December 2014

IAH

George Bush Intercontinental Airport

Mickey Leland

International Terminal

Program Definition Manual

FINAL

HOUSTON AIRPORTS

HNTB

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Table of Contents

ES.0 EXECUTIVE SUMMARY 15

ES1.0 INTRODUCTION 15
- **ES.1.1 Project Purpose 15**
- **ES.1.2 Planning Process 15**
- **ES.1.3 Findings 17**
  - ES.1.3.1 Baggage Level Plan (74) 17
  - ES.1.3.2 Ticketing/Check-In Level Plan (88) 17
  - ES.1.3.3 Apron Level Plan (100) 17
  - ES.1.3.4 Departure Level Plan (116) 17
  - ES.1.3.5 Club/Sterile Corridor Level Plan (132) 17
  - ES.1.3.6 Landside Components 17
  - ES.1.3.7 Program Phasing 17
    - ES.1.3.7.0 Phase 0 – Terminal B North Pier 17
    - ES.1.3.7.1 Phase 1 – Enabling Projects 17
    - ES.1.3.7.2 Phase 2 – D1 Pier and Central Core/Processor 36
    - ES.1.3.7.3 Phase 3 – D2 Pier 36
    - ES.1.3.7.4 Phase 4 – Final Terminal D Demolition 36
    - ES.1.3.7.5 Completed MLIT 36
  - ES.1.3.8 Rough Order of Magnitude Cost Estimates 36
- **ES.1.4 Recommendation 36**

1.0 INTRODUCTION 39
- **1.1 Background 39**
- **1.2 Process 39**
  - 1.2.1 Terminal Assessment 39
  - 1.2.2 Strategic Plan 39
  - 1.2.3 Terminal D A380 Project Development Document 40
  - 1.2.4 Decision Point Study 40
  - 1.2.5 Terminal D Modernization Program - Program Definition Manual 41
  - 1.2.6 East Terminal 41
  - 1.2.7 Mickey Leland International Terminal – Program Definition Manual 41
- **1.3 Project Purpose 43**
- **1.4 PDM Objectives 44**

2.0 DESIGN DAY SCHEDULE 47
- **2.1 Terminal D Summer 2014 Foreign Flag Flight Schedule 47**
- **2.2 Mickey Leland International Terminal Design Day Flight Schedule 48**
  - 2.2.1 Flight Schedule Development 48
  - 2.2.2 Gating Analysis 48
  - 2.2.3 United Airlines Future Gate Inventory 48
  - 2.2.4 Allocation Rules 48
  - 2.2.5 Findings 50
  - 2.2.6 MLIT Gating Analysis Gantt Charts 50
- **2.3 Summary 50**

3.0 EXISTING CONDITIONS 59
- **3.1 Terminal Building 59**
  - 3.1.1 Space Utilization 59
    - 3.1.1.1 Basement Level (74) 59
    - 3.1.1.2 Ticketing Level (88) 59
    - 3.1.1.3 Apron Level (100) 59
    - 3.1.1.4 Intermediate/Sterile Corridor Level (106/110) 62
    - 3.1.1.5 Departure Level (121) 62
    - 3.1.1.6 Existing Terminal D Wayfinding 62
  - 3.1.2 Terminal Mechanical/Electrical/Plumbing (MEP) Systems 66
    - 3.1.2.1 Chilled Water 66
    - 3.1.2.2 Hot Water System 66
    - 3.1.2.3 Temperature Control 66
    - 3.1.2.4 Air Handling Units 68
    - 3.1.2.5 Electrical System 68
    - 3.1.2.6 Standby Power Distribution 68
    - 3.1.2.7 Lighting 69
    - 3.1.2.8 Natural Gas 69
    - 3.1.2.9 Fire Suppression and Life Safety 69
    - 3.1.2.10 Dewatering System 75
    - 3.1.2.11 Life Safety System 76
    - 3.1.2.12 Information Technology 76
    - 3.1.2.13 Building Automation System (BAS) 76
- **3.2 Airside 76**
  - 3.2.1 Gate Layout 76
  - 3.2.2 Gating Capabilities 80
  - 3.2.3 Vehicle Service Road 80
  - 3.2.4 Aircraft Flow 80
  - 3.2.5 Apron Utilities 83
    - 3.2.5.1 Aircraft Ground Power (GPU) 83
    - 3.2.5.2 Aircraft Pre-Conditioned Air (PCA) 83
    - 3.2.5.3 Passenger Boarding Bridges (PBB) 83
    - 3.2.5.4 Passenger Boarding Bridge Potable Water Cabinets 83
    - 3.2.5.5 Hydrant Fueling 83
- **3.3 Site Utilities 85**
  - 3.3.1 12.5kV Site Power 85
  - 3.3.2 Water Supply System 85
  - 3.3.3 Fire Protection Water Supply System 85

