Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

2014 Federal Audit Executive Council Annual Conference

September 3, 2014

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Report at a Glance

Project Controls Weak or Ineffective

- *Design*
- *Implementation*
- *Effectiveness*

Deficiency with 14 of 22 controls
Alpha Corporation Subject Matter Expert Report

Compressive Strength

Addition of Water

Test specimens indicate more water at end of pour than beginning

Cold Weather Curing

- *Incorrectly Implemented*
- *Protection not maintained*
- *Temperature maintenance and monitoring*

Concrete cured outside acceptable tolerances

Test Specimens Not Representative of In-Situ Concrete

Primary test specimens did not capture impact of water & cold

Concrete Placement

- *Thickness not uniform*
- *Early identification*
- *Unresolved*

Insufficient reinforcement cover evident
November 2010: Pour process never modified

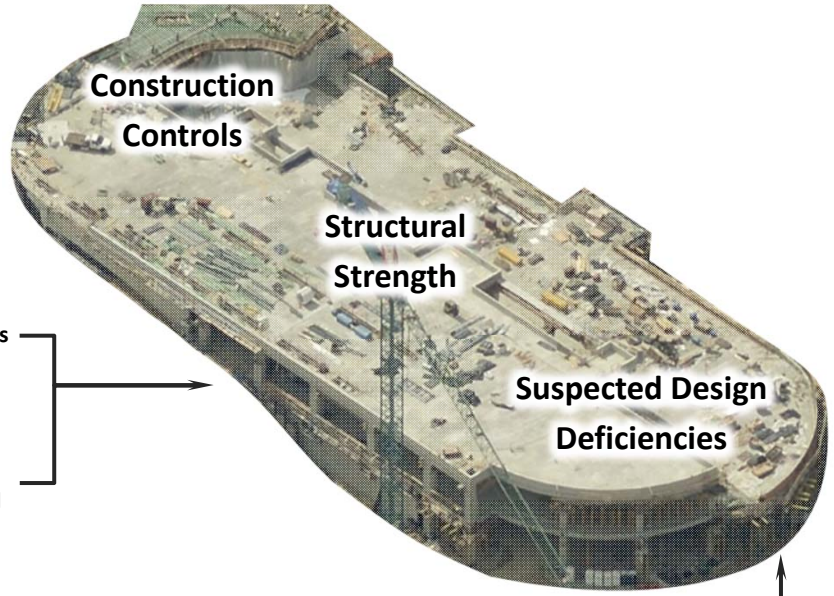
Pour Strip Construction Deficiency

- *Drawing submittal process weak*
- *Professional error*

No control to identify expected shop drawings
Drawing omissions not detected by reviewers

Contract Requirements Not Met

Deficiencies Not Detected



Thermal & Flexural Design Issues Identified Early Into Project

- *Directed to Structural Engineer of Record to resolve*
- *Cracking persisted throughout all stages of construction*

Despite early detection of cracking, project management did not effect correction

Structural Design & Construction Problems Not Effectively Addressed by Project Management

- *Repeatedly addressed at stakeholder meetings*
- *Not addressed effectively*

Project management responsibilities distributed among multiple stakeholders

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

The Paul S. Sarbanes Silver Spring Transit Center (SSTC)

A ground transportation facility located in downtown Silver Spring, Maryland at the intersection of Colesville Road and Wayne Avenue

Constructed by Montgomery County, to be operated by the Washington Metropolitan Are Transit Authority

Bus loops located on ground (Level 305) and second (Level 330) floors

Private vehicles and taxis use the third, smaller floor (Level 350)

Integrated with Metro Red Line and MARC Brunswick Line

KCE's post-construction structural evaluation of the superstructure recommended

Strengthening and repairs required to increase the combined shear and torsional capacity of certain beams and girders

Properly detailed concrete overlay on the top surface for the slabs of Levels 330 and 350 required to provide long-term durability.

Conditions at SSTC were caused in varying degrees by errors and omissions of:

- the designer, Parsons Brinckerhoff (PB)
- the contractor, Foulger-Pratt Contracting, LLC (FP) and its subcontractors, and
- the inspection and materials testing firm and Special Inspections Program Special Inspector, The Robert B. Balter Company (RBB)

Why Montgomery County Office of the Inspector General Did This Inspection

Our objective: Identify and document any project management deficiencies during the construction of the Silver Spring Transit Center.

We attempted to determine:

- which project management controls failed,
- how these controls should have functioned,
- why they failed,
- what the project managers did know, could have know, and should have know, and
- what measures should be taken to ensure controls will be effective in future projects undertaken by Montgomery County.

Construction history of the SSTC

Construction began in 2009

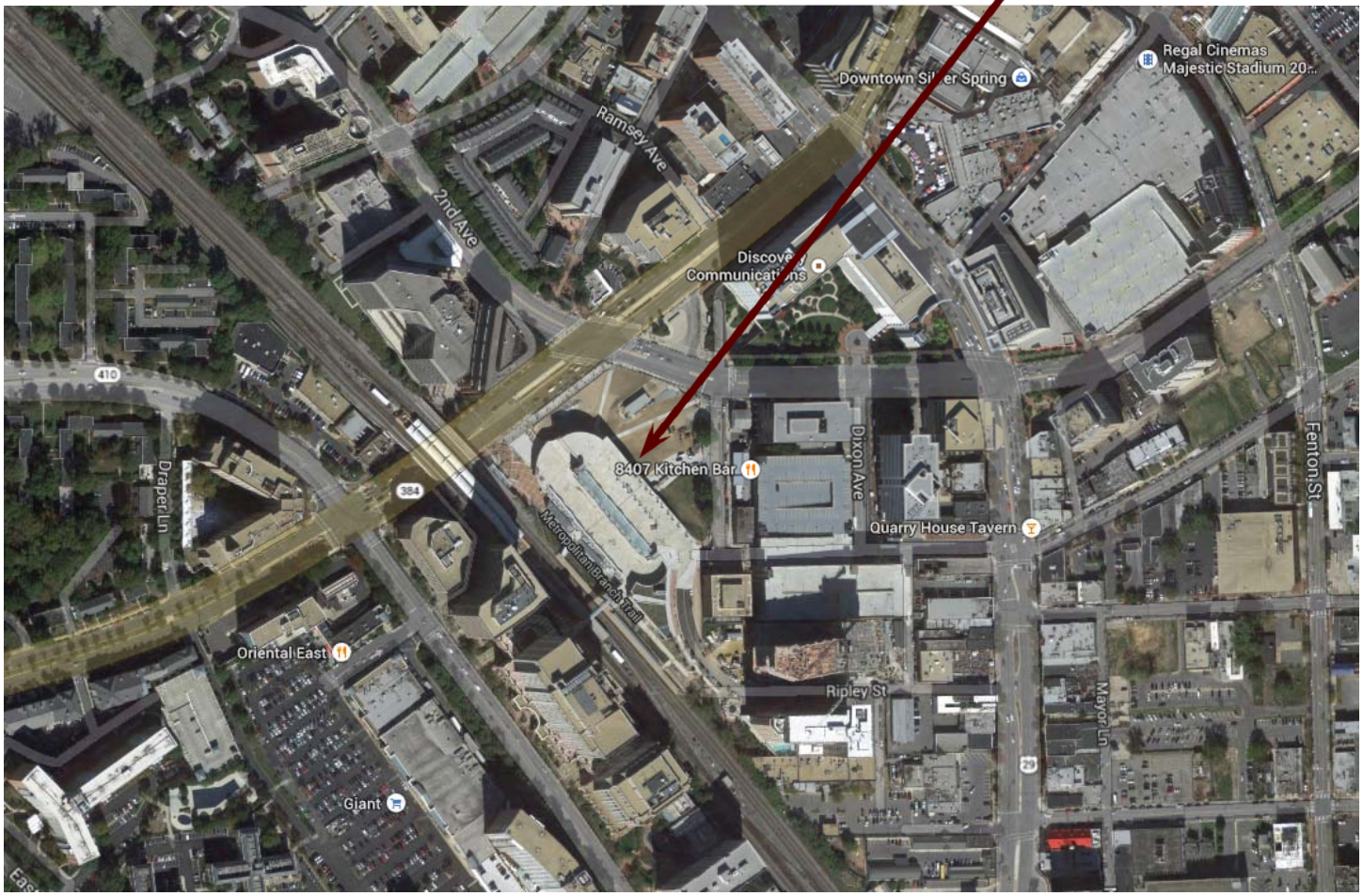
By June 2010, project already several months behind schedule due to unforeseen contaminated soil and utility relocations

By November 2010, visible evidence of structural issues and concerns about durability had emerged, including:

- Cracks discovered in the concrete slabs, beams and girders;
- Concrete that broke away from the finished drive surface (spalling), revealing post-tensioned tendons and evidencing that an insufficient concrete cover had been placed over the tendons;
- Issues related to post-tensioned tendon elongations and tensioning; and
- Reinforcing bars that were incorrectly installed or partially omitted in a slab pour.

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Location in downtown Silver Spring, Maryland
Intersection of Colesville Road and Wayne Avenue



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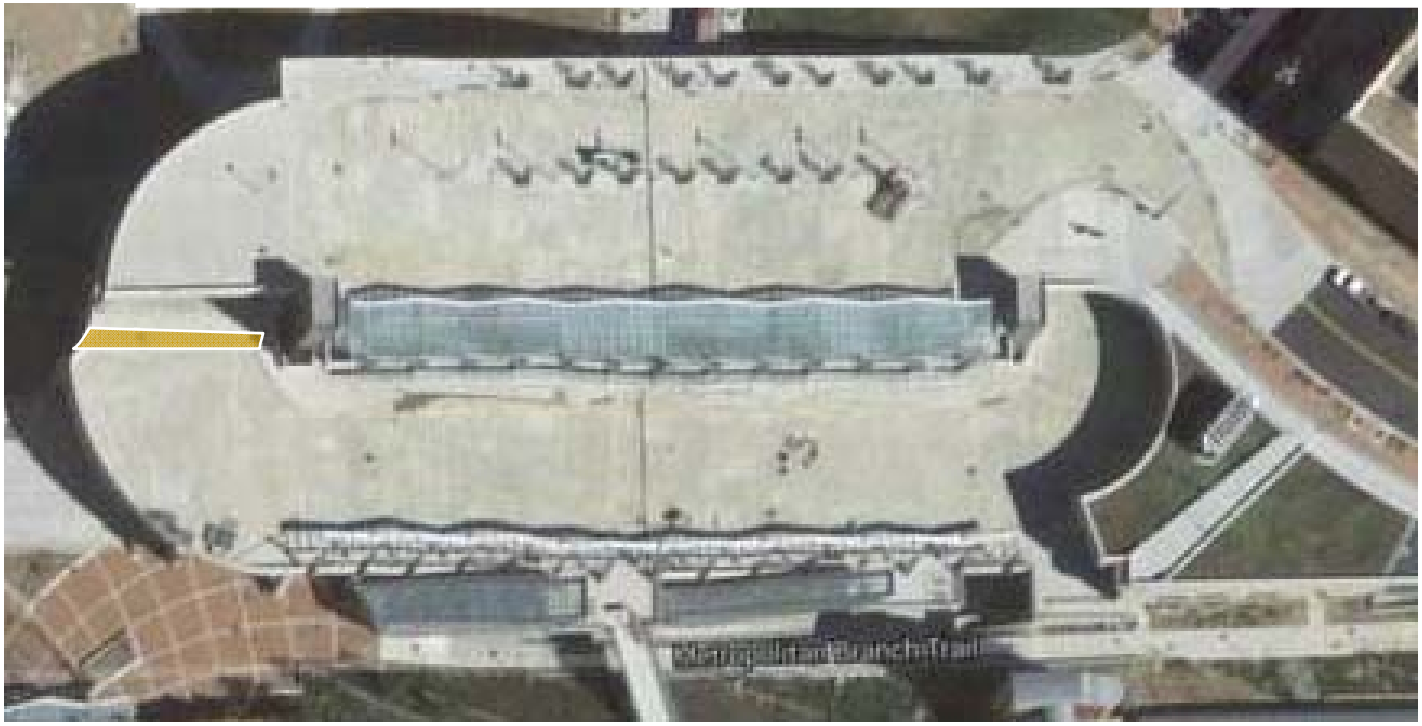
Timeline:

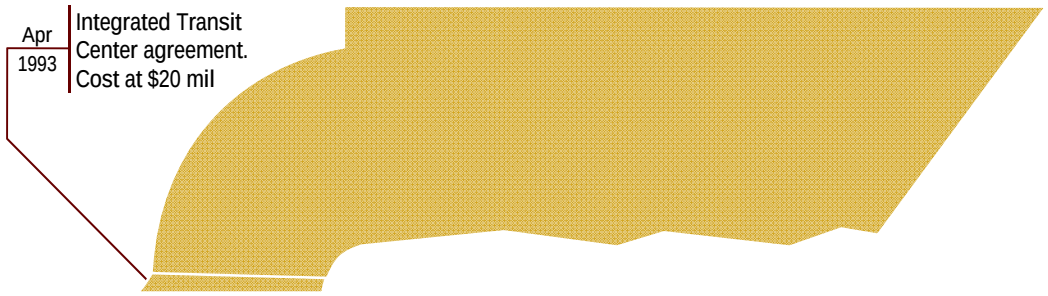
October, 1993 – April 2007:

MTA and County agree to MARC station relocation into new transit center. County Executive Douglas M. Duncan says the $20 million transit center will be complete in 1998.



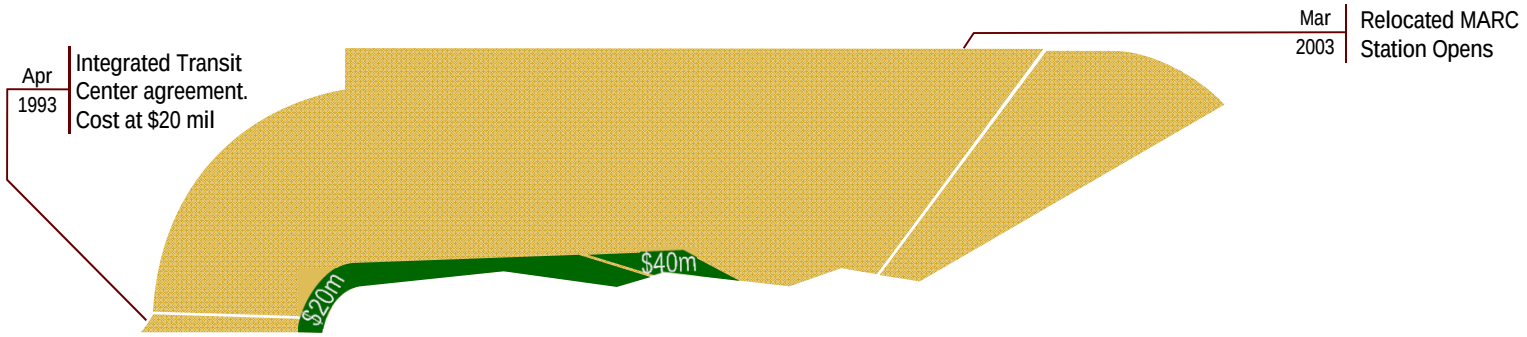
Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline: March, 2003: Relocated MARC station opens.



