			6				6		SS cr4.1
2.4.2	Alternative Transportation: Bicycle Access, Storage and Changing Rooms			1				1		SS cr4.2
2.4.3	Alternative Transportation: Low-Emitting and Fuel-Efficient Vehicles (Non-Construction)			3				3		SS cr4.3
2.4.4	Alternative Transportation: Parking Capacity			2				2		SS cr4.4
2.5.1	Stormwater Design: Quantity Control		1	1	1		1	1	1	SS cr6.1
2.5.2	Stormwater Design: Quality Control		1	1	1		1	1	1	SS cr6.2
2.6.1	Landscape and Exterior Design to Reduce Heat Islands: Non-Roof	1	1	1	1	1	1	1	1	SS cr7.1
2.6.2	Landscape and Exterior Design to Reduce Heat Islands: Roof			1	1			1	1	SS cr7.2
2.7	Light Pollution Reduction									

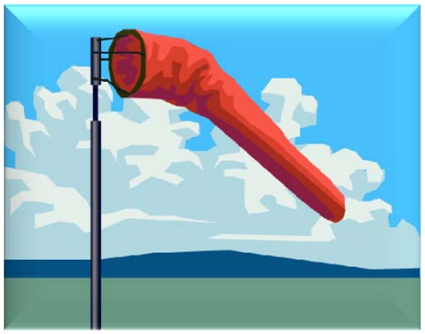
Why Vegetated Roofs?

- CDA desires to Lead By Example with a Visible Environmental Commitment
  - ORD visited by 67 million passengers in 2010
  - MDW visited by 17.6 million passengers in 2010
- SAM requires that vegetated roofs be installed wherever possible to reduce the heat island effect, conserve energy, and reduce storm water runoff
  - Consistent with LEED® 2009 credits
- Supports a broader City-wide interest in green roofs
  - With over 500,000 ft^2, Chicago is the green roof capital of the U.S.



Airport-Specific Vegetated Roof Considerations

Wildlife	• Concern that plants could attract wildlife hazardous to aircraft operations
"Mission Critical"	• Essential to maintain runway lighting, airport traffic control, and other equipment located underneath roofs
Wind Uplift and FOD	• Foreign Object Debris could damage aircraft and vehicles
Maintenance	• Plants may require maintenance in secured and/or restricted areas (permits, badging, security)
Plant survivability	• Plants subject to unobstructed Chicago winds, including wind sheer off buildings and aircraft that can cause drought
Cost ($$) versus benefits	• Anticipated benefits of installing and maintaining vegetated roofs must outweigh the costs



Plant Species & Wildlife

- Sedum species were chosen for their tolerance to drought, lack of food production (berries or seeds), and deficiency of habitat, thereby reducing their attractiveness to wildlife
- All species are native to North America

Sedum Species	Common Name	Flower	Height (cm)
album	White Stonecrop	White	5-10
sexangulare	Tasteless Stonecrop	Yellow	5-10
spurium	Dragon's Blood Stonecrop	Pink	10-15
relfexum	Blue Spruce	Yellow	10-15
floriferum	Weihenstephaner Gold	Yellow	10-15
kamtschaticum	Orange Stonecrop	Yellow	10-15
acre	Goldmoss Stonecrop	Yellow	5-10

Wind Uplift and Foreign Object Debris (FOD)

- FOD potential reduced by designing vegetated roofs in compliance with the wind speed requirements identified in Factory Mutual Global Property Loss Prevention Data Sheet 1-35: “Green Roof Systems”
- Fully adhered = assembled directly on the roof

Vegetated Roof Structure

- Extensive Vegetated Roofs
  - Profile < 6”
  - Fully saturated weight from 10-50 pounds per ft^2
    - (intensive systems require > 1 foot soil plus irrigation & drainage systems)
- Contract requires maintenance/irrigation for up to 2 years
  - Protects from heavy wind updrafts, soil erosion, & direct sunlight exposure