3.3.4 Sanitary Sewer ... 85
3.3.5 Storm Sewer System ... 88
3.3.6 Natural Gas ... 88
3.4 Terminal C Building ... 88
3.4.1 Terminal C Central Building ... 88
3.4.2 Terminal C North Concourse ... 88
3.4.2.1 Terminal C North Structural Assessment ... 88
3.4.2.2 Terminal C North Ramp Control Tower ... 97
3.4.3 Terminal Link Station C ... 97
3.4.4 Passenger Circulation ... 97
3.4.5 Baggage Circulation ... 97
3.4.6 Terminal Mechanical/Electrical/Plumbing (MEP) Systems ... 97
3.4.6.1 Chilled Water ... 99
3.4.6.2 Hot Water System ... 99
3.4.6.3 Temperature Control ... 99
3.4.6.4 Air Handling Units ... 99
3.4.6.5 Electrical System ... 99
3.4.6.6 Standby Power Distribution ... 99
3.4.6.7 Lighting ... 99
3.4.6.8 Natural Gas ... 99
3.4.6.9 Fire Suppression and Life Safety ... 99
3.4.6.10 Dewatering System ... 108
3.4.6.11 Life Safety System ... 108
3.4.6.12 Information Technology ... 108
3.4.6.13 Building Automation System ... 108
3.5 Airside ... 108
3.5.1 Gate Layout ... 108
3.5.2 Gating Capabilities ... 108
3.5.3 Vehicle Service Road ... 112
3.5.4 Apron Utilities ... 112
3.5.4.1 Aircraft Ground Power Units (GPU) ... 112
3.5.4.2 Aircraft Pre-Conditioned Air (PCA) ... 112
3.5.4.3 Passenger Boarding Bridges (PBB) ... 112
3.5.4.4 Passenger Boarding Bridge Potable Water Cabinets ... 112
3.5.4.5 Hydrant Fueling ... 112
3.6 Site Utilities ... 114
3.6.1 12.5kV Site Power ... 114
3.6.2 Water Supply System ... 115
3.6.3 Fire Protection Water Supply System ... 115
3.6.4 Sanitary Sewer ... 115
3.6.5 Storm Sewer System ... 115
3.6.6 Natural Gas ... 115
3.7 Landside ... 115
3.7.1 Roadways ... 115
3.7.2 Curbside ... 120
3.7.3 Garage Traffic ... 120

4.0 PROGRAM REQUIREMENTS ... 123
4.1 Overview ... 123
4.2 Program Requirements Summary ... 123
4.3 Demand Activity – Flight Schedule ... 127
4.4 Level-of-Service Standards and Performance Criteria ... 128
4.4.1 Level of Service Standards ... 128
4.4.2 Performance Criteria ... 129
4.5 Simulation Assumptions – Passenger Attributes ... 129
4.5.1 Show-Up Profiles ... 130
4.5.2 Checked Baggage ... 130
4.5.3 Past Studies, Industry Standards and Applicable Documents ... 130
4.5.4 Program Requirements ... 130
4.6 Check-in ... 131
4.7 Holdrooms ... 132
4.8 Outbound Baggage Make-up ... 134
4.9 Inbound Baggage Drop-off ... 136
4.10 Pre-clearance Baggage Claim ... 137
4.11 Airline Clubs ... 138
4.12 Airline Support Space ... 138
4.12.1 Airline Offices and Sales Counters ... 138
4.12.2 Common-Use Airline Service Counters ... 139
4.12.3 Airline Baggage Service Offices ... 139
4.12.4 Ramp Level Facilities ... 139
4.13 Department of Homeland Security ... 140
4.13.1 Passenger Security Screening Checkpoint and TSA Support ... 140
4.13.2 TSA Checked Baggage Inspection System (CBIS) ... 142
4.14 Other Amenities ... 143
4.14.1 Commercial Program and Other Amenities ... 143
4.14.2 Chapel/Foot Wash Areas ... 144
4.14.3 Diplomacy/Diplomatic Suite ... 144
4.14.4 HAS Maintenance Rooms ... 144
4.14.5 Air Marshal Conference Rooms ... 144
4.14.6 Children's Play Area ... 144
4.14.7 Loading Dock ... 144
4.14.8 Wheelchair Storage Areas ... 144
4.14.9 Electric Cart Storage ... 144
4.14.10 Employee Break Room ... 144
4.14.11 Shared Airline Storage Closets ... 145
4.14.12 Restrooms ... 145
4.14.13 Areas Dependent on Building Configuration ... 145
4.14.14 MEP and IT Services ... 145
4.14.15 Public and Non-Public Circulation ... 145