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline: April, 2004: Parsons Brinckerhoff awarded design contract.



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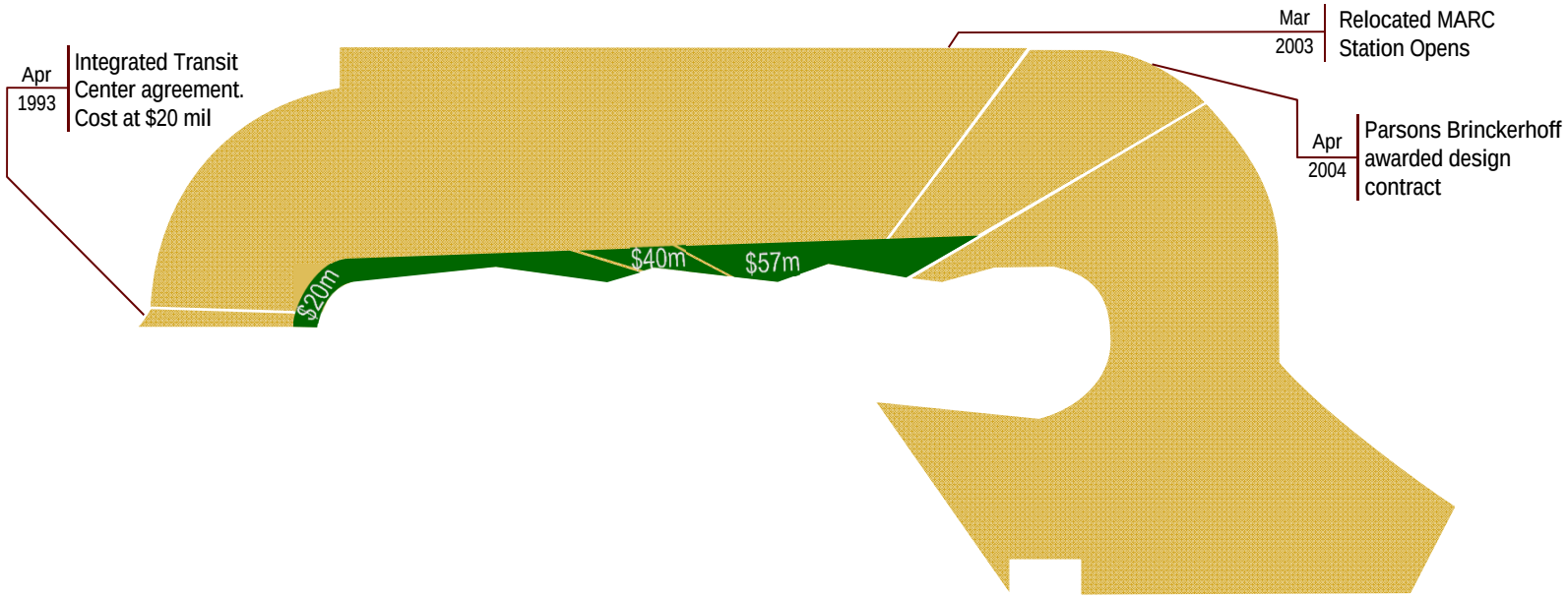
Timeline: May, 2008: Foulger-Pratt awarded construction contract.



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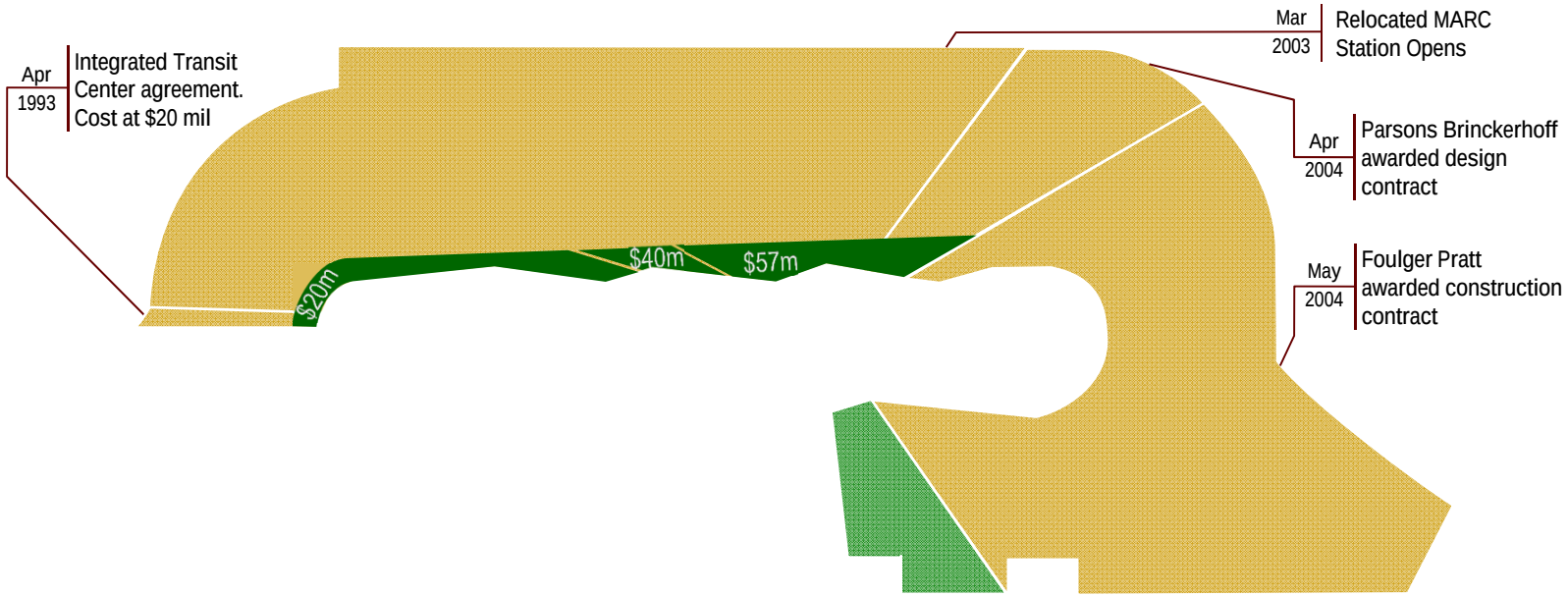
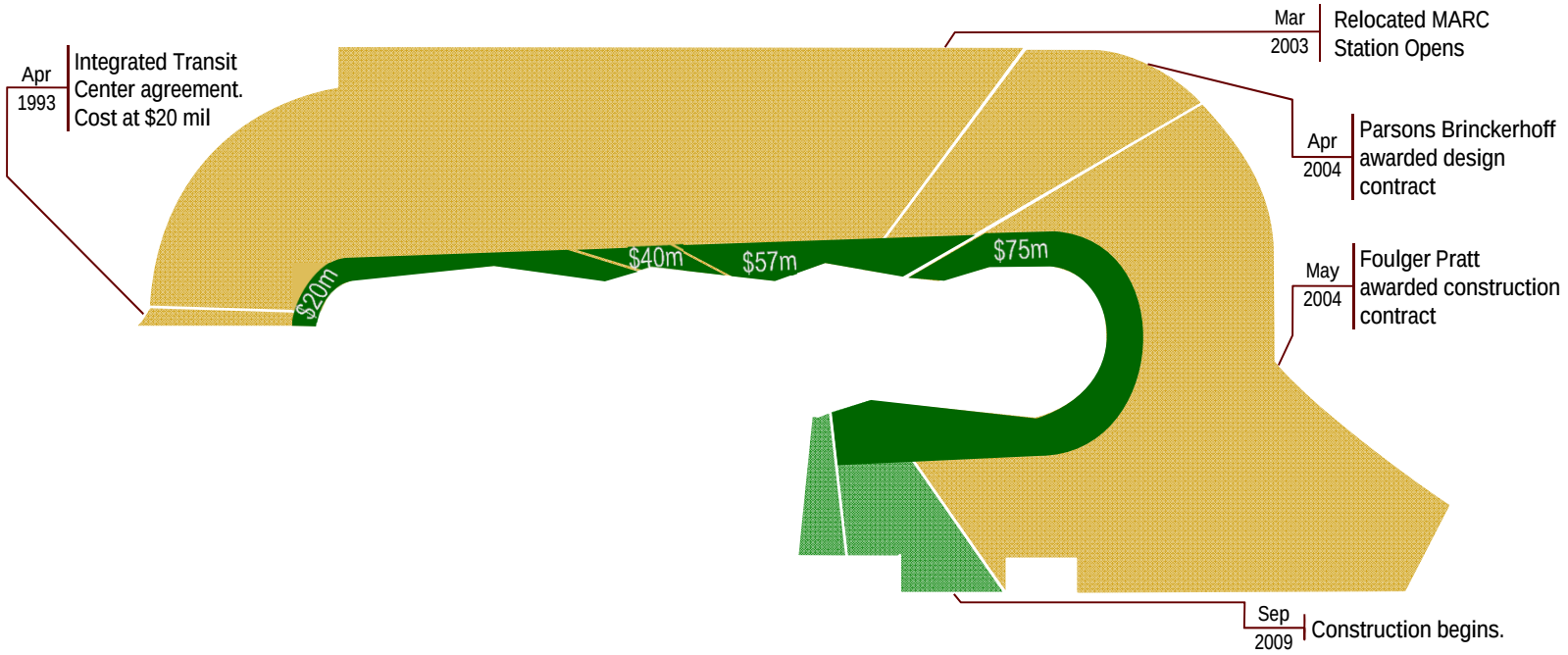
Timeline: September, 2009: Construction begins on Silver Spring Transit Center.



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline:

April, 2010: Montgomery County Department of Permitting Services inspector raises concerns that post tensioning of the slabs and girders with the built in wall would create a zone of cracking in the slabs along certain points. Project budget increases to $95 million.



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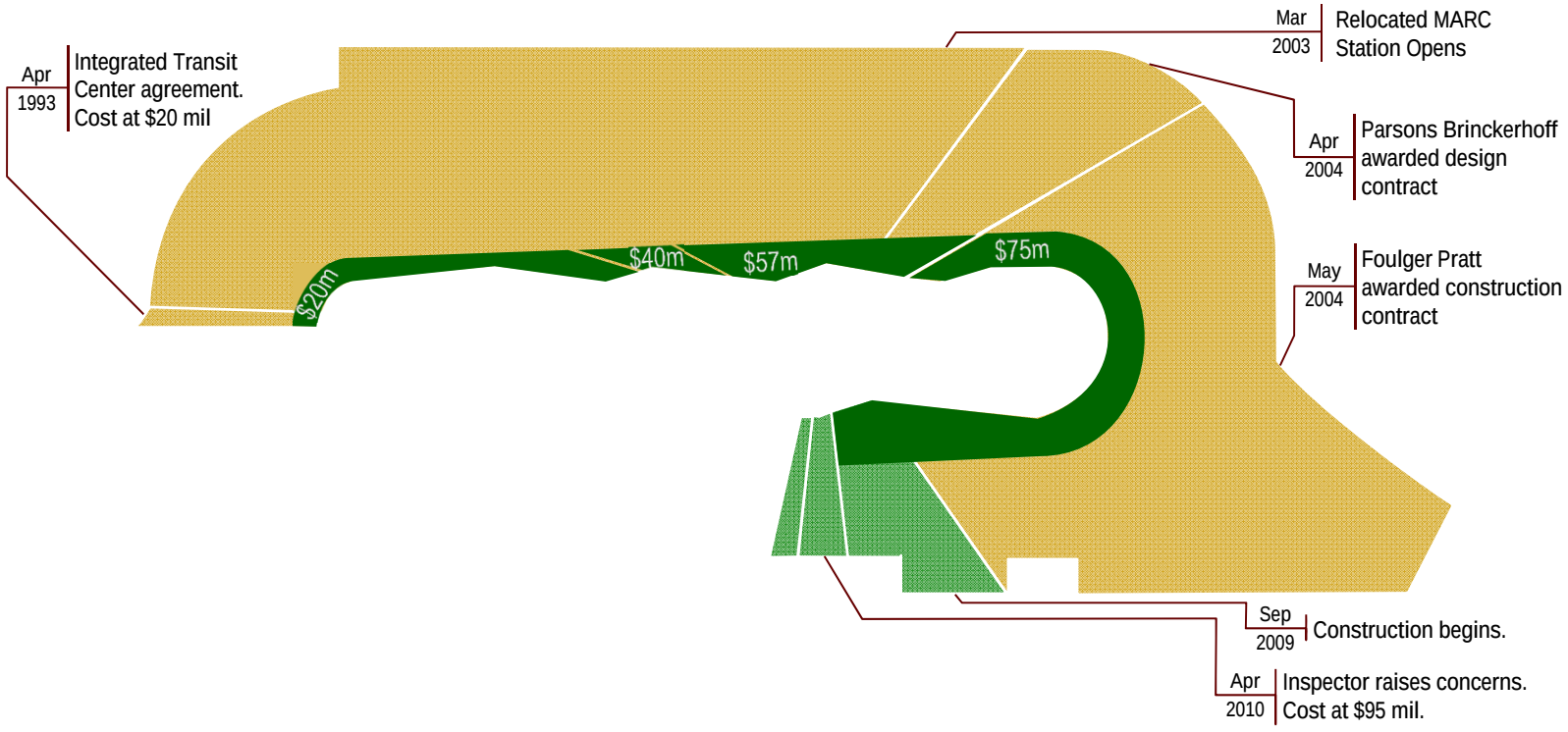
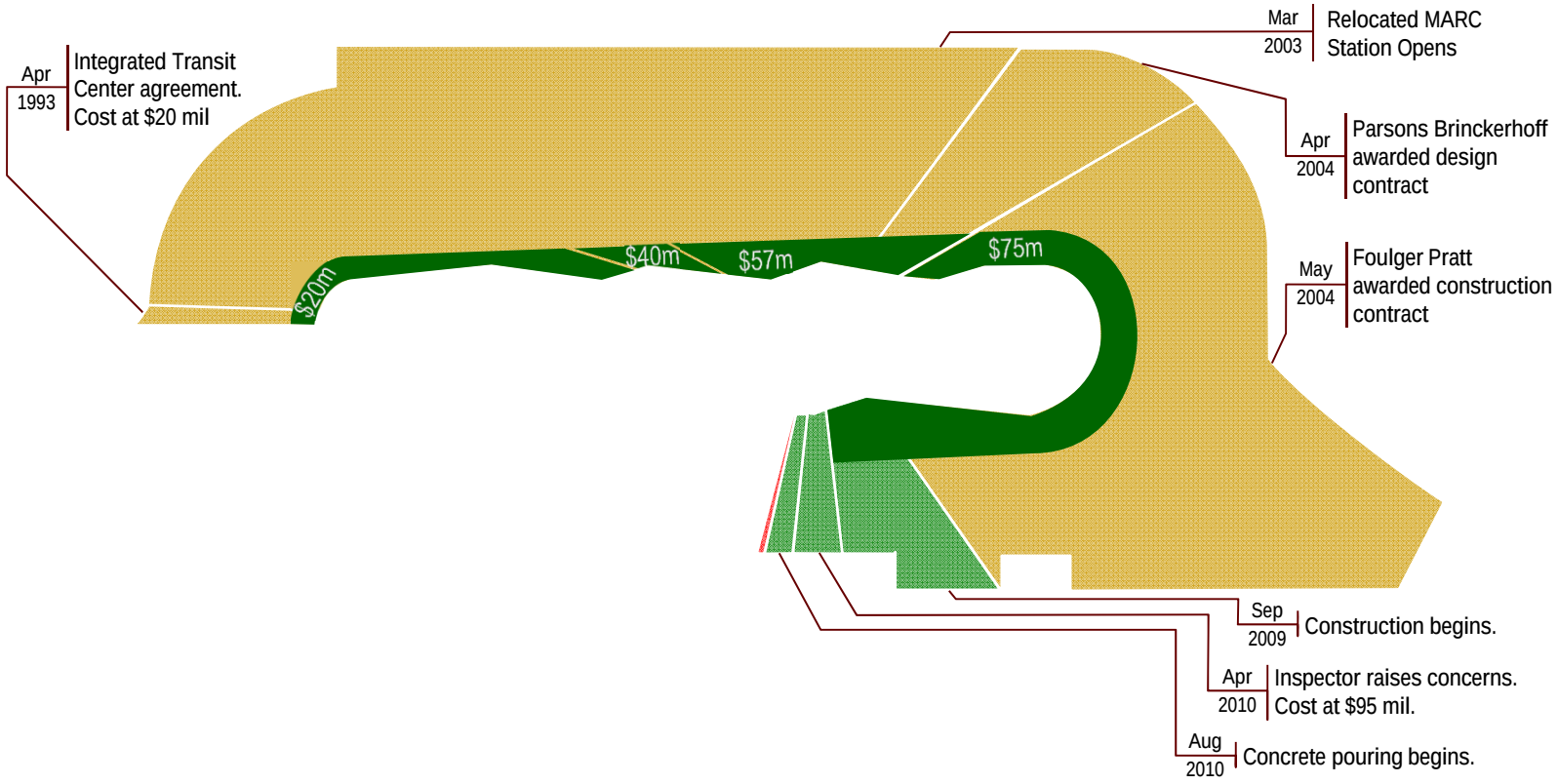
Timeline: August, 2010: Concrete pouring begins.