Sedum Species

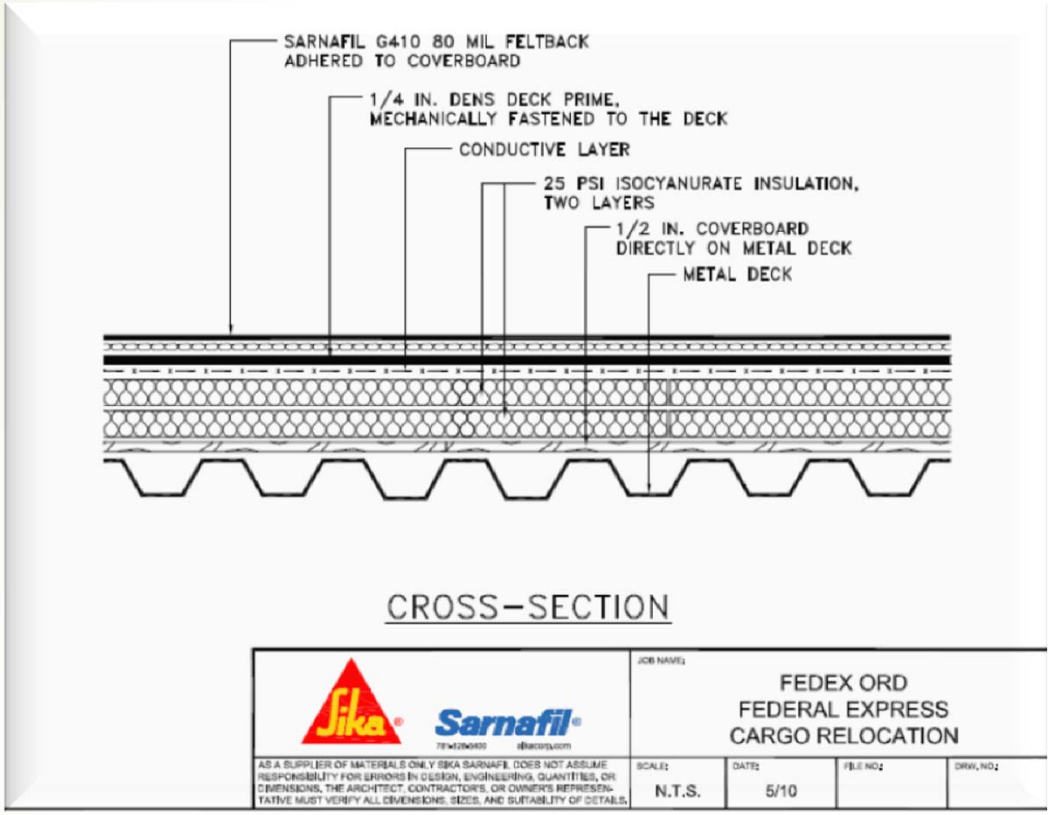
Engineered Soil

Filter Fabric

Moisture Retention Layer

Structural Loads

FedEx O'Hare Roofing System Section



O'Hare and Midway Vegetated Roof Inventory

Location of Existing Vegetated Roofs	Vegetated Area (ft^2)	Year Completed
ORD Aircraft Rescue and Firefighting Station #3	3,440	2006
ORD Guard Post #1 Canopy	6,500	2007
ORD South Airfield Lighting Control Vault	14,200	2008
ORD North Airport Traffic Control Tower Base Building	8,910	2008
ORD North Airport Traffic Control Tower Electrical Building	917	2008
ORD Booster Pump Station (Building 815)	1,278	2008
ORD FedEx Vehicle Maintenance Building	3,170	2009
ORD FedEx World Services Center	10,024	2010
ORD FedEx Main Sort Building	174,442	2010
ORD Enterprise Rental Car Maintenance Building	3,627	2010
ORD Enterprise Rental Car Customer Service Center	2,847	2010
MDW Economy Parking Structure and Electrical Vault (Combined)	3,179	2008
SUBTOTAL (Existing)	**232,534**	
Vegetated Roofs under Construction/Proposed		
ORD United Airlines Cargo Building	108,816	
MDW Consolidated Rental Car Facility	17,640	
TOTAL (Existing + Proposed)	**358,990**	