5.0 PREFERRED DEVELOPMENT PLAN 149
5.1 Airside Infrastructure 149
5.1.1 Aircraft Parking Layout 149
5.1.2 Gate Separation 152
5.1.3 Analysis 152
5.1.4 Line of Sight Review 152
5.1.5 Vehicle Service Road Network 152
5.1.6 Passenger Boarding Bridges 152
5.1.7 Ground Service Equipment 157
5.1.7.1 Aircraft Tractor 157
5.1.7.2 Baggage Handling 158
5.1.7.3 Cabin Service 158
5.1.7.4 Catering 158
5.1.7.5 International Waste 159
5.2 Apron Utilities 159
5.2.1 Aircraft Fueling System 159
5.2.2 Ground Power 159
5.2.3 Potable Water 159
5.2.4 Pre-conditioned Air (PCA) 159
5.2.5 Aircraft Sanitary Waste 159
5.2.6 General Note 161
5.3 Terminal Building 161
5.3.1 Basement Plan (Level 74) 161
5.3.1.1 Checked Baggage Inspection System 161
5.3.1.2 Baggage Tunnel (to CBIS) 166
5.3.1.3 Tug Drive Tunnels (To/from existing Terminal C North and FIS Processor) 166
5.3.1.4 Pedestrian Tunnel 166
5.3.1.5. Utility Tunnel 166
5.3.2 Ticketing/Check-In Level Plan (Level 088) 166
5.3.2.1 Ticket Lobby 167
5.3.2.2 Security Screening Checkpoint (SSCP) 167
5.3.2.3 Transportation Security Administration (TSA) 170
5.3.2.4 Pre-Cleared Baggage Claim 170
5.3.2.5 Circulation 170
5.3.2.6 Restrooms 171
5.3.2.7 Concessions 171
5.3.2.8 Concession Storage 171
5.3.2.9 Loading Dock 171
5.3.2.10 Employee Break Room 171
5.3.2.11 Airline Ticket Offices 171
5.3.2.12 Mechanical/Electrical/Plumbing (MEP) Spaces 171
5.3.2.13 Airport Operations/Building Maintenance 171
5.3.2.14 Pet Relief Areas 171
5.3.2.15 Wheelchair Storage Areas 171
5.3.2.16 Art Program/Museum 172
5.3.3 Apron Plan (Level 100) 172
5.3.3.1 Outbound Baggage 172
5.3.3.2 Inbound Baggage 174
5.3.3.3 Airline Operations/Storage 174
5.3.3.4 Restrooms 174
5.3.3.5 Mechanical/Electrical/Plumbing (MEP) Spaces 174
5.3.3.6 Information Technology (IT) Spaces 174
5.3.3.7 Ground Service Equipment (GSE) Parking/Charging 174
5.3.3.8 Circulation 174
5.3.4 Departure Concourse Plan (Level 116) 174
5.3.4.1 Departure Lounges/Holdrooms 174
5.3.4.2 Club Lobbies 174
5.3.4.3 Concession Core 174
5.3.4.4 Concession Storage 178
5.3.4.5 Restrooms 178
5.3.4.6 Family Restrooms 178
5.3.4.7 Airport Operations/Building Maintenance 178
5.3.4.8 Chapel/Meditation/Prayer Space 178
5.3.4.9 Children's Play Area 178
5.3.4.10 United Service Organization (USO) 178
5.3.4.11 Nursery 178
5.3.4.12 Performance Stage 178
5.3.4.13 Wheelchair Storage Areas 179
5.3.4.14 Electric Carts/Transport Vehicles 179
5.3.4.15 "Texas Experience" 179
5.3.4.16 Ramp Control Tower/Gate Control 179
5.3.4.17 Art Program/Museum 179
5.3.4.18 Diplomatic Suite 179
5.3.4.19 Circulation 179
5.3.5 Club/Sterile Corridor Plan (Level 132) 179
5.3.5.1 Airline Clubs 179
5.3.5.2 Wheelchair Storage Areas 179
5.3.5.3 Electric Carts/Transport Vehicles 179
5.3.5.4 Circulation 179
5.3.6 Terminal Building Summary 186
5.4 Terminal MEP Systems 195
5.4.1 Chilled Water System 195
5.4.2 Hot Water System 195
5.4.3 HVAC 195
5.4.4 Domestic Water System 195
5.4.5 Sanitary Waste and Vent System 195
5.4.6 Electrical System 195
5.4.6.1 Grounding System 203
5.4.7 Information Technology 203
5.4.7.1 General LAN Requirements 210
5.4.7.2 Access Control System (ACS) 210
5.4.8 Natural Gas 210
5.4.9 Fire Suppression 211
5.4.10 Fire Alarm System 211
5.4.11 Building Automation System (BAS) 211
5.5 Site Utilities 214

5.5.1 Site Power 214
5.5.2 Site Communication/IT 214
5.5.3 Water System 217
5.5.4 Sanitary Sewer System 217
5.5.5 Apron Grading and Drainage 220
5.5.6 Hydrant Fueling 220
5.5.7 Utility Infrastructure (Tenants) 224
5.6 Landside 224
5.6.1 Roadways 224
5.6.2 Curb 224
5.6.3 Parking 224