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline: September, 2010: Cracking first observed and workers report concrete is too thin in some areas of the center.



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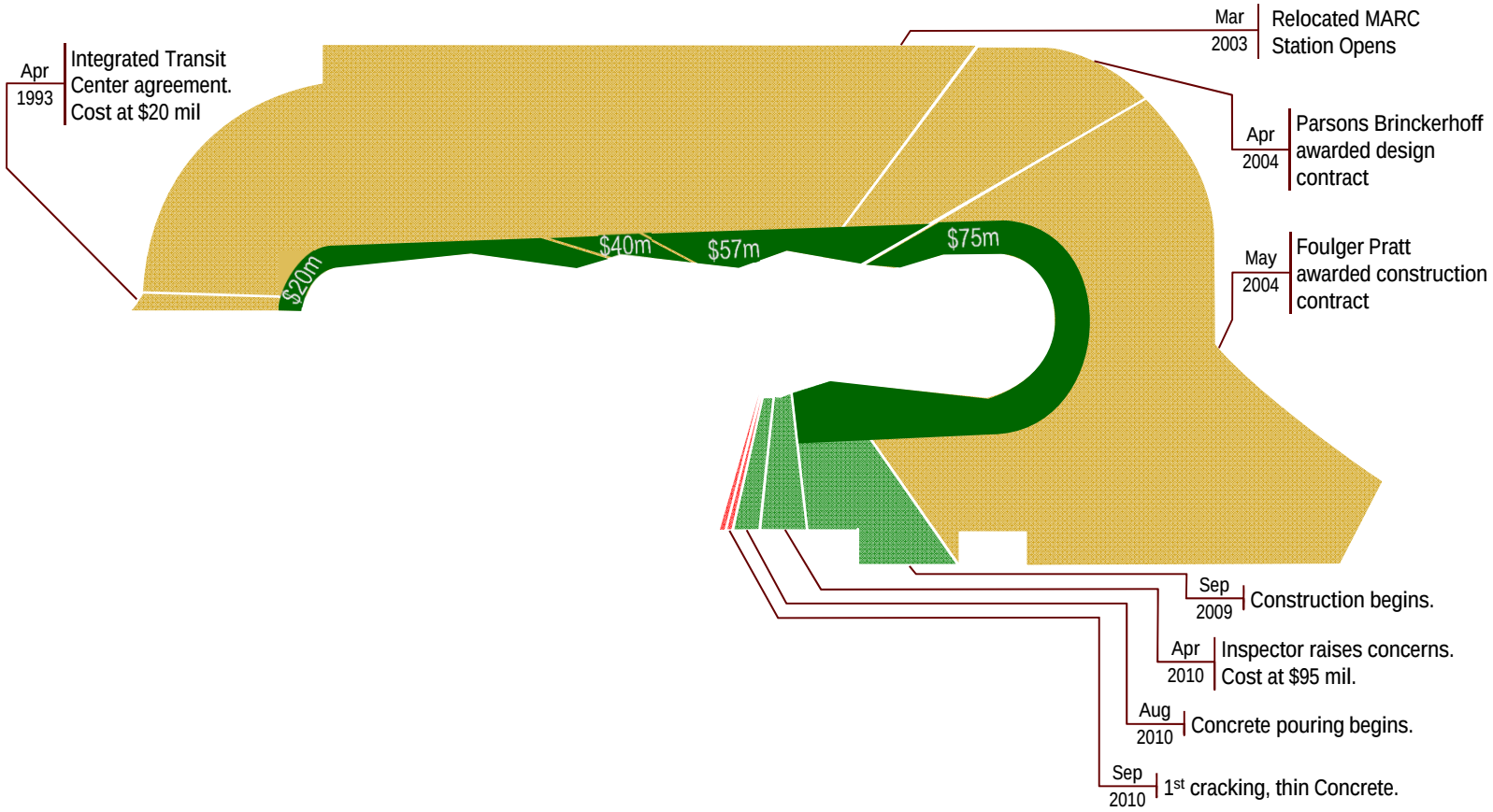
Timeline:

October, 2010: Cracking observed in concrete slabs in some areas before post-tension commences. Spalling observed.



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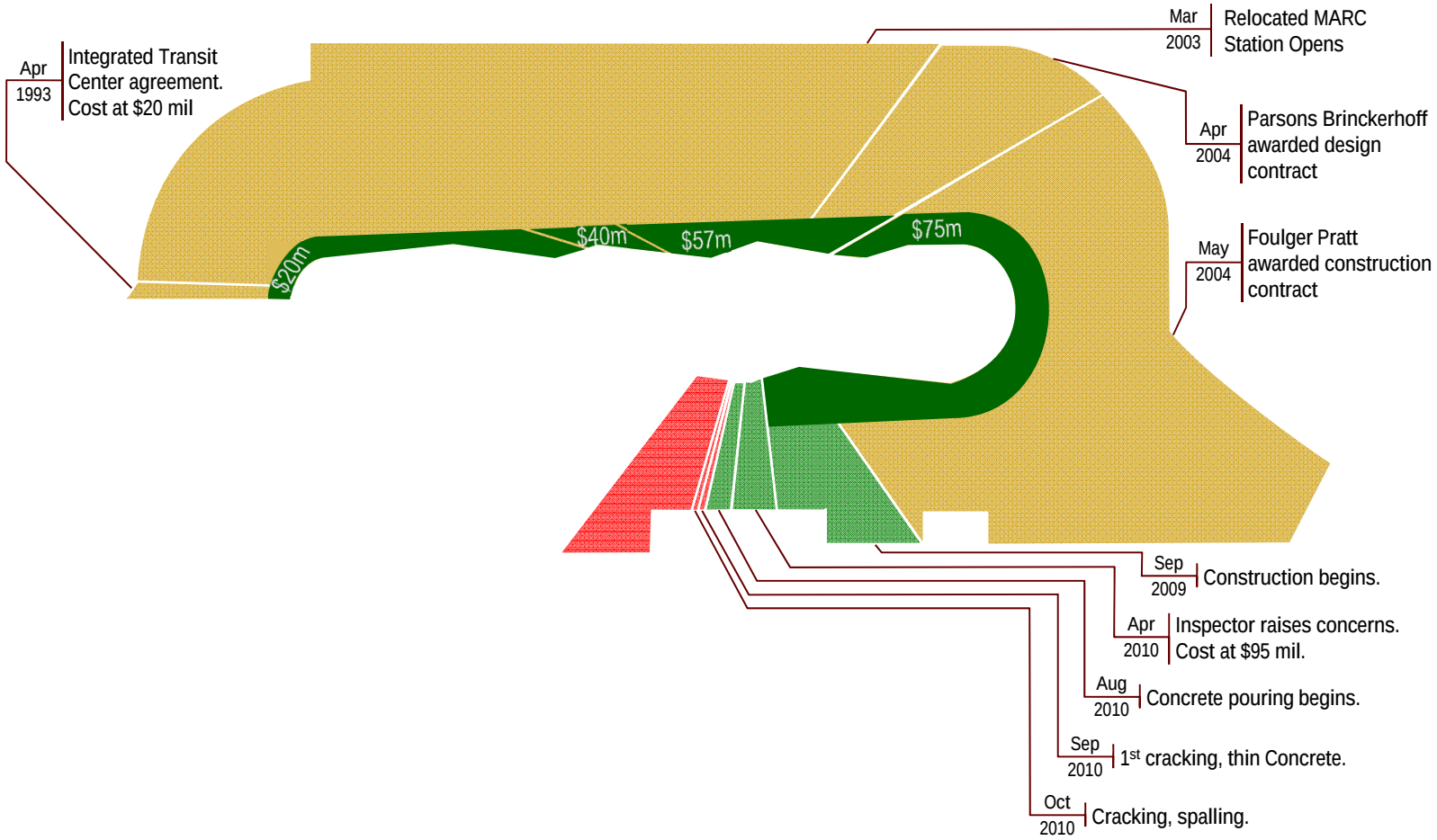
Timeline: October, 2011: Project Management Plan maintained by project team indicates Substantial Completion of Project Construction milestone is achieved.



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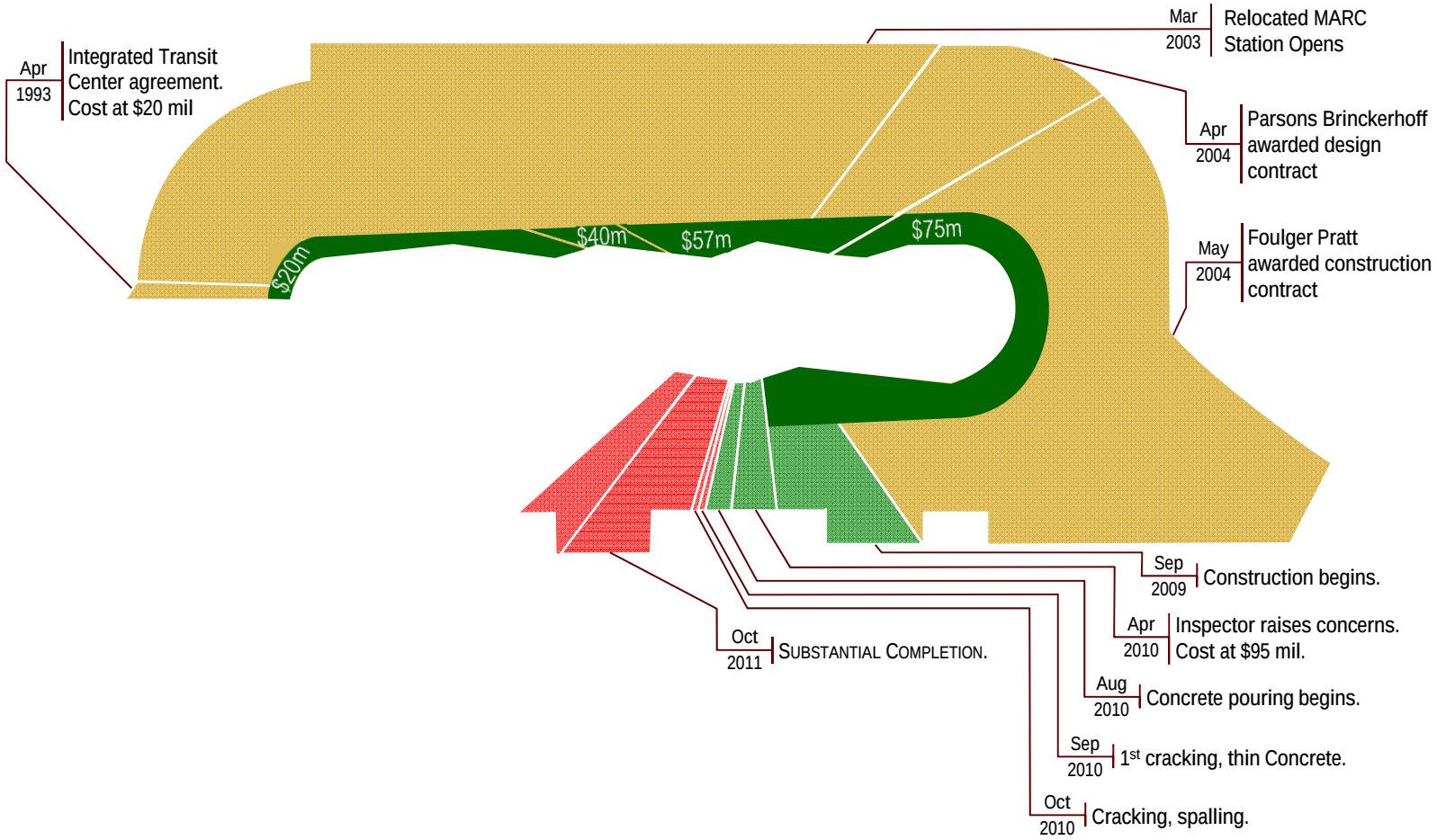
Timeline:

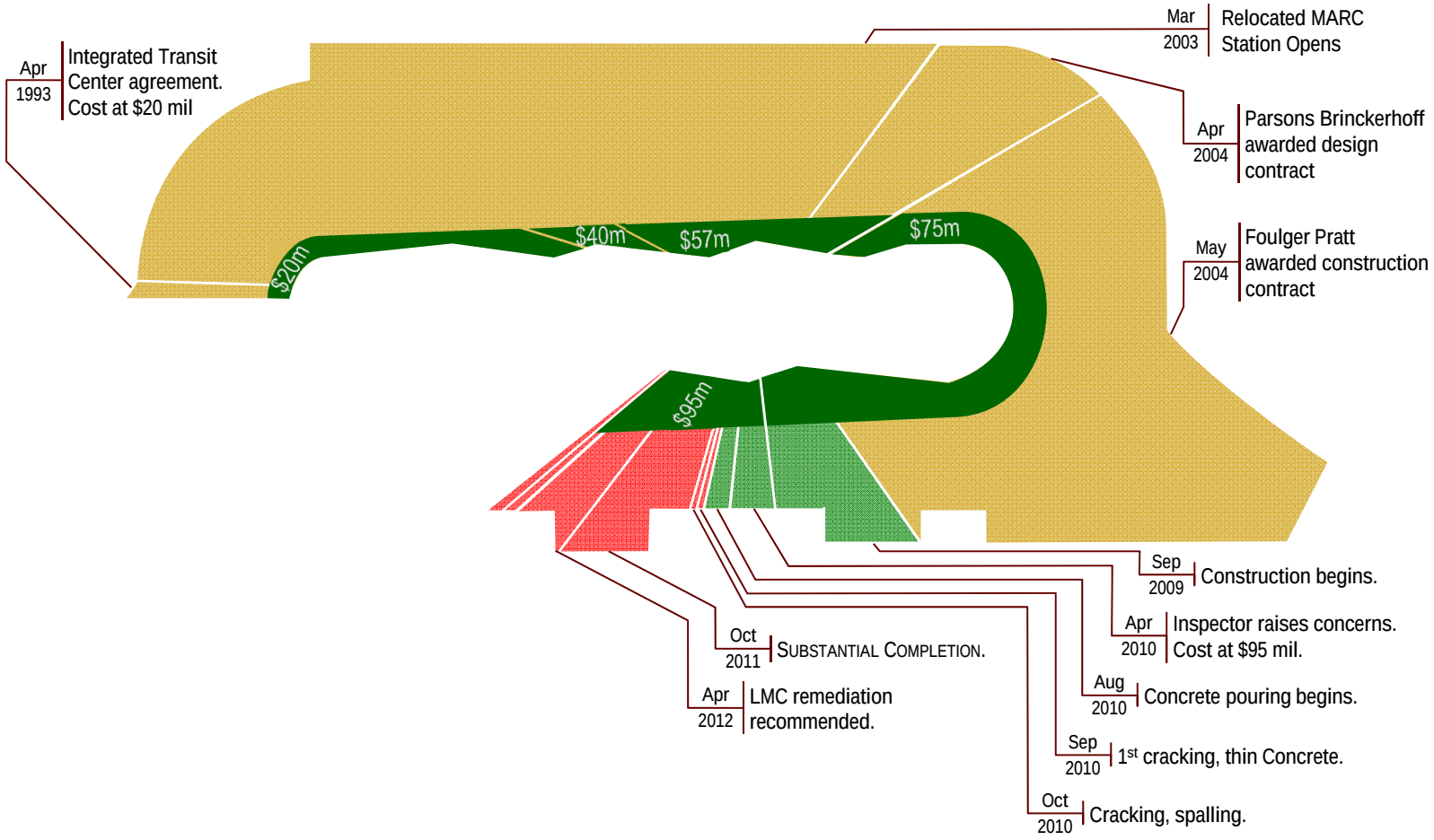
April, 2012: Remediation plan incorporating 2 inch Latex Modified Concrete (LMC) overlay is recommended.



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline:

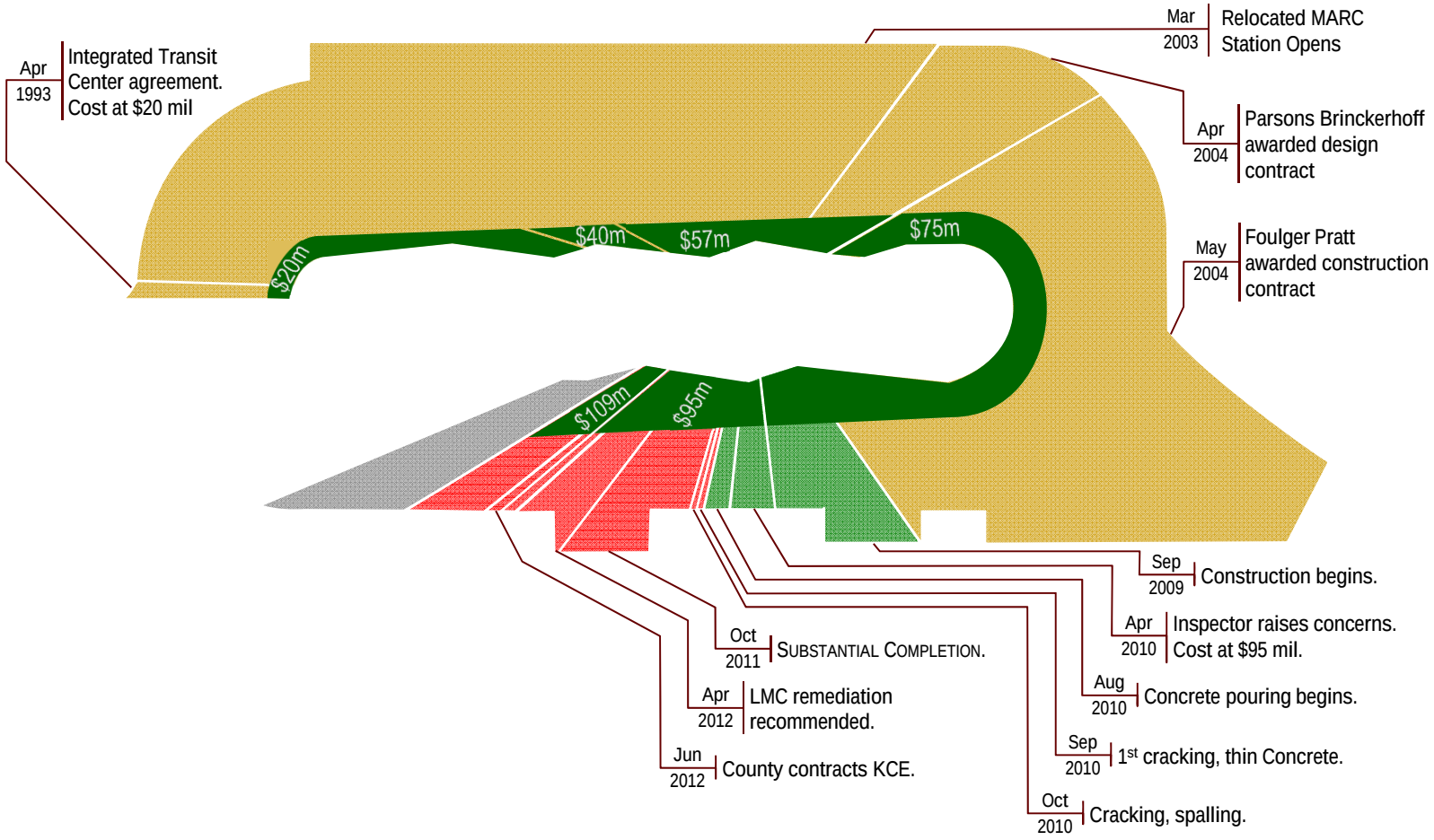
May, 2012: Montgomery County contracts with KCE Structural Engineers, P.C. (KCE) to conduct a document review and structural evaluation of in-situ conditions at the SSTC



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline:

March, 2013: KCE Structural Engineers issues report on the SSTC stating the facility is "severely compromised" and requires extensive remedial strengthening and repair to meet Building Code and WMATA requirements.



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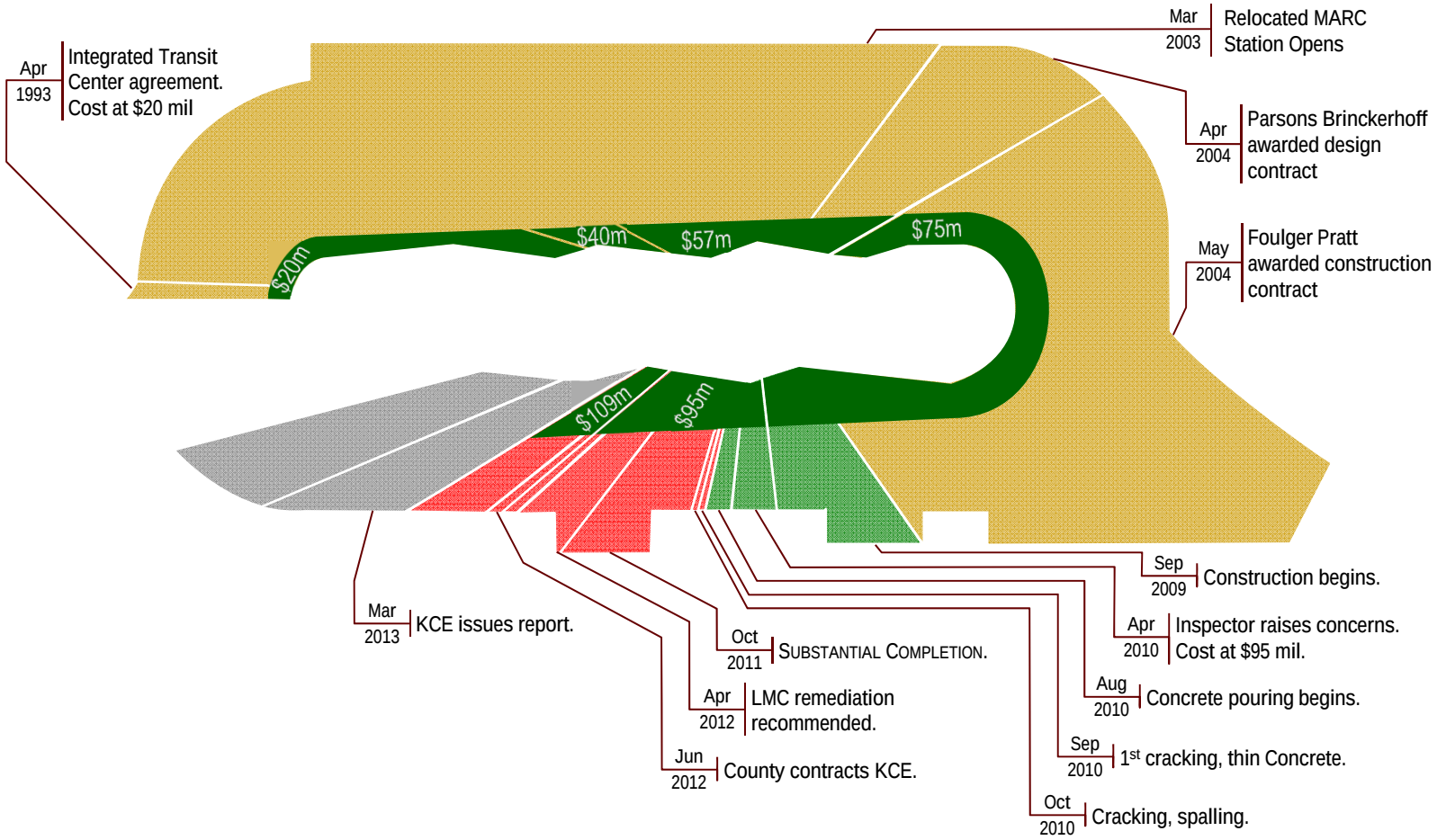
Timeline: July, 2013

OIG advises Montgomery County Chief Administrative Officer that it will conduct an inspection to identify and document any project management deficiencies during the construction of the Silver Spring Transit Center.



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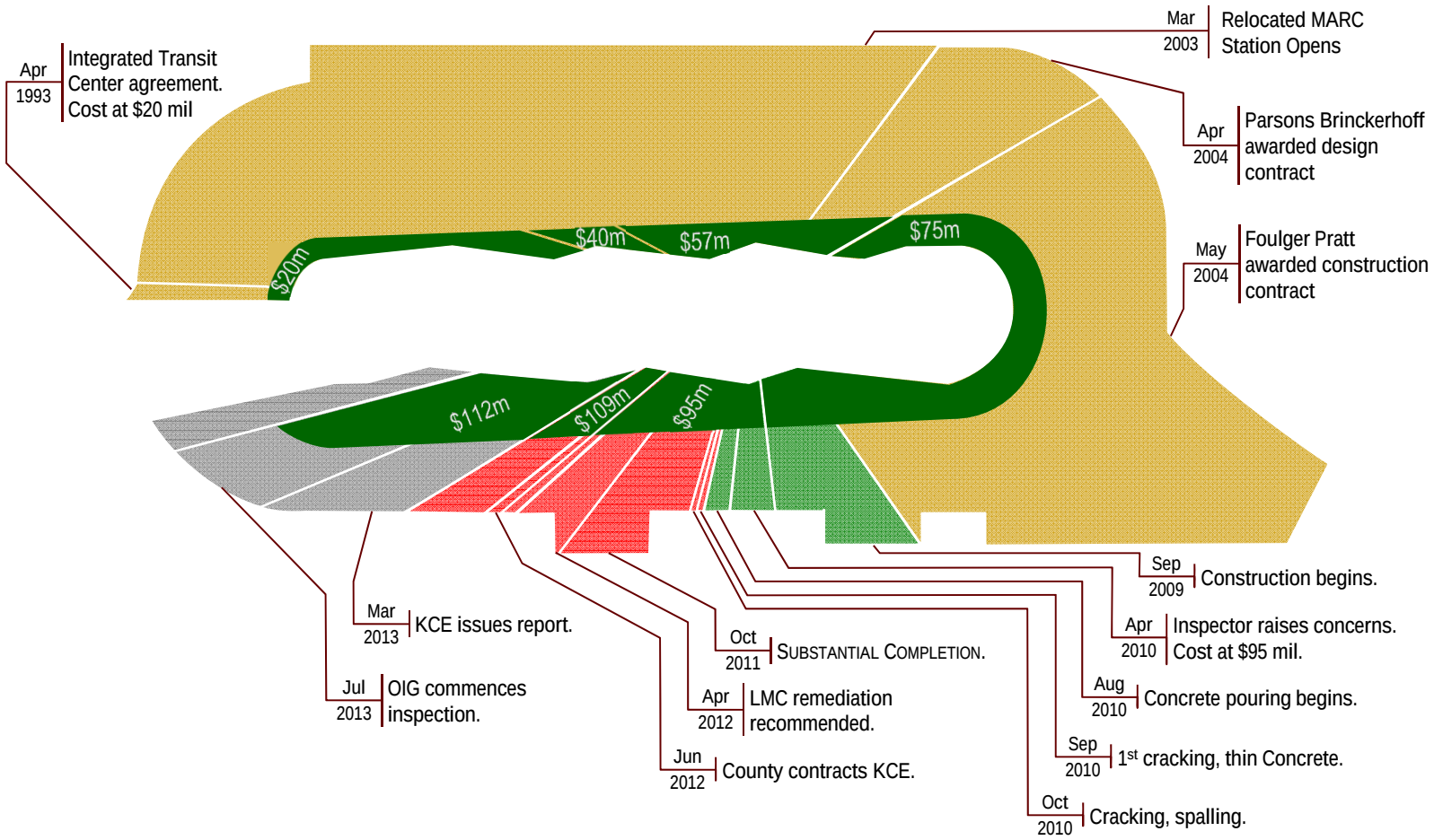
Timeline: September, 2013: Latex Modified Concrete (LMC) overlay remediation approved