O'Hare Green Roofs

ORD Aircraft Rescue & Firefighting (ARFF) Station #3

- Size: 3,440 ft^2
- Year: 2006
- Chicago Rank: 29
- World Rank: 442

ORD Guard Post #1 Canopy

- Size: 6,500 ft^2
- Year: 2007
- Chicago Rank: 25
- World Rank: 324

O'Hare Green Roofs (continued)

South Airfield Lighting Control Vault

- Size: 14,200 ft^2
- Year: 2008
- Chicago Rank: 15
- World Rank: 189

"Mission Critical" – Provides and regulates power for new and future runway & taxiway lighting

O'Hare Green Roofs (continued)

North Airport Traffic Control Tower Base Building

- Size: 8,910 ft^2
- Year: 2008
- Chicago Rank: 15
- World Rank: 269

North Airport Traffic Control Tower Electrical Building

- Size: 917 ft^2
- Year: 2008
- Chicago Rank: 40
- World Rank: 634

1st on-airport FAA facility in the nation with a vegetated roof

Critical airport traffic control equipment is housed underneath the vegetated roof in the administration and electrical buildings

Worked with University of Illinois Center of Excellence for Airport Technology and a local contractor to find a mix of plant material that is less attractant to wildlife

O'Hare Green Roofs (continued)

ORD Enterprise Rental Car Maintenance Building

- Size: 3,627 ft^2
- Year: 2010
- Chicago Rank: 28
- World Rank: 431

ORD Enterprise Customer Service Center

- Size: 2,847 ft^2
- Year: 2010
- Chicago Rank: 32
- World Rank: 480

ORD Booster Bump Station (ORD Building 815)

- Size: 1,278 ft^2
- Year: 2010
- Chicago Rank: 38
- World Rank: 594

Midway Green Roofs

MDW Economy Parking Structure & Electrical Vault

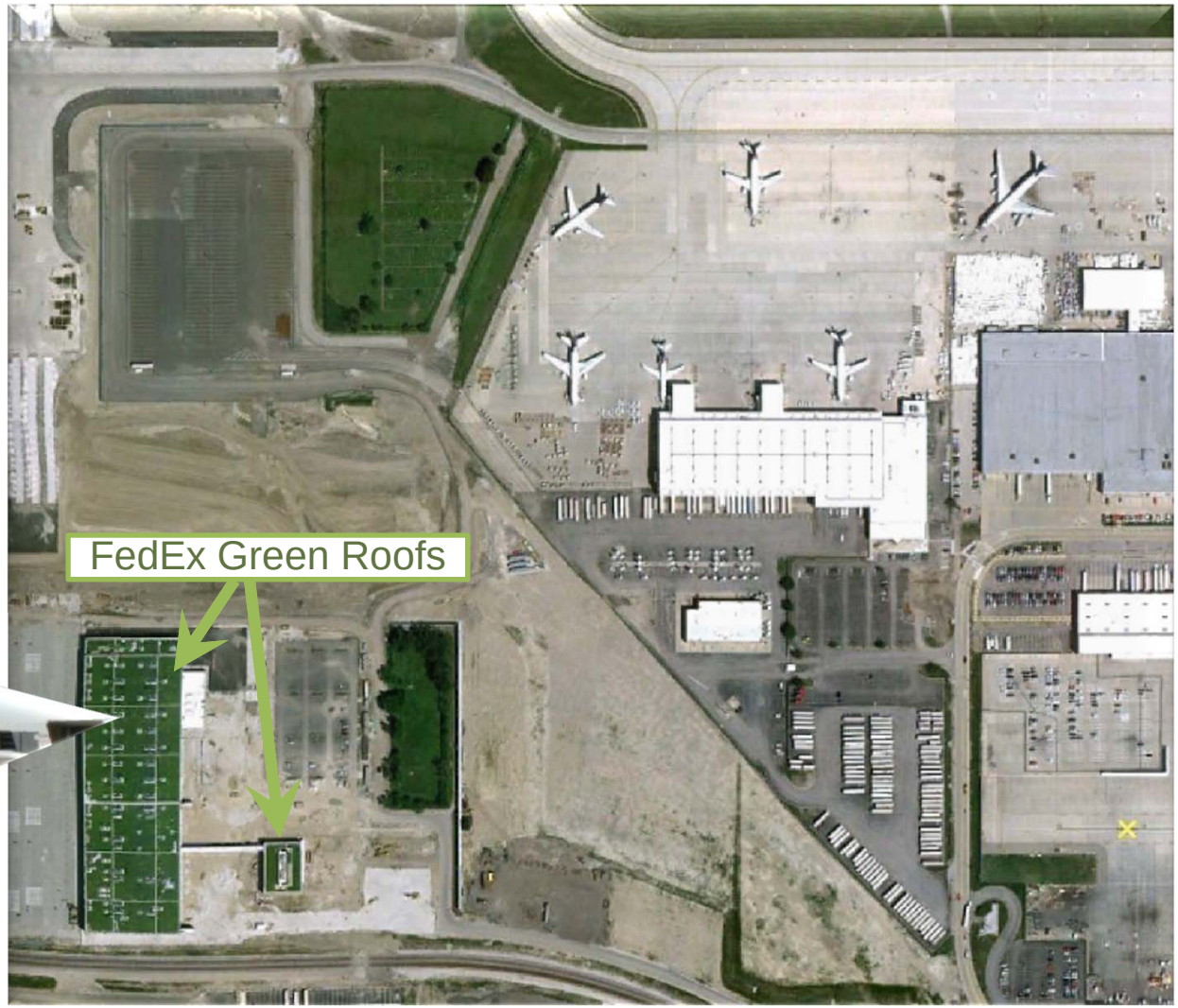
- Size: 3,040 ft^2 (combined)
- Year: 2008
- Chicago Rank: 31
- World Rank: 459