6.0 PROGRAM CONCEPT DESIGN CRITERIA 231
6.1 Architectural 231
6.1.1 Level of Finish 231
6.1.2 Architectural Concept 231
6.2 Governing Codes and Standards 244
6.3 Art Program 246
6.3.1 Integrated/Permanent Art 246
6.3.2 Portable/Rotating Art 247
6.3.3 Multimedia Displays 247
6.3.4 Gallery 248
6.3.5 Civic Art 248
6.3.6 Portable Works 252
6.4 Wayfinding 253
6.4.1 Background 253
6.4.2 Purpose 253
6.4.3 Scope 254
6.4.4 Wayfinding Analysis 254
6.4.4.1 Evaluation Criteria 254
6.4.5 Wayfinding Plan - MLIT 255
6.4.5.1 Design Description - New HAS Wayfinding Signage System 255
6.4.5.2 Sign Types - General Overview 255
6.4.5.3 Wayfinding Sign Family 255
6.4.5.4 Sign Type Identification System 255
6.4.5.5 Graphic Standards and Guidelines 255
6.4.5.6 General Sign Placement 264
6.4.5.7 Conceptual Wayfinding Floor Plans 264
6.4.5.8 Transitional Wayfinding 264
6.4.5.9 Final Wayfinding Plans and Signage Design Intent 264
6.5 Best Practices/Sustainability 269
6.5.1 Sustainability Regulations 270
6.5.2 Comprehensive List of International Rating Systems 271
6.5.3 Technical Sustainability Tools 271
6.5.4 Energy 272
6.5.5 Project Specific Design Strategies for MLIT 273

7.0 PROGRAM PHASING: PHASE ZERO 277
7.0.1 Terminal MEP Systems 277
7.0.1.1 Chilled Water Systems 277
7.0.1.2 Hot Water Systems 277
7.0.1.3 Domestic Water System 281
7.0.1.4 Natural Gas 281
7.0.1.5 Fire Suppression 281
7.0.2 Site Utilities 281
7.0.2.1 12.5kV Site Power 281
7.0.2.2 Water System 281
7.0.2.3 Sanitary Sewer System 281
7.0.2.4 Hydrant Fueling 285
7.1 PROGRAM PHASING: PHASE ONE (ENABLING PROJECTS) 287
7.1.1 Airside Infrastructure 287
7.1.1.1 Aircraft Parking Layout 287
7.1.1.2 Gate Separation 287
7.1.1.3 Passenger Boarding Bridges 287
7.1.2 Terminal Building 287
7.1.2.1 Ticketing/Check-In Level 289
7.1.2.2 Departure Concourse Level 290
7.1.3 Terminal MEP Systems 290
7.1.3.1 Domestic Water System 290
7.1.3.2 Electrical System 290
7.1.3.3 Fire Suppression 290
7.1.4 Site Utilities 290
7.1.4.1 12.5kV Site Power 290
7.1.4.2 Site Communication/IT 290
7.1.4.3 Water System 290
7.1.4.4 Hydrant Fueling 290
7.2 PROGRAM PHASING: PHASE TWO 297
7.2.1 Airside Infrastructure 297
7.2.1.1 Passenger Boarding Bridges 297
7.2.2 Terminal Building 297
7.2.2.1 Ticketing/Check-In Plan (Level 88) 297
7.2.3 Terminal MEP Systems 299
7.2.3.1 Chilled Water System 299
7.2.3.2 Hot Water System 299
7.2.3.3 HVAC 299
7.2.3.4 Domestic Water System 299
7.2.3.5 Sanitary Waste and Vent System 299
7.2.3.6 Electrical System 302
7.2.3.7 Natural Gas 302
7.2.3.8 Fire Suppression 302
7.2.3.9 Fire Alarm 302
7.2.4 Site Utilities 302
7.2.4.1 12.5kV Site Power 302
7.2.4.2 Site Communication/IT 302
7.2.4.3 Water System 307