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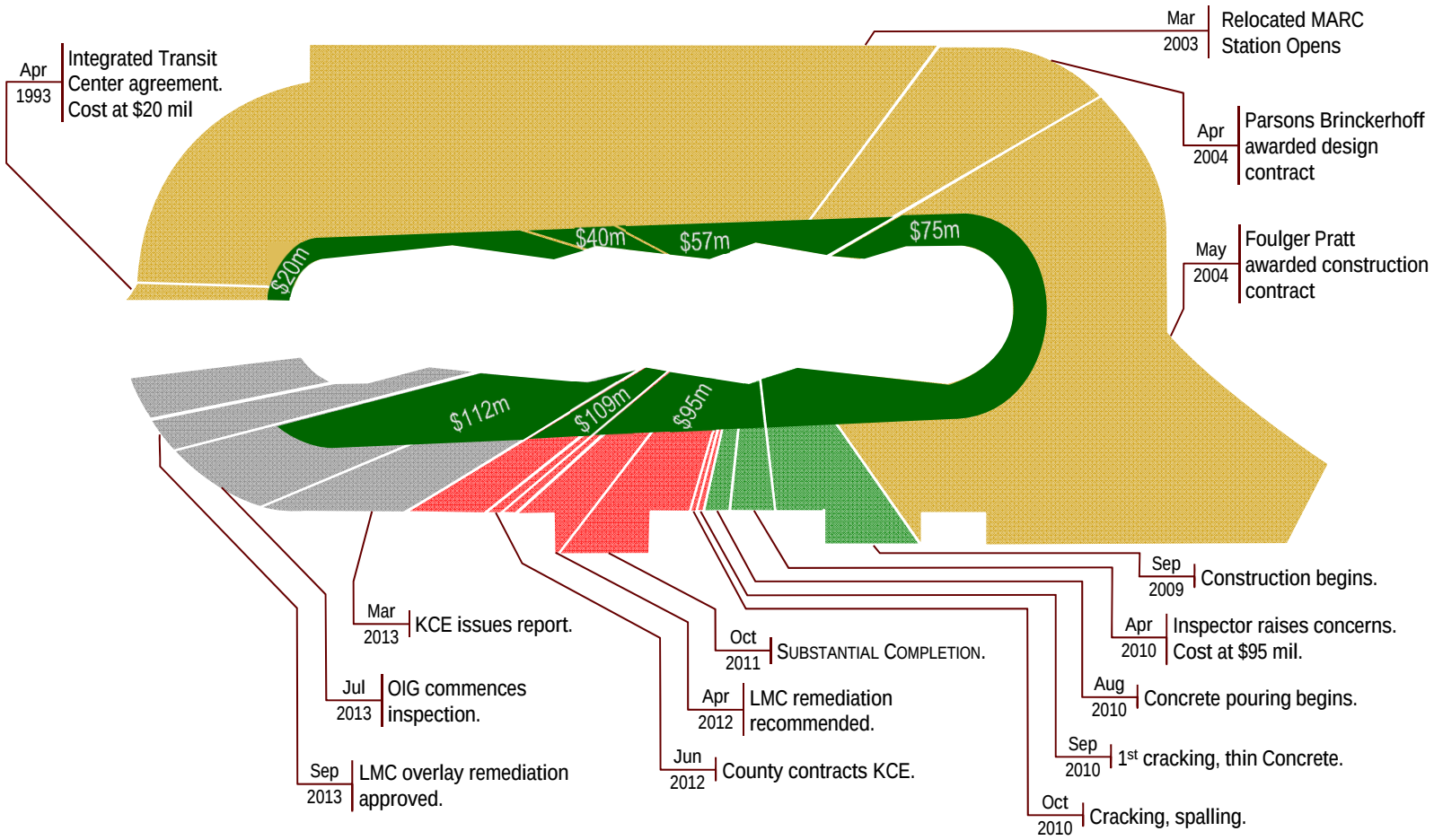
Timeline: December, 2013: Remedial work on pour strip reinforcement complete.



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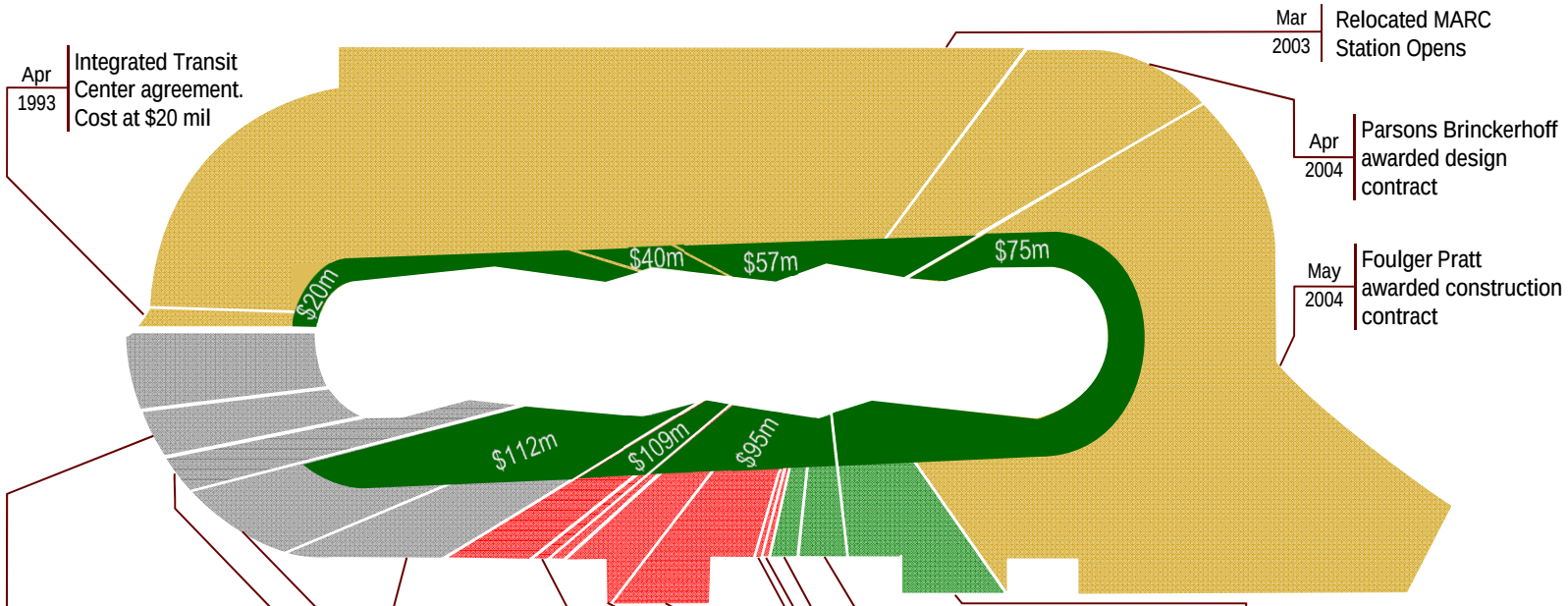
Timeline:

April, 2014: OIG provides its report for comment by county. Advisory committee appointed by County Executive recommends addressing safety hazard by strengthening structure and protecting post tensioning and reinforcement. Estimate additional cost of $11M and eight month delay.



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Oct 2010 — Cracking, spalling.

Oct 2011 — SUBSTANTIAL COMPLETION.

Apr 2012 — LMC remediation recommended.

Jun 2012 — County contracts KCE.

Mar 2013 — KCE issues report.

Jul 2013 — OIG commences inspection.

Sep 2013 — LMC overlay remediation approved.

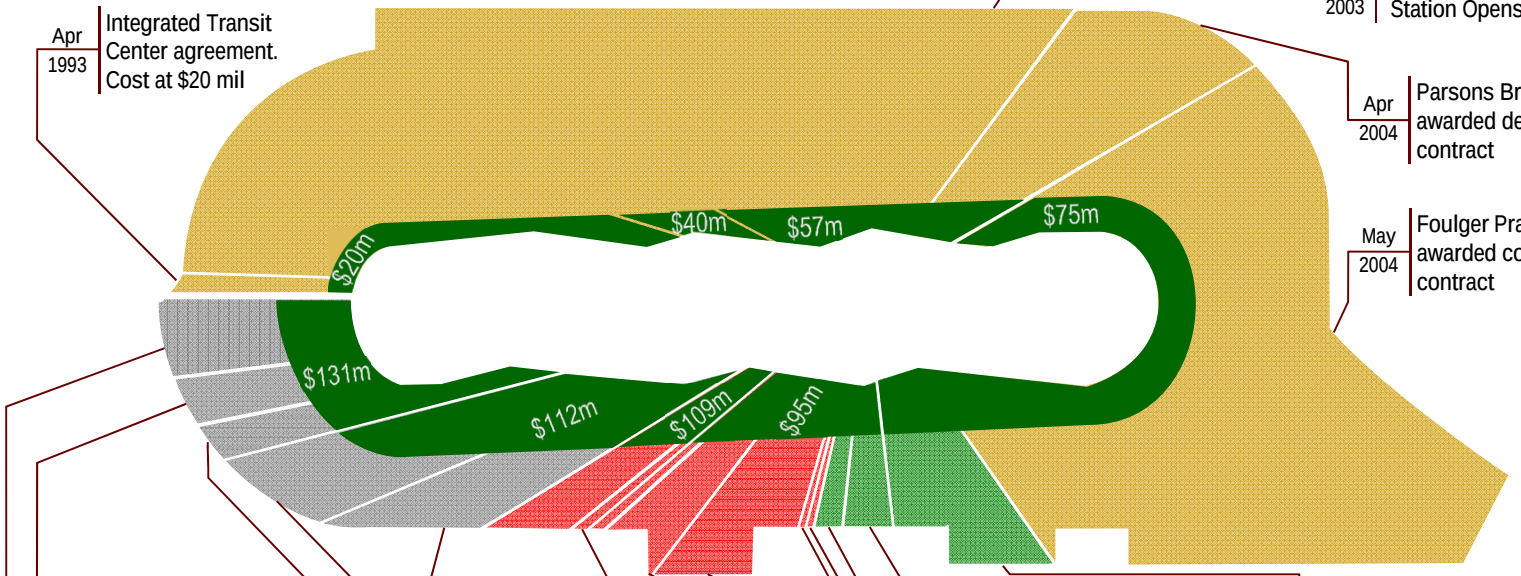
Dec 2013 — Pour strip remediation completed.

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline:

Today:

Remediation work to install additional load bearing beams and place 2" LMC overlay continues under direction of KCE. Advisory Group commissioned by County Executive projects completion around April 2015 at a cost of $131 million. KCE's chief executive officer opines "When I know how long it will take, I can tell them when I'll be done."



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Construction 101: Terminology - Cement

Portland cement is a fine powder produced by heating materials in a kiln to form what is called cement clinker, which is ground, and to which small amounts of other materials are added

The materials in cement clinker are alite, belite, tri-calcium aluminate, and tetra-calcium alumino ferrite.

Construction 101: Terminology - Concrete

A composite material in which Portland cement, water, aggregates, and admixtures are bound together through a chemical and physical reaction of cement with water (hydration) in the presence of sufficient water and heat.

Concrete construction requires proper curing to increase concrete strength and durability.

Construction 101: Recipe for Concrete

Concrete - 8,000 psi

1,850	lbs	stone/gravel
1,000	lbs	sand
550	lbs	Portland cement
360	lbs	slag
297	lbs	water (36 gal)
17	lbs	admixtures to taste to obtain requisite concrete characteristics (dry time, workability, etc.)

Combine ingredients in large drum mounted to back of truck. Rotate drum at least 70 turns to mix. Do not add any additional ingredients after mixing. Serve within 90 minutes. Maintain surface temperature between 55^{O} f and 75^{O} f until cured.

Makes 10 cubic yards

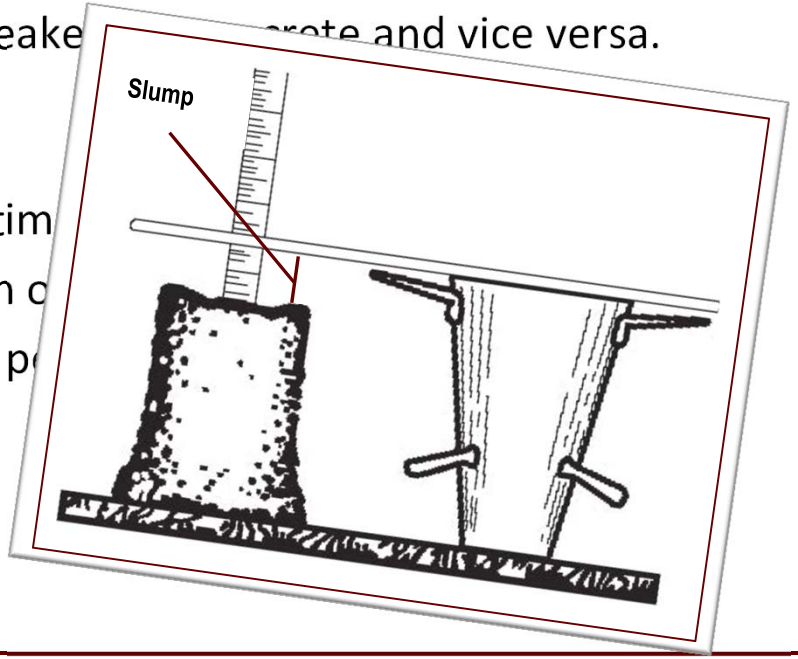
Construction 101: Terminology - Water to cement ratio (w/c)

The ability of cement to bind the aggregates together is affected by the ratio of water to cement

w/c is the factor that most influences concrete strength – the higher the ratio of water to cement, the weake[illegible]rete and vice versa.