O'Hare Green Roofs (continued)

FedEx Main Sort Building

- Size: **174,442 ft²**
- Year: 2010
- Chicago Rank: 3
- World Rank: 25

Largest at any airport in the world ~ 3.5 football fields!



O'Hare Green Roofs (continued)

FedEx World Services Center

- Size: 10,024 ft^2
- Year: 2010
- Chicago Rank: 18
- World Rank: 236

FedEx Vehicle Maintenance Building

- Size: 3,170 ft^2
- Year: 2010
- Chicago Rank: 30
- World Rank: 448

Case Study – FedEx Main Sort Building

FedEx Corporate Environmental Mission Statement

- FedEx is committed to providing global connections while minimizing our environmental impact. We have integrated responsible environmental practices into our daily operations, and we continuously set goals that challenge us to increase efficiencies and reduce waste.

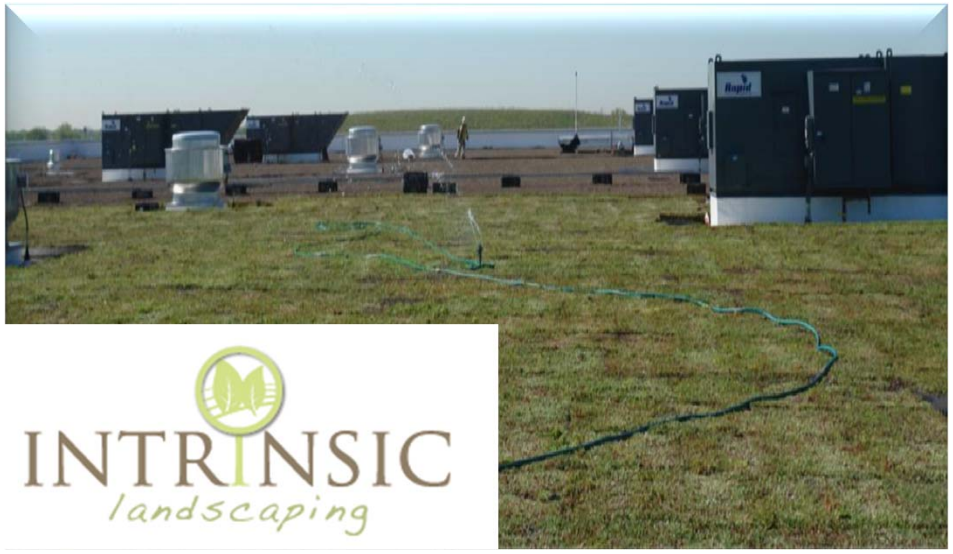
- Challenges:
  - Goals/Objectives different for CDA and FedEx
  - Did not necessarily embrace the City's goals up-front
  - Concessions on both sides
  - Factory Mutual Insurance Requirements
  - Roof as a staging area
  - Roof exposed over winter
  - Close proximity to aircraft engines - minimize FOD
  - Access to water
  - Working airside
  - Erosion control