7.2.4.4 Sanitary Sewer System 307
7.2.4.5 Apron Grading and Drainage 307
7.2.4.6 Hydrant Fueling 307
7.2.5 Landside 307
7.3 PROGRAM PHASING: PHASE THREE 313
7.3.1 Terminal Building 313
7.3.1.1 Ticketing/Check-In Plan (Level 88) 313
7.3.1.2 Chilled Water System 313
7.3.1.3 Hot Water System 313
7.3.1.4 HVAC 316
7.3.1.5 Domestic Water System 316
7.3.1.6 Sanitary Waste and Vent System 316
7.3.1.7 Electrical System 316
7.3.1.8 Natural Gas 316
7.3.2 Site Utilities 316
7.3.2.1 12.5kV Site Power 316
7.3.2.2 Site Communication/IT 316
7.3.2.3 Water System 316
7.3.2.4 Sanitary Sewer System 316
7.3.2.5 Apron Grading and Drainage 327
7.3.2.6 Hydrant Fueling 327
7.3.3 Landside 327
7.4 PROGRAM PHASING: PHASE FOUR 331
7.4.1 Terminal Building 331
7.4.1.1 Ticketing/Check-In Plan (Level 88) 331
7.4.1.2 Chilled Water System 331
7.4.1.3 Hot Water System 334
7.4.1.4 HVAC 334
7.4.1.5 Domestic Water System 334
7.4.1.6 Sanitary Waste and Vent System 334
7.4.1.7 Electrical System 334
7.4.1.8 Natural Gas 344
7.4.1.9 Fire Suppression 344
7.4.2 Site Utilities 344
7.4.2.1 12.5kV Site Power 344
7.4.2.2 Site Communication/IT 344
7.4.2.3 Water System 344
7.4.2.4 Sanitary Sewer System 344
7.4.2.5 Apron Grading and Drainage 350
7.4.2.6 Hydrant Fueling 350
7.4.3 Landside 350

8.0 PROGRAM COST ESTIMATES 359
8.1 Basis of Estimate 359
8.2 Basis of Pricing 359
8.2.1 Procurement Method 359
8.2.2 Wage Rates 359
8.2.3 Phasing 359
8.2.4 Access and Security 359
8.3 Mark-Up and Contingency Assumptions 359
8.4 Statement of Probable Cost of Construction 360
8.5 Project Scope Clarifications 360
8.5.1 Foundations 360
8.5.2 Basement Construction 360
8.5.3 Superstructure 360
8.5.4 Exterior Enclosure 360
8.5.5 Roofing 360
8.5.6 Interior Construction 361
8.5.7 Stairs 361
8.5.8 Interior Finishes 361
8.5.9 Conveying Systems 361
8.5.10 Plumbing 361
8.5.11 HVAC 361
8.5.12 Fire Protection 361
8.5.13 Electrical 361
8.5.14 Services 361
8.5.15 Equipment 361
8.5.16 Furnishings 361
8.5.17 Demolition 361
8.5.18 Airside Site Work 361
8.5.19 Landside Improvements 361
8.5.20 Utility Enabling Projects 361
8.5.21 Other Enabling Projects 361
8.6 Exclusions 362

APPENDIX A Passenger Show-Up Profiles ..... A

APPENDIX B Check-in Attributes ..... B

List of Tables

ES.1 MLIT Cost Estimate Comparison 36
1.1 Preliminary Decision Point Development Options for Terminal D 41
2.1 Summer 2014 Terminal D Foreign Flag Carrier Flight Schedules 47
2.2 MLIT Foreign Flag Carrier – Design Day Flight Schedule – International Departures 54
2.3 MLIT Foreign Flag Carrier – Design Day Flight Schedule – International Arrivals 55
3.1 Existing Terminal D Functional Space Allocation (sf) 62
3.2 Terminal Space Facts Summary 62
3.3 Existing Terminal D Gate Inventory 80
3.4 Existing Terminal C Gate Inventory 112
4.1 Program Requirements Summary (1 of 3) 124
4.1 Program Requirements Summary (2 of 3) 125

4.1 Program Requirements Summary (2 of 3 continued) ... 126
4.1 Program Requirements Summary (3 of 3) ... 127
4.2 Flight Schedule Summary ... 128
4.3 Gate Requirement Summary ... 128
4.4 Performance Criteria ... 129
4.5 Percentages of Originating Passengers Checking Bags ... 130
4.6 Check-in Program Requirements ... 131
4.7 Holdroom Requirement ... 134
4.8 Airline Club Requirements ... 138
4.9 Airline Office and Support Space Requirements (1 of 2) ... 139
4.9 Airline Support Space Requirements (2 of2) ... 140
4.10 Projected Concession Sales per Enplanement (at PAL 33, in 2014 Dollars) ... 143
4.11 Preliminary Supportable Concessions Space (PAL 33, in Square Feet) ... 144
4.12 Concession Support Space Projections ... 144
4.13 MEP and Circulation Requirements ... 145
5.1 Future Terminal D Aircraft Gating Capabilities ... 149
5.2 Typical Aircraft Tractors ... 157
5.3 Ground Service Equipment Characteristics ... 158
5.4 Typical Ground Power Unit Characteristics ... 159
8.1 Soft Costs and Contingencies ... 360
8.2 MLIT Program Cost Estimate Summary ... 362