Can only be determined:

- By weight measurement at tim[illegible]
- By petrographic examination o[illegible]
- Can be estimated at time of p[illegible]



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Construction 101: Terminology - Spalling

Spalling is the process of surface failure in which flakes of a material (spall) are broken off a larger solid body and shed. Spalling is usually caused by corrosion, weathering, cavitation, or excessive pressure.

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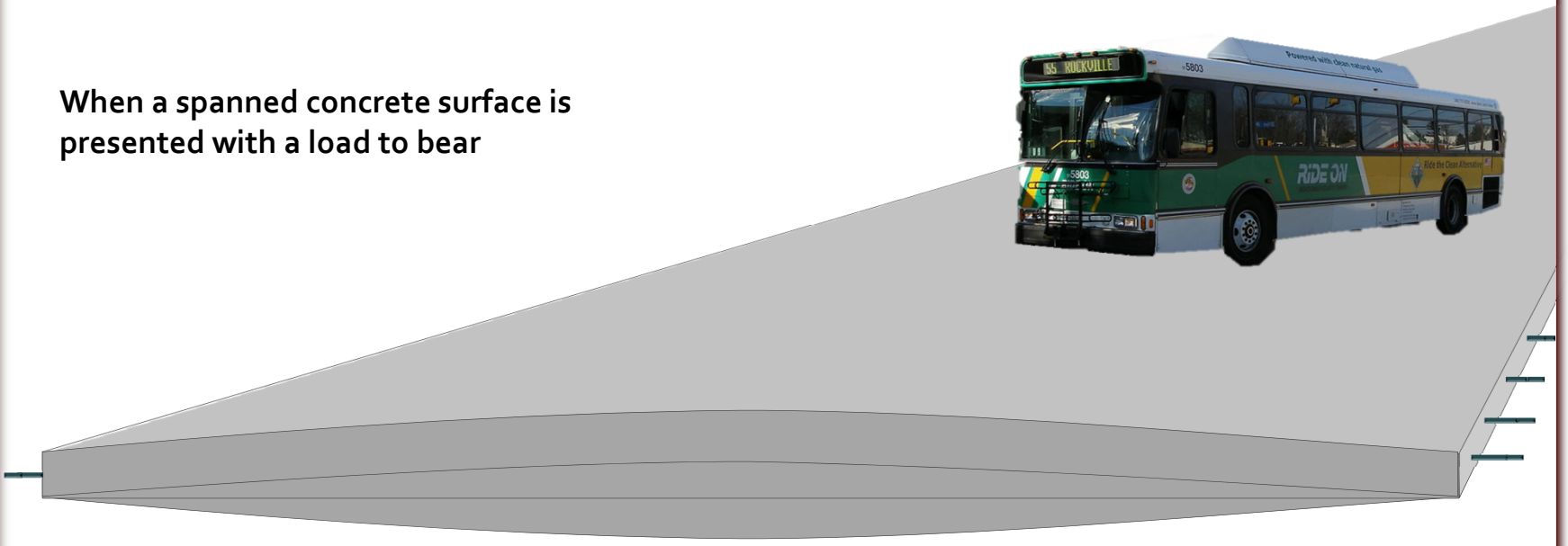
Construction 101: Terminology - Post-tensioned concrete

When a spanned concrete surface is presented with a load to bear



- **The surface will bow in deference to the load**
- **However, when post-tension tendons are embedded within the concrete span**
- **And the tendons are stressed within three days of pouring the concrete**
- **The surface will convex**
- **Allowing it to counteract the load**

Construction 101: Terminology - Columns, Girders, Beams, and Slabs

Underside of 3rd Floor
(Level 350)

- Slab (deck) - Underside
- Beam
- Girder
- Column
- Slab (deck) - Topside

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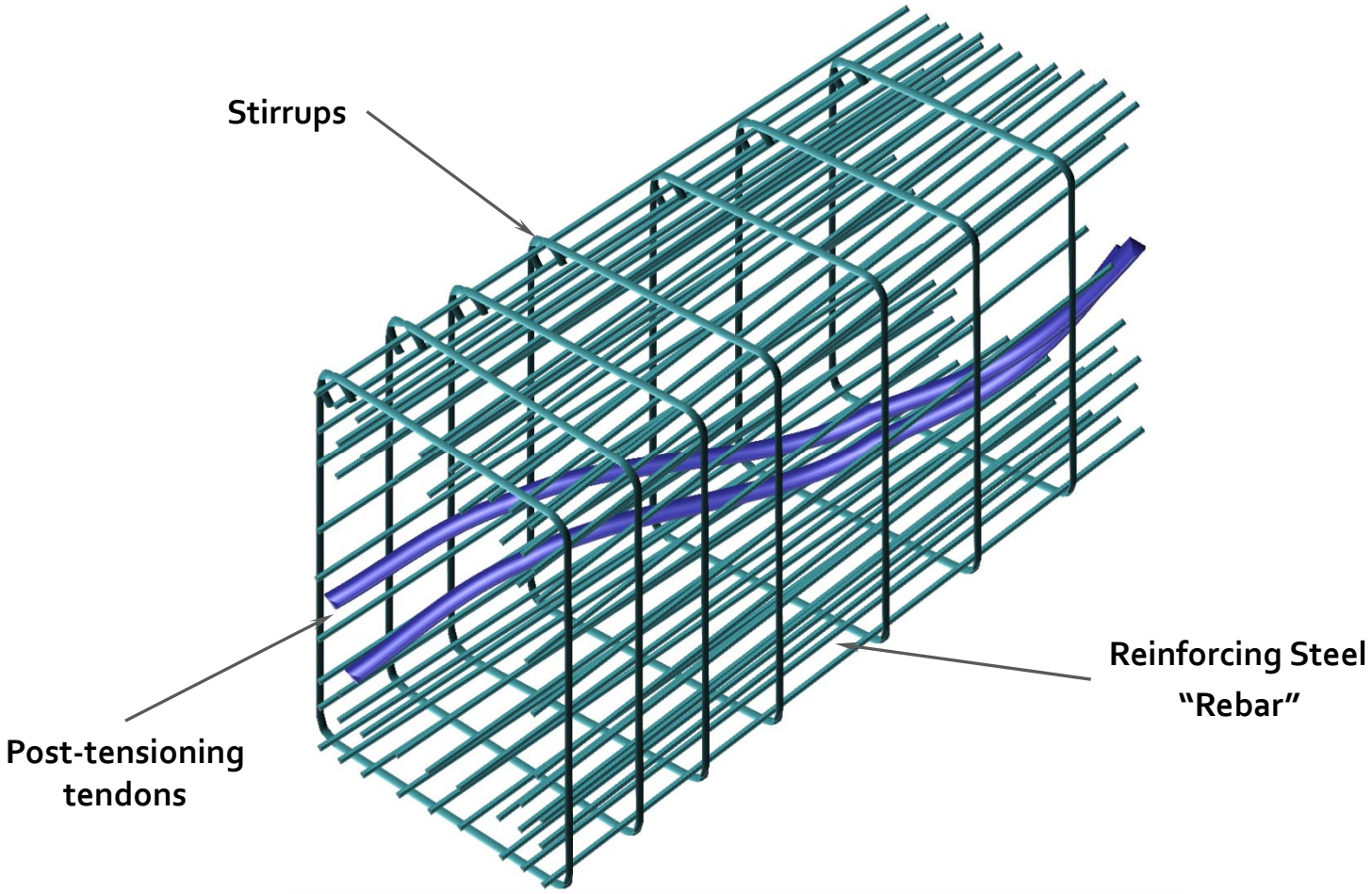
Construction 101: Structural reinforcement assembly



Project Management Deficiencies i… …g the…

Paul S. Sarb…

6. Pour the concr…
7. and allow the …
8. Remove the f…
9. and stress th…
10. and hope the…
11. *Oops!*

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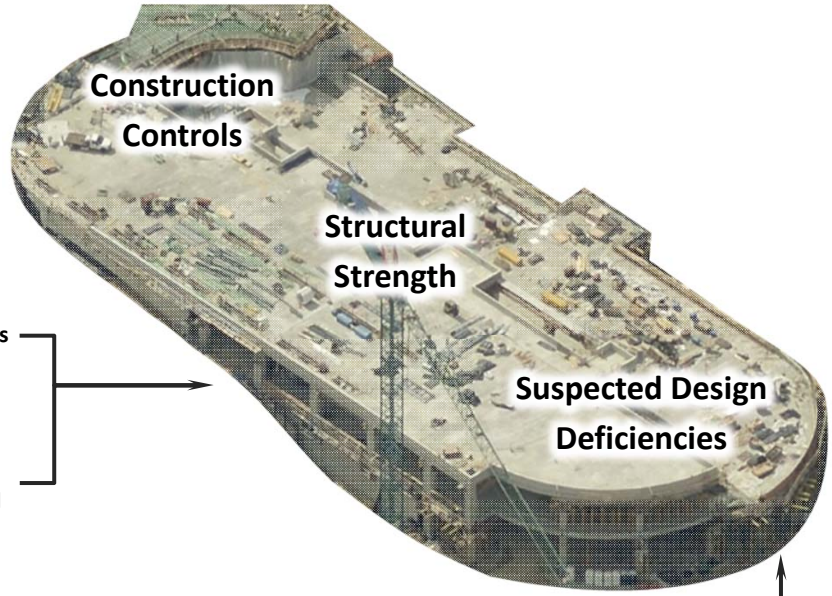

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Weak or ineffective project controls

- **project controls used during the construction of the SSTC evaluated by Subject Matter Expert, Alpha Corporation**
- **deficiencies identified in KCE and WDP reports related to 14 weak or ineffective controls out of 22**
- **could and should have directly controlled the construction activities**

Control	Deficiency Observed in Control			Effectiveness Unknown	No Deficiency
	Design	Implementation	Effectiveness		
Pour Strips					
RFIs & Meetings			✓		
Submittal Review		✓	✓		
Pre-Installation Conference	✓		✓		
Daily Reports			✓		
Concrete Composition					
Pumped Concrete Samples	✓		✓		
Batch Plant Inspections	✓	✓	✓		
Concrete Mix Design					✓
Water Added at Site			✓		
Slump Measurements	✓				
Cold Weather Curing	✓	✓	✓		
Surface Curing	✓	✓			
Entrapped Air					✓
Entrained Air		✓		✓	
Concrete Placement					
PT Tendon Placement			✓		
Steel Rebar Placement		✓		✓	
Floor Thickness	✓	✓	✓		
Post Tensioning					
Stressing Records					✓
Concrete Stresses	✓	✓	✓		
Grout Strength		✓		✓	
Time to Grouting		✓		✓	
Strength at Stressing	✓				
Age at Stressing					✓

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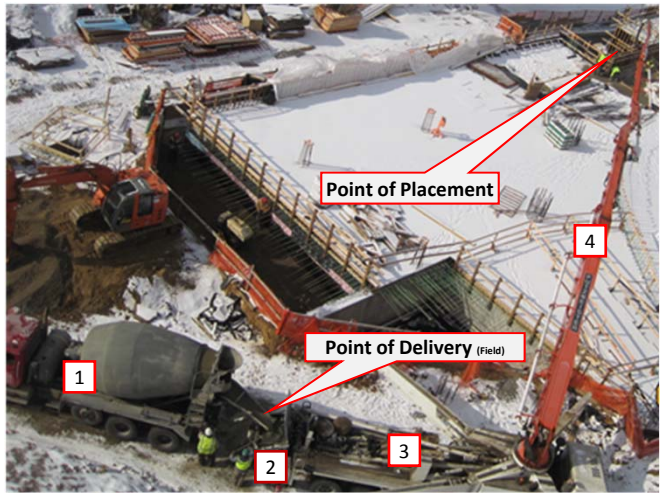
Location of Concrete Specimen Testing Sample Collection

- **Specimen testing samples should have been collected at point of placement**
- **Consistently weaker than anticipated test results should have led to discovery / correction of concrete mixture issues at early stage**
- **Weak concrete in structure could have been avoided**
- **Stronger overall structure**
- **Would have diminished impact of stress cracks due to tensioning of premature concrete**

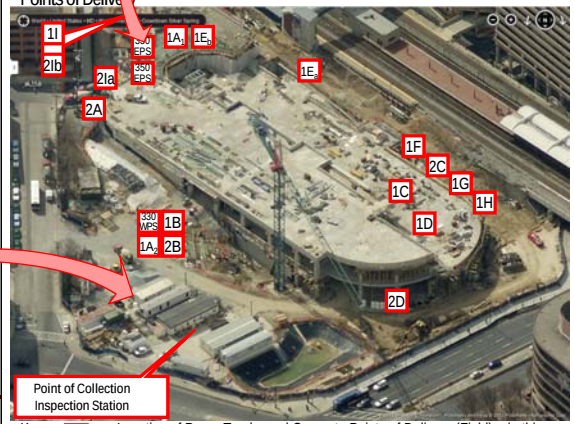
Image 4: Level 330 East Pour Strip Concrete Placement – January 12, 2011



Legend: 1 – Concrete Truck 3 – Concrete Pump Truck
2 – Pump Hopper 4 – Pump Discharge Pipe, Hose, & Crane Assembly
Source: Montgomery County Maryland Department of General Services

Image 3a: Inspection Station Orientation

Image 5: Transit Center Site Plan with Locations of Inspection Station & Concrete Points of Delivery



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Specified Design Strength of In-situ Concrete

- **Strength of in-situ concrete significantly lower than construction specimens even after 1+ year**
- **Weaker concrete acted to exacerbate other deficiencies**
  - **slab thickness**
  - **pour strip reinforcing and tensions**
  - **design**
  - **stress cracking due to tendon tensioning**

Chart 3: Comparison of Same Batch, Inspection Station to Surface Deck Field Cured Strength Results