Case Study – FedEx Main Sort Building

- Cost (174,442 ft^2)

Vegetation Cost	Roof Structure Cost	Total Cost
• $2,534,642 = $14.53 ft^2 (about 2X the cost of a normal roof)	• $1,815,941 = $10.41 ft^2 (negligible difference vs. normal roof)	• $4,350,583 = $24.94 ft^2

- 4” Extensive, pre-vegetated, fully adhered (installed on-site) vegetated roof



Case Study – FedEx Main Sort Building

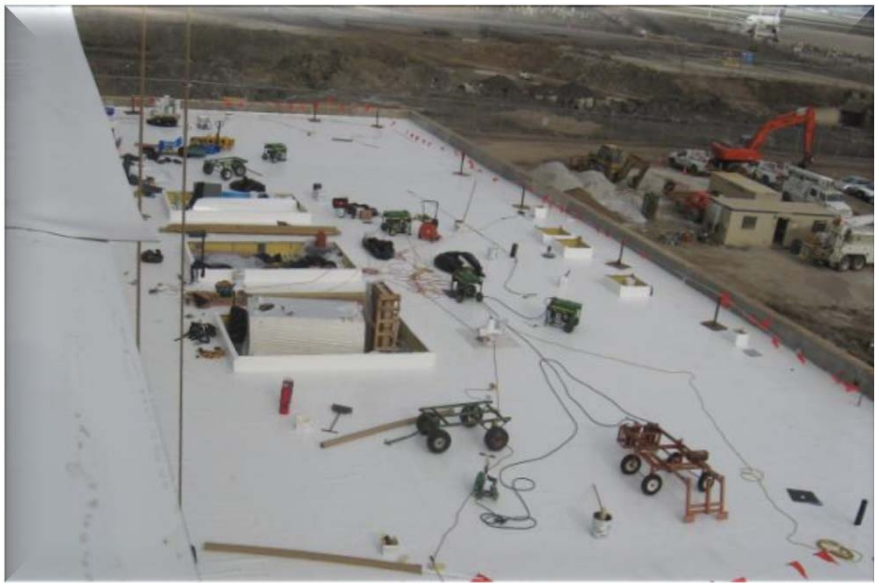
- 3 Buildings:
  - Sort Building – built in 17 days
  - Vehicle Maintenance Facility – built in 1 day
  - World Services/Admin Building – built in 1 day
- Roughly 5 football fields in total roof coverage
  - 2,000 yds^3 of growing media
  - 3.1 miles of edge restraint

Case Study – FedEx Main Sort Building

- Comprehensive 20 year warranty includes:
  - Water tightness
  - Success of plants
  - Overburden removal & replacement
- Single-source warranty landscape partner
  - Intrinsic Landscaping included since 2008
- Followed Factory Mutual Insurance Property Loss Prevention Data Sheets
  - FM 1-35 *Green Roof Systems* used as basis of design
  - FM 1-60 *Asphalt-Coated/Protected Metal Buildings* adhered roofing assembly for wind uplift protection
- Leak detection layer integrated into the roofing system
- 5 years maintenance included