List of Figures

ES.1 Renovate vs. Rebuild Summary ... 17
ES.2 MLIT Rebuild Option L074 – Baggage Level ... 18
ES.3 MLIT Rebuild Option L088 – Ticketing Level ... 19
ES.4 Central Processor – Ticketing ... 20
ES.5 Interior View of Ticketing Hall ... 21
ES.6 Interior View of Security ... 22
ES.7 MLIT Rebuild Option L100 – Apron Level ... 23
ES.8 MLIT Rebuild Option L116 – Departure Level ... 24
ES.9 Interior View of Pier ... 25
ES.10 Concourse – Blended Holdroom ... 26
ES.11 Interior View of Concessions ... 27
ES.12 Interior View of Airline Club ... 28
ES.13 Interior View of Airline Club ... 29
ES.14 MLIT Rebuild Option L132 – Club Level ... 30
ES.15 Roadway Alternative 1A (Terminal E Bypass) ... 31
ES.16 Exterior Landside ... 32
ES.17 Exterior - Landside ... 33
ES.18 Exterior - Airside ... 34
ES.19 Phasing Summary – Rebuild ... 35
1.1 Strategic Plan Timeline ... 40
1.2 Decision Point Study Process ... 40
1.3 Previous Terminal D Replacement Alternatives ... 42
1.4 IAH Historical and Forecast International Passengers ... 43
1.5 Busiest U.S. International Gateways ... 43
2.1 MLIT Gate Numbers ... 49
2.2 MLIT D1 Pier (West) Gates Design Day Flight Schedule – PAL 33 ... 51
2.3 MLIT D Front Gates (Design Day Flight Schedule) – PAL 33 ... 52
2.4 MLIT D2 Pier (East) Gates – Design Day Flight Schedule – PAL 33 ... 53
3.1 Existing Terminal D Ticketing Level (88) ... 60
3.2 Existing Terminal D Apron Level (100) ... 61
3.3 Existing Terminal D Intermediate/Sterile Corridor Level (106/110) ... 63
3.4 Existing Terminal D Departure Level (121) ... 64
3.5 Terminal D Existing Wayfinding Signage Conditions Example ... 65
3.6 Existing Terminal D Basement Level (74) ... 67
3.7 Water System Pumps (Basement Level) ... 66
3.8 Switchgear Line-Up ... 68
3.9 Typical Secondary Switchboard ... 69
3.10 Electric One-Line Diagram – Main SWGR ... 70
3.11 Existing Generator ... 71
3.12 Electric One-Line Diagram – Existing Standby Power ... 72
3.13 Electric One-Line Diagram – Existing Standby Power ... 73
3.14 Water Tank Name Plate ... 74
3.15 Fire System Inspection Report ... 74
3.16 Water/Fire Protection System Valves (Basement Level) ... 75
3.17 Dewatering System (Basement Level) ... 75
3.18 IT "Hub and Spoke" Distribution ... 76
3.19 Terminal D – Existing Floor Plans ... 77
3.20 Terminal D – Existing Floor Plans ... 78
3.21 Terminal D – Existing Gate Layout ... 79
3.22 East Flow Taxi Routes ... 81
3.23 West Flow Taxi Routes ... 82
3.24 Existing Hydrant Fuel Lines ... 84
3.25 Existing Terminal D Water Lines ... 86
3.26 Existing Terminal D Sanitary Sewer Lines ... 87
3.27 Existing Terminal D Storm Sewer/Apron Drainage ... 89
3.28 Existing Apron Grading ... 90
3.29 Existing Terminal D Natural Gas System ... 91
3.30 Terminal C – Level 1 ... 92
3.31 Terminal C – Level 2 ... 93
3.32 Terminal C – Level 3 ... 94
3.33 Terminal C – North Concourse Level 1 ... 95
3.34 Terminal C – North Concourse Level 2 ... 96
3.35 Existing Ramp Control Tower ... 98
3.36 Terminal C North Chilled Water Flow Diagram ... 100
3.37 Terminal C Building Chilled Water Flow Diagram ... 101
3.38 Terminal C North Hot Water Flow Diagram ... 102
3.39 Terminal C Building Hot Water Flow Diagram ... 103
3.40 ITT & Apron Levels – AHU Location Plan ... 104
3.41 Penthouse and Mezzanine Levels – AHU Location Plan ... 105
3.42 Terminal C – Central Electrical One Line Diagram ... 106