Concrete Batch			Sample	RBB Strength Test		Slump	Air	Added	Revs	W/C	Time	3-Day Strength		28-Day Strength	
Pour	Truck #	Ticket #		#	Location		Content	H_2O (gal)		ratio	Lapse	Sample 1	Sample 2	Sample 1	Sample 2
1 D	67	91818	Set 1	518	Inspection Station	6.5	5.1%	20.0	71	0.25	53	10,480	10,220	13,100	13,440
				519	Deck	6.5	5.3%	20.0	71	0.25	74	5,140	5,020	10,620	10,890
	77	91837	Set 2	523	Inspection Station	7.0	6.2%	0.0	112	0.26	45	9,190	9,580	12,100	11,820
				524	Deck	8.0	5.7%	0.0	112	0.26	65	3,820	3,930	7,550	7,410
	79	91883	Set 3	530	Inspection Station	7.0	5.7%	0.0	250	0.26	53	9,910	10,190	11,470	11,460
				531	Deck	7.5	7.5%	0.0	250	0.26	73	4,460	4,130	9,120	9,510
1 F	77	92269	Set 1	543	Inspection Station	7.5	5.0%	0.0	116	0.26	19	6,560	6,730	12,220	11,700
				544	Deck	7.0	4.7%	0.0	150	0.26	44	6,910	6,960	8,780	9,340
	62	92282	Set 2	547	Inspection Station	8.0	6.3%	0.0	120	0.26	45	7,930	7,810	12,690	12,660
				548	Deck	7.5	5.8%	0.0	153	0.26	75	6,120	6,670	9,160	9,250
	32	92316	Set 3	554	Inspection Station	8.0	6.1%	0.0	128	0.25	52	5,700	5,310	12,040	11,910
				555	Deck	7.5	5.9%	15.0	160	0.27	101	7,190	7,550	8,680	8,730
2 B	67	91088	Set 1	481	Inspection Station	8.0	6.3%	0.0	195	0.25	41	4,080	4,150	11,150	10,670
				482	Deck	8.0	5.1%	0.0	195	0.25	62	4,270	4,590	9,280	8,840
	69	91152	Set 2	493	Inspection Station	7.5	5.1%	0.0	119	0.26	77	6,840	6,910	12,680	12,790
				494	Deck	8.0	4.6%	0.0	119	0.26	101	5,990	6,060	11,180	11,310
	37	91251	Set 3	507	Inspection Station	7.0	4.7%	0.0	88	DNA	78	4,300	3,960	11,240	10,130
				508	Deck	7.0	4.2%	0.0	88	DNA	94	5,750	5,740	10,100	10,260
2 C	67	92950	Set 1	578	Inspection Station	7.0	4.5%	0.0	176	0.26	57	7,060	6,490	11,400	11,600
				579	Deck	8.0	4.3%	20.0	195	0.28	67	7,080	7,170	11,200	11,140
	81	92978	Set 2	585	Inspection Station	8.0	5.6%	0.0	110	0.26	60	5,380	5,300	12,890	13,120
				586	Deck	8.0	5.4%	0.0	110	0.26	75	8,030	8,060	12,830	12,700
	61	93053	Set 3	594	Inspection Station	7.0	4.8%	0.0	250	0.26	95	6,380	6,590	13,170	12,650
				595	Deck	8.0	5.1%	0.0	250	0.26	109	5,390	5,160	9,620	9,110

DNA = Data Not Available. Source: Robert B. Balter Company Report of Concrete Cylinder Test and Rockville Fuel and Feed Company, Inc. job batching and delivery tickets.

3-Day Strength results for Pour 1 F were actually tested on Day 4.

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Cold Weather Curing

- **Concrete test specimens should have been cured on deck under curing blankets**
- **3-day test results would more accurately reflect condition of in-situ concrete**
- **Timing of post-tensioning commencement corrected to avoid cracks from premature tensioning**

Chart 5b: Comparison of Cold Weather Curing Temperatures (Degrees Fahrenheit) - *continued*

Pour Location / Pour Date	NOAA Average Ambient Temp	Mix Temp Day of Pour	Test Period: Day	Time	Temp	On Slab Surface: Min	Max	@ Inspection Station: Min	Max	@ Deck Cure Box: Min	Max	In Cure Shed: Min	Max	Under Deck
Pour 2 B 7 Dec 2010	29	62	Day 1 12/8/10	AM	25	89		44	64					
				Noon	32	114		42	64					77
				PM	33	116		42	64					76
			Day 2 12/9/10	AM	24	106		40	64			70	88	74
				PM	34	Thermometer Broker		50	80	52		74	94	77
			Day 3 12/10/10	AM	19	76	94	46	78	42	56	82	88	76
				PM	35	72	90			43	55	72	75	75
			Day 6 12/13/10	AM		62	96			42	54	80	84	70
				PM		60	76			38	52	82	62	46
			Day 7 12/14/10	AM	22	61	74	58	78	24	40	72	74	38
				PM	29			67				70	84	

> 20°

Observations for Pour 2B: This was the longest recorded data set of any cold weather pour. The heater under the slab appears to have been turned off during the morning of Day 6 - temperatures dropped from the 70's to 46 and then 38. Yet, there was a 39 degree difference between ambient and slab temperatures, so cold weather curing should have continued. Although inspectors recorded full data on the mornings of Day 3 and Day 7, inspectors were still inconsistent at recording data.

Pour 2 C 14 Jan 2011	34	58	Day 3 1/17/11	AM	25	44	104							
				PM										

< 55°

Observations for Pour 2C: January 14 was a Friday pour - the only data recorded was on the following Monday. Between the time of the pour and the recording of data, a minimum temperature of 44 degrees was recorded - 11 degrees colder than allowed by standards and specifications.

Pour 2 D 31 Jan 2011	28	57	Day 1 2/1/11	AM	30	46	104					70	77	91
				PM	32	90	90							62
			Day 2 2/2/11	AM	35	78	87					70	72	92
				PM	40	80	84					65	75	88
			Day 3 2/3/11	AM	30	72	79					68	74	88
				PM	30	82	89					69	79	57

< 55°

> 20°

Observations for Pour 2D: On the last entry of recorded data, there was a 52 degree difference between ambient and slab temperatures, yet some cold weather curing was stopped as evidenced by the drop in "under deck" temperature from 88 to 57 consistent with turning off the heater under the slab .

Sources: The Robert B. Baier Company Concrete Slab Temperature Reports and 56-Day Reports of Concrete Cylinder Tests; KCE Report Table 12 C Alternative ACI 214R-10 PSI. Two cold weather pours - Pour 2 C and the Level 330 East Pour Strips - are not included in the evaluation due to a lack of statistically significant data.

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Data Documenting Deficiencies Existed – Was Not Analyzed

- **Routine construction records documented construction & control deficiencies**
- **Available to all stakeholders**
- **Evidenced deficiencies that should have been investigated as to cause(s)**
- **Though not a requirement, available data, if analyzed, would have identified deficiencies**
- **Known deficiencies were not effectively corrected**

Image 9: Silver Spring Transit Center Construction Progress – December 2, 2010

9:56 am on 2 Dec 2010 (img_3024.jpg)

Source and courtesy of the Montgomery County Maryland Department of General Services.

Image 8: Slab Cracking Evident 2 Days Following Placement of Pour 1B

12:41 pm on 4 Oct 2010 (img_2239.jpg)

Source and courtesy of the Montgomery County Maryland Department of General Services.

"The County will be looking to you as the SER to provide us the guidance in this issue. We all are sensitive to keeping with schedule, but that should not keep us from doing what is right for the long term of the facility."

Donald Scheuerman, Jr., Chief, Project Management Section, DGS
October 28, 2010

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Independent Peer Review

- **An independent "peer review" contractor should have been employed**
- **Work with the Parsons Brinckerhoff-led design team to validate:**
  - **design engineering and architecture**
  - **engineering calculations**
  - **project controls**
- **Identify design issues that could have been avoided**

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Independent Construction Manager

- **An independent construction manager should have been employed**
- **Oversee project from planning to completion**
- **Ensure requisite course corrections are made early upon discovery**

SSTC "Construction Management" Responsibilities as Performed

Construction Management Element	Foulger Pratt	Parsons Brinckerhoff	Balter	MontCo DGS
Conduct & Document Periodic Progress Meetings		✓		✓
Document Control	✓			
Cost Tracking & Management				✓
Evaluation of Payment Requests,				✓
Change Order Management,	✓			✓
Quality Management	✓			
Review Daily Quality Control (QC) reports				✓
Complete Daily CM Log	✓			
Schedule Control	✓			
Review and verify contractor's project record drawings are updated		✓		
Monitoring Contractor Safety	✓			
Conduct inspections			✓	
Issue inspection deficiency letter to the contractor		✓		

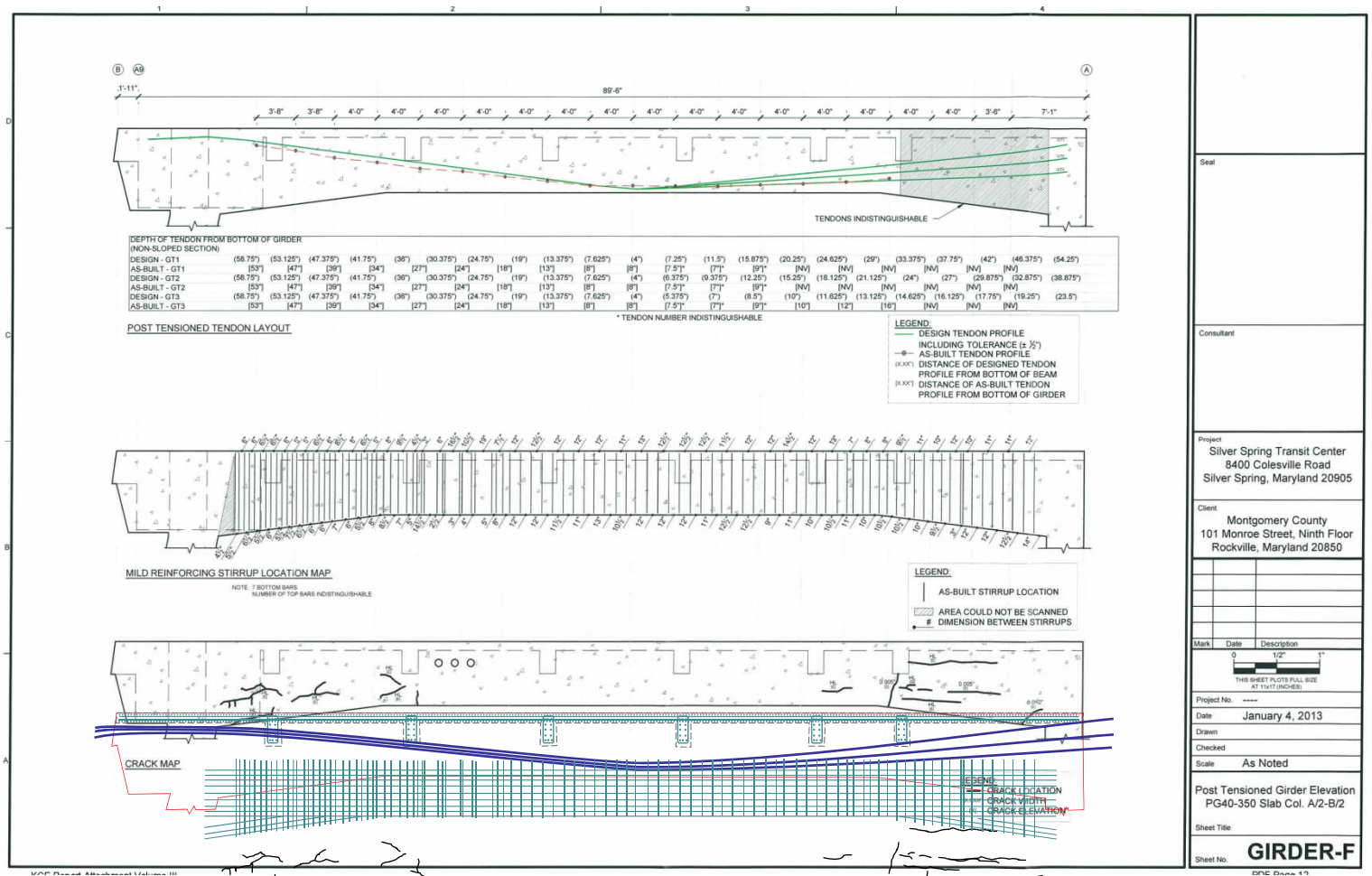
Source: OIG Staff Analysis

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

"When I know how long it will take, I can tell them when I'll be done."

Allyn Kilsheimer
CEO, KCE Structural Engineers
Washington Post Interview, August 17, 2014

Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

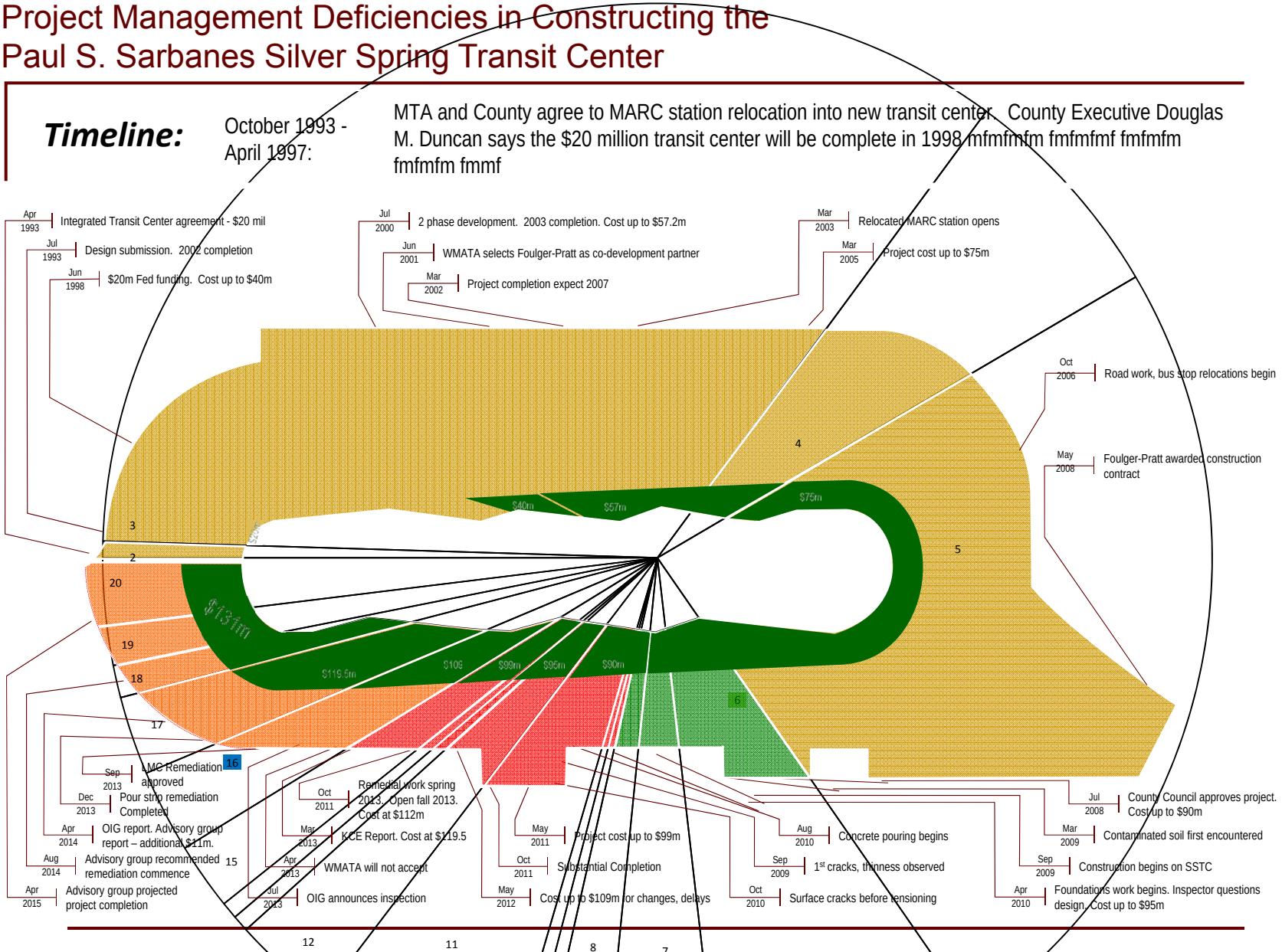


Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

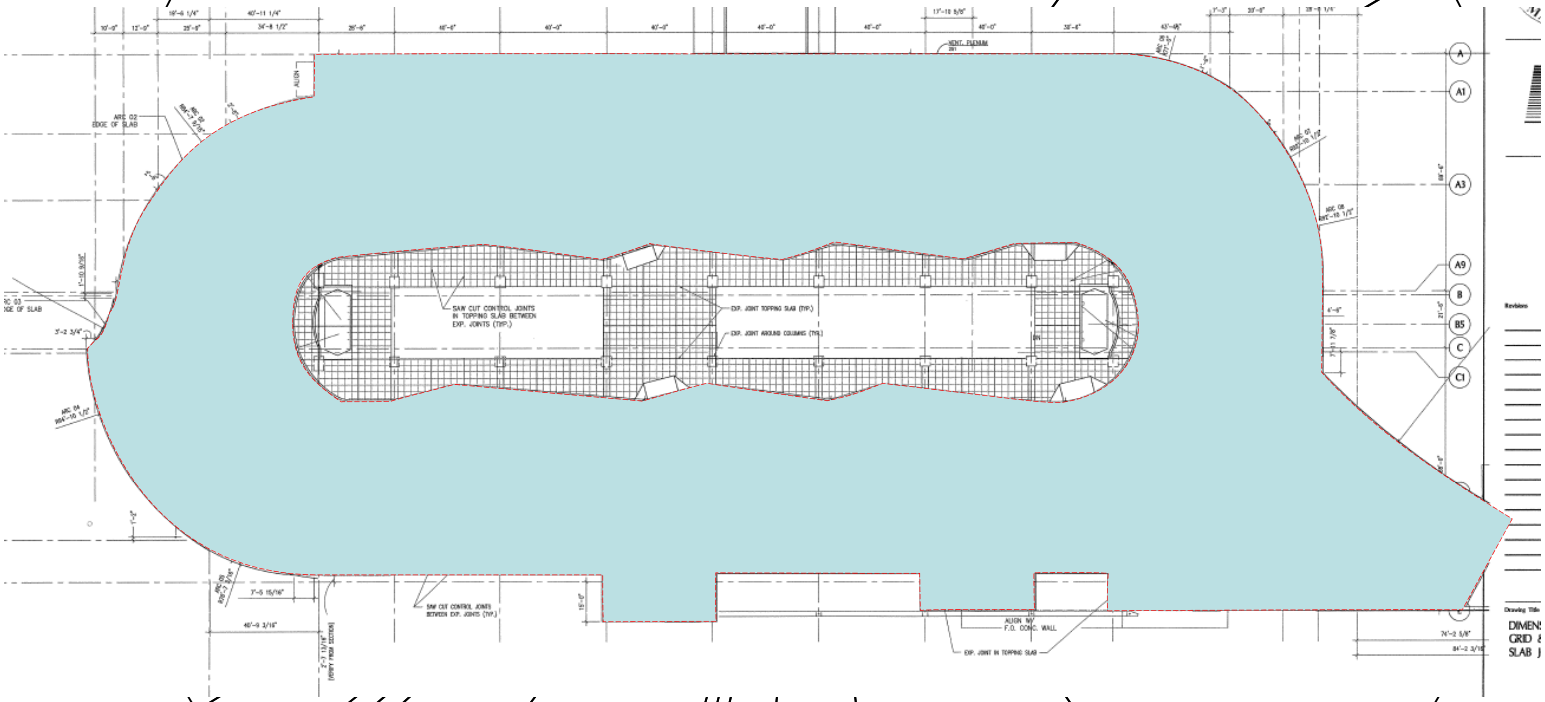
Timeline:

October 1993 - April 1997:

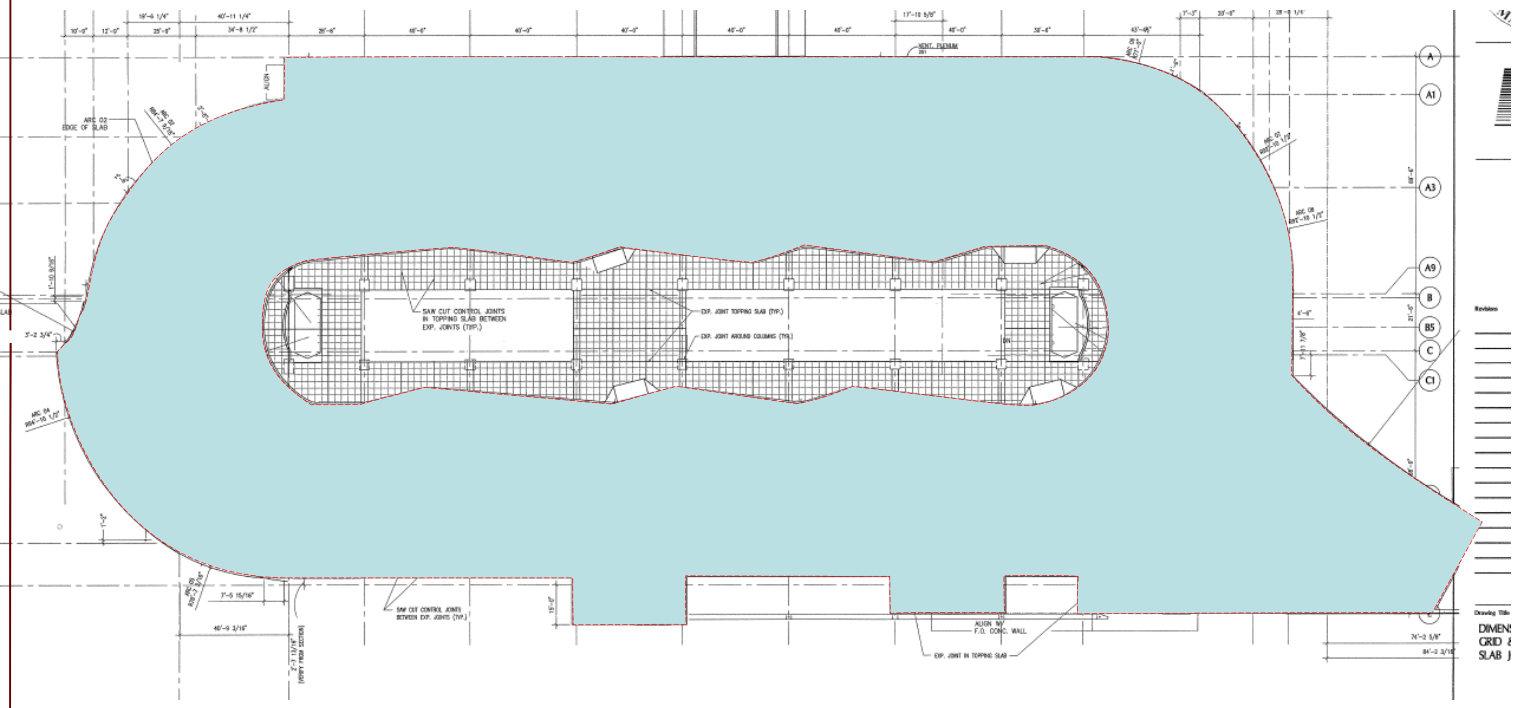
MTA and County agree to MARC station relocation into new transit center. County Executive Douglas M. Duncan says the $20 million transit center will be complete in 1998 mfmfmfm fmfmfmf fmfmfm fmfmfm fmmf



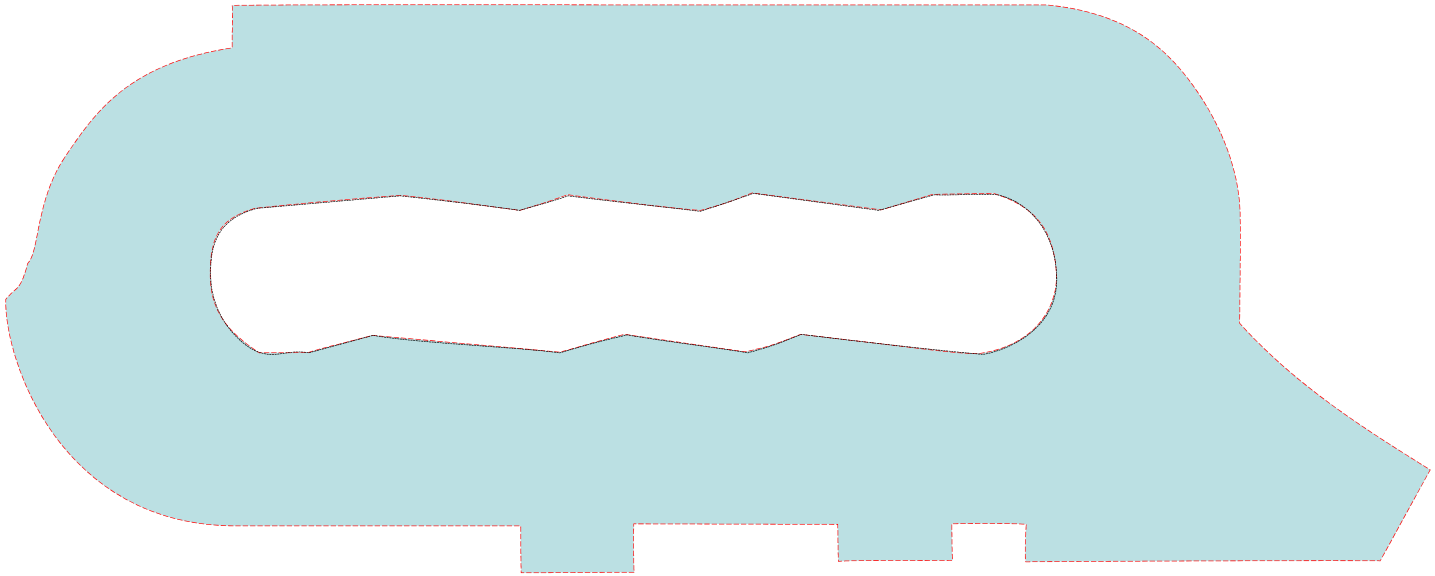
Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center



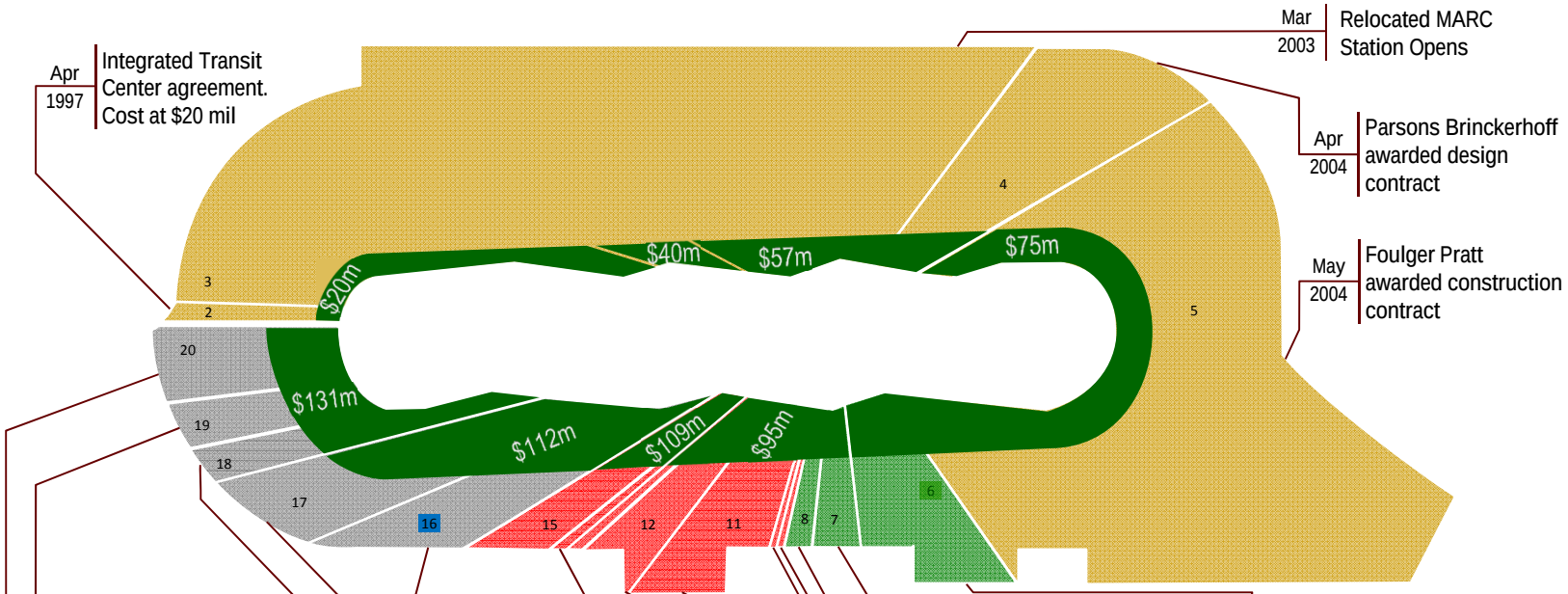
Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center



Project Management Deficiencies in Constructing the Paul S. Sarbanes Silver Spring Transit Center

Timeline:

April, 2010: Montgomery County Department of Permitting Services inspector raises concerns that post tensioning of the slabs and girders with the built in wall would create a zone of cracking in the slabs along certain points. Project budget increases to $95 million.



Apr 1997 — Integrated Transit Center agreement. Cost at $20 mil

Mar 2003 — Relocated MARC Station Opens

Apr 2004 — Parsons Brinckerhoff awarded design contract

May 2004 — Foulger Pratt awarded construction contract

Sep 2009 — Construction begins.

Apr 2010 — Inspector raises concerns. Cost at $95 mil.

Aug 2010 — Concrete pouring begins.

Sep 2010 — 1st cracking, thin Concrete.

Oct 2010 — Cracking, spalling.

Oct 2011 — SUBSTANTIAL COMPLETION.

Apr 2012 — LMC remediation recommended.

Jun 2012 — County contracts KCE.

Mar 2013 — KCE issues report.

Jul 2013 — OIG commences inspection.

Sep 2013 — LMC overlay remediation approved.

Dec 2013 — Pour strip remediation completed.

Apr 2014 — OIG issues report. Advisory Group issues recommendations. Cost at $131 mil. Est. completion Apr 2015.