Case Study – FedEx Main Sort Building

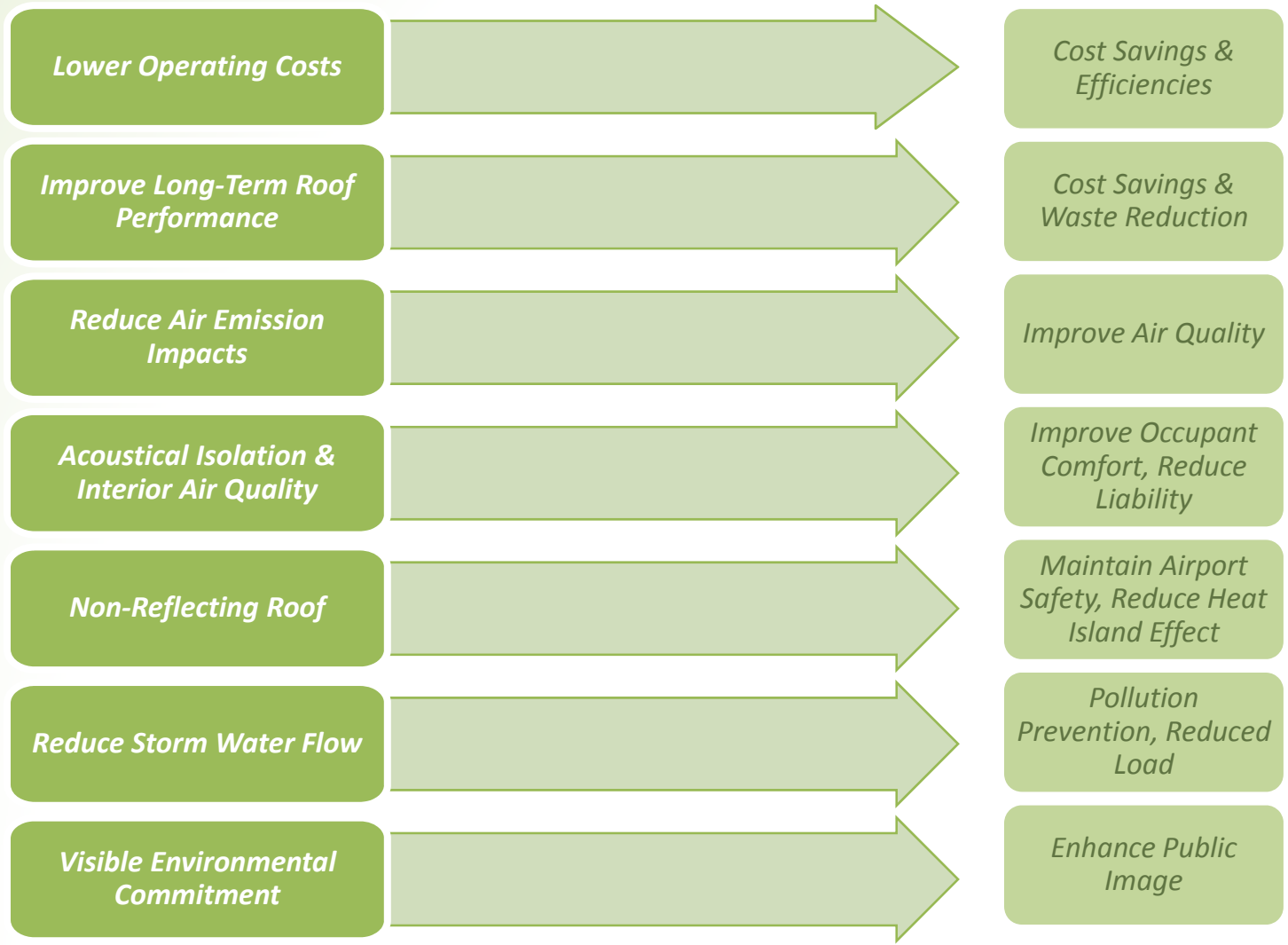
- Lessons learned:
  - Need buy-in from key stakeholders
  - Facilitation – learning, educating, reach out
  - Define goals early
  - Goals don't always align → find common ground
  - Not a perfect process; not an easy process
  - Be transparent