3.43 Terminal C – North Electrical One Line Diagram 107
3.44 Existing Terminal C Core IT 109
3.45 Existing Terminal C. North Baggage Level – IT 110
3.46 Terminal C – North Overall Airfield Plan 111
3.47 Existing Hydrant Fueling 113
3.48 Existing Terminal C North Water Lines 116
3.49 Existing Terminal C North Sanitary Sewer Lines 117
3.50 Existing Terminal C North Storm Sewer Lines 118
3.51 Existing Roadway Terminal Allocation 119
4.1 PAL 33 Diurnal Activity 127
4.2 IATA Level of Service Framework – Passenger Queue 129
4.3 IATA Level of Service Framework – Passenger Circulations 129
4.4 International Check-in Demand Activity 131
4.5 Check-in Counter 133
4.6 Holdroom Space Template 135
4.7 Make-Up Carousel Size and Spacing 134
4.8 Bag Room Vehicle Flow (partial view) 136
4.9 Pre-Cleared Flight Reclaim Carousels (Standard Bags) 137
4.10 PAL 33 Checkpoint Demand Activity 142
4.11 TSA Security Screening Checkpoint Space Template 141
4.12 Single Line Diagram of CBIS 142
4.13 CBIS Layout 143
5.1 Future IAH Terminal Area 150
5.2 Terminal D Aircraft Parking and Gate Allocation 151
5.2a Terminal D Aircraft Parking of B737-900ERW 153
5.3 MLIT Rebuild – Part 77 154
5.4 MLIT Rebuild – Part 77 (Profile) 155
5.5 Line-of-Sight Study (Rebuild Option) 156
5.6 Aircraft Tractors 158
5.7 Typical Catering Truck 158
5.8 MLIT Proposed Hydrant Fueling Preferred 160
5.9 Original Terminal C North Concept 162
5.10 Original Terminal C North and Terminal D Concept 163
5.11 Renovate vs. Rebuild Summary 164
5.12 MLIT Rebuild Option L074 – Baggage Level 165
5.13 Example of a Linear CBIS Design 166
5.14 MLIT Rebuild Option L088 – Ticketing Level 168
5.15 Ticketing Layout 169
5.16 MLIT Rebuild Option L100 – Apron Level 173
5.17 Bag Room Vehicle Flow (partial view) 174
5.18 MLIT Rebuild Option L116 – Departure Level 175
5.19 Section – Concession Core 176
5.20 Section – Club/Pier – Concession Core 177
5.21 Ramp Control Tower 180
5.22 MLIT Rebuild Option L132 – Club Level 181
5.23 Club Boarding Concept 1 – L132 – Club Level 182
5.24 Club Boarding Concept 2 – L132 – Club Level 183
5.25 Club Boarding Concept 3 – L132 – Club Level 184
5.26 Club Boarding Concept 4 – L132 – Club Level 185
5.27 MLIT Cross Section Through Pier D1 (A) 189
5.28 MLIT Cross Section Through Pier D1 (B) 190
5.29 MLIT Cross Section Through Pier D1 (C) 191
5.30 MLIT Cross Section Through Pier D1 192
5.31 MLIT Cross Section Through Central Terminal 193
5.32 MLIT Cross Section Through Pier D2 Baggage Functions 194
5.33 Hot Water and Chill Water Distribution 196
5.34 Chilled & Hot Water System L088 – Ticketing Level 197
5.35 MEP – Rooms L100 – Apron Level 198
5.36 MEP – Rooms Roof 199
5.37 Plumbing System L088 – Ticketing Level 200
5.38 Power Distribution Option 1 201
5.39 Power Distribution Option 2 202
5.40 Power Distribution Option 3 204
5.41 Power Distribution Option 3 205
5.42 MEP-Rooms L088 – Ticketing Level 206
5.43 MEP-Rooms L074 – Baggage Level 207
5.44 MEP-Rooms L116 – Departure Level 208
5.45 MEP-Rooms L132 – Club Level 209
5.46 Proposed Natural Gas Preferred 212
5.47 Proposed Fire Protection Preferred 213
5.48 Preferred Alternative 12.5 KV Distribution 215
5.49 Preferred Alternative IT Distribution 216
5.50 MLIT Proposed Waterline 218
5.51 MLIT Proposed Sewer Line 219
5.52 MLIT Rebuild Proposed Apron Grading 221
5.53 MLIT Drainage Area Map 222
5.54 MLIT Proposed Storm Drainage 223
5.55 Roadway Alternative 1 225
5.56 Roadway Alternative 2 226
5.57 Roadway Alternative 1A (Terminal E Bypass) 227
6.1 Interior View of Ticketing Hall 232
6.2 Central Processor-Ticketing 233
6.3 Interior View of Security 234
6.4 Interior View of Pier 235
6.5 Concourse – Blended Holdroom 236
6.6 Interior View of Concessions 237
6.7 Interior View of Airline Club 238
6.8 Interior View of Diplomacy/Diplomatic Suite 239
6.9 Interior View of Airline Club 240
6.10 Exterior Landside 241
6.11 Exterior - Landside 242
6.12 Exterior Airside 243
6.13 Example of Permanent Piece by Paul Vilinski 246
6.14 Example of Permanent Piece by Ed Wilson 246