Life Cycle Cost Summary - Cargo

	Green Roof	Fully Adhered PVC	Cost Variance Green Roof to PVC
Roof *	$7.00 ft^2 – Insul/Membrane $6.00 ft^2 – Vegetation	$7.00 ft^2 - Insul/Membrane	+$6 ft^2
Structural *	$2.00 ft^2	$0.00 ft^2	+$2 ft^2
Irrigation *	$0.75 ft^2	$0.00 ft^2	+$0.75 ft^2
Total First Cost	$15.75 ft^2	$7.00 ft^2	+$8.75 ft^2
Energy Savings	-$0.20 ft^2/Year (-$4.10 ft^2/20 Years)	$0.00 ft^2	-$4.10 ft^2
Re-Roofing Cost *@15-20 Years	$0.00 ft^2	$9.00 ft^2 Includes tear off and re-roofing	-$9.00 ft^2
Total 20 Year Cost	**$11.65 ft^2**	**$16.00 ft^2**	**$-4.35 ft^2**

Green Roof Benefits



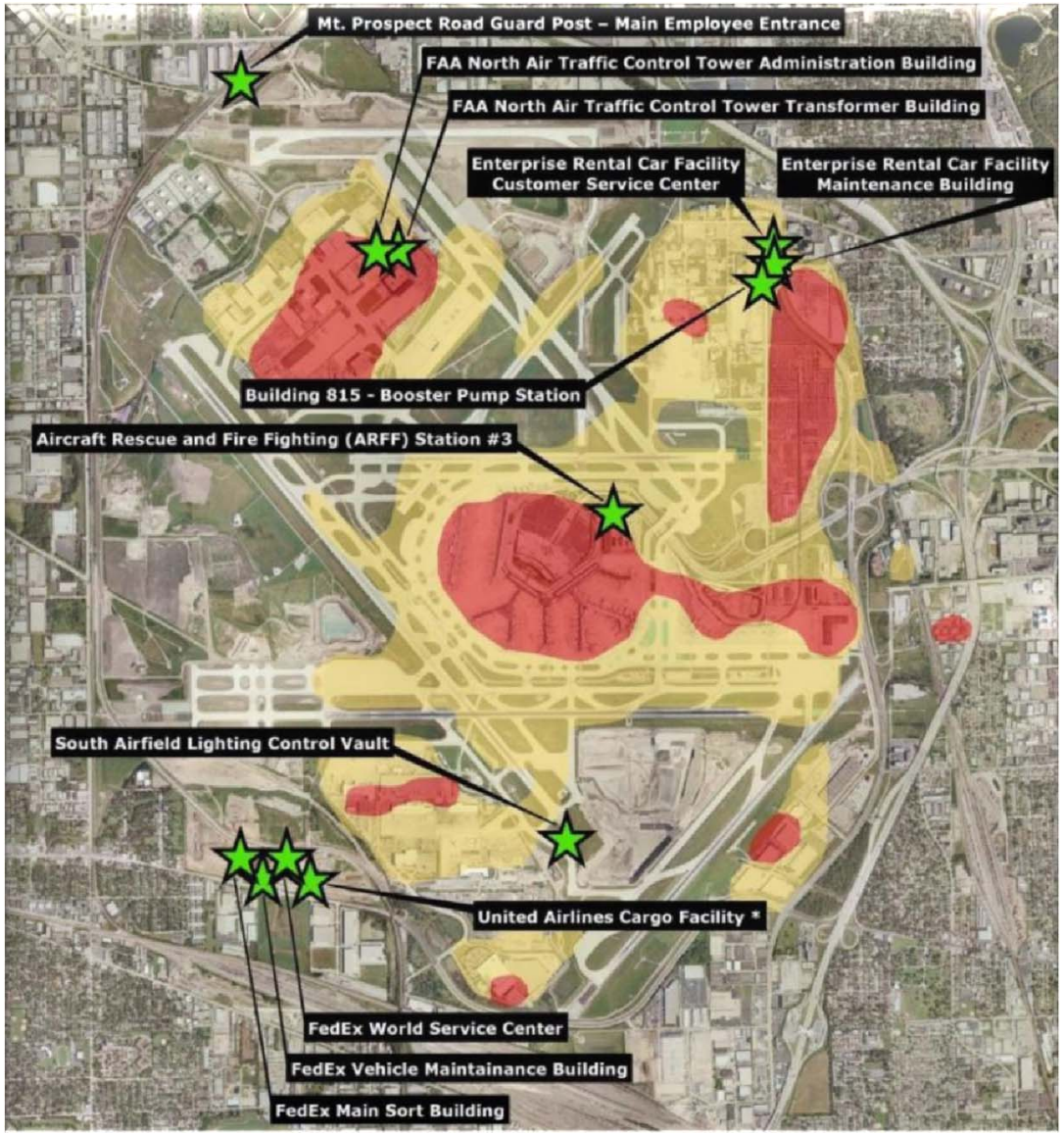
Green Roof Benefits

- Reduces Heat Island Effect
  - Heat Island – Urban area where temperature is hotter than the surrounding countryside because of large impervious surface areas
  - Leads to excessive energy consumption on cooling and air conditioning, and pollution from the generation of electricity

Heat Island Priority Tiers

Tier 1

Tier 2



Green Roof Benefits

- Increased Roof Life Cycle
  - Prolongs roof life from 15-20 years to 40-50 years, reducing maintenance & replacement costs
  - Protects roofing membrane from exposure to UV rays, temperature extremes, and precipitation
- Storm Water Retention
  - Increase storm water retention, filtration, and evaporation, and decrease the need to expand or rebuild drainage infrastructure
  - Retain 70-90% of the precipitation that falls on them during the summer and 25-40% in the winter
- Reduce Air Emission Impacts
  - Foliage absorbs dust and greenhouse gases and filters airborne particles
  - 1 m^2 of vegetated roof removes ~4.4 pounds of PM per year
    - 232,534 ft^2 total roof space = ~95,000 pounds of PM removed per year

Green Roof Benefits

- Noise Reduction
  - Absorb sound waves produced by machinery, traffic, and airplanes
    - A vegetated roof with a 4.7 inch substrate layer can reduce sound by 40 decibels
    - A 7.9 inch substrate layer can reduce sound by 46-50 decibels
- Aesthetics & Visibility
  - ORD had > 64 million passengers in 2009
  - Mount Prospect Road, or when flying overhead, making the CDA's commitment to the environment very visible.
  - Sedum species have white or yellow flowers and green, light green, or maroon foliage

Lessons Learned & Next Steps

- A vegetated roof pays for itself within 25-30 years
  - Varies on size, government subsidies, and the cost of electricity and water
- Many benefits cannot be quantitatively valued: reduction in heat island effect, noise reduction, air quality protection, and marketability
- Airports interested in vegetated roof technologies should:
  - Develop a sustainable design/construction policy and checklist for vegetated roofs
  - Understand mission-critical, FOD, and wildlife attractant considerations
  - Develop a cost-benefit evaluation of recommended installations
  - Coordinate with the end user to address design, construction, and O&M issues
  - Develop a material and installation specification
    - Include drought tolerant, low maintenance, and non-wildlife attracting plant species
  - Include a multi-year maintenance warranty that establishes watering, weeding, fertilizing, and replacement (as needed) procedures
  - Install meters/monitoring devices to quantify gained economic, operational, and environmental benefits
  - Promote achievements using kiosks, displays, brochures, and/or presentations

Thank You for Your Time

Eugene Peters, Ricondo & Associates, Inc.

1 (773) 462-7333

e-mail: epeters@ricondo.com

While focusing on providing our clients with financially, operationally, and environmentally sustainable solutions, we understand that our own continued success, the well-being of our employees, and the health of our planet also depends on our ability to operate in the most sustainable manner possible.

RICONDO®
& ASSOCIATES