6.15 Example of a Display Case ... 247
6.16 Preferred Flatwork Display Case ... 247
6.17 Larger Integrated Flatwork Display ... 247
6.18 Example of a Multimedia Station ... 248
6.19 Wayfinding – Design Description ... 256
6.20 Kit of Parts ... 257
6.21 Planned Sign Family 1 of 2 ... 258
6.21 Planned Sign Family 2 of 2 ... 259
6.22 Graphics 1 of 2 ... 261
6.22 Graphics 2 of 2 ... 262
6.23 Messages ... 263
6.24 Wayfinding Plan Baggage Level ... 265
6.25 Wayfinding Plan Ticketing Level ... 266
6.26 Wayfinding Plan Departures Level ... 267
6.27 Wayfinding Plan Club Level ... 268
6.28 Elements of Life Cycle Costing ... 272
7.0.1 Phasing – Existing Conditions ... 278
7.0.2 Phasing Summary - Rebuild ... 279
7.0.3 Phase 0 (Not in Scope) ... 280
7.0.4 Proposed Natural Gas – Phase 0 ... 282
7.0.5 MLIT/Terminal B Airside Limit Line ... 283
7.0.6 12.5KV Site Power – Phase 0 ... 284
7.0.7 Proposed Hydrant Fueling – Phase 0 ... 286
7.1.1 Phase 1 (Enabling Projects) ... 288
7.1.2 Proposed Domestic Water/Fire Protection – Phase 1 ... 291
7.1.3 Electrical One – Line Diagram ... 292
7.1.4 Electrical One – Line Diagram – Main SWGR ... 293
7.1.5 Power Distribution – Phase 1 ... 294
7.1.6 Proposed Hydrant Fueling – Phase 1 ... 295
7.2.1 Phase 2 ... 298
7.2.2 Chilled and Hot Water Pipe Routing – Phase 2 (A, B, & C) ... 300
7.2.3 Plumbing Pipe Routing – Phase 2 (A, B, & C) ... 301
7.2.4 Power Distribution – Phase 2 (A, B, & C) ... 303
7.2.5 Proposed Domestic Water/Fire Protection – Phase 2 ... 304
7.2.6 Phase 2 – Option 1 12.5KV Distribution ... 305
7.2.7 Phase 2 – IT Distribution ... 306
7.2.8 Proposed Sanitary Sewer – Phase 2 ... 308
7.2.9 Proposed Storm Sewer – Phase 2 ... 309
7.2.10 Proposed Hydrant Fueling – Phase 2 ... 310
7.2.11 Landside – Rebuild (Phase 2) ... 311
7.3.1 Phase 3 ... 314
7.3.2 Chilled and Hot Water Pipe Routing – Phase 3 (A, B, C, & D) ... 315
7.3.3 Plumbing Pipe Routing – Phase 3 (A, B, C, & D) ... 317
7.3.4 Power Distribution – Phase 3 (A, B, C, & D) ... 318
7.3.5 Electrical One-Line Diagram – MSGR-A ... 319
7.3.6 Electrical One-Line Diagram – MSGR-A ... 320
7.3.7 Proposed Natural Gas – Phase 2 ... 321
7.3.8 Phase 3 – Option 1 12.5KV Distribution ... 322
7.3.9 Phase 3 IT Distribution ... 323
7.3.10 Proposed Domestic Water/Fire Protection – Phase 3 ... 324
7.3.11 Proposed Sanitary Sewer – Phase 3 ... 325
7.3.12 Proposed Sanitary Sewer – Phase 3 ... 326
7.3.13 Proposed Storm Sewer – Phase 3 ... 328
7.3.14 Proposed Hydrant Fueling – Phase 3 ... 329
7.3.15 Landside – Rebuild (Phase 3) ... 330
7.4.1 Phase 4 (A-C) ... 332
7.4.2 Phase 4 (D-H) ... 333
7.4.3 Chilled and Hot Water Pipe Routing – Phase 4 (A, B, C, & D) ... 335
7.4.4 Chilled and Hot Water Pipe Routing – Phase 4 (D, E, F, G, & H) ... 336
7.4.5 Plumbing Pipe Routing – Phase 4 (A, B, C, & D) ... 337
7.4.6 Plumbing Pipe Routing – Phase 4 (D, E, F, G, & H) ... 338
7.4.7 Power Distribution – Phase 4 (A, B, C, & D) ... 339
7.4.8 Electrical One-Line Diagram – MSGR-B ... 340
7.4.9 Electrical One-Line Diagram – MSGR-B ... 341
7.4.10 Electrical One-Line Diagram – MSGR-A ... 342
7.4.11 Electrical One-Line Diagram – MSGR-A ... 343
7.4.12 Power Distribution – Phase 4 (D, E, F, G, & H) ... 345
7.4.13 Proposed Domestic Water/Fire Protection – Phase 4 ... 346
7.4.14 Phase 4 – Option 1 12.5KV Distribution ... 347
7.4.15 Phase 4 – IT Distribution ... 348
7.4.16 Proposed Sanitary Sewer ... 349
7.4.17 Proposed Storm Sewer ... 351
7.4.18 Proposed Hydrant Fueling Phase 4B ... 352
7.4.19 Proposed Hydrant Fueling Phase 4F ... 353
7.4.20 Landside – Rebuilt (Phase 4 A, B, C & D) ... 354
7.4.21 Landside – Rebuilt (Phase 4 E, F, G & H) ... 355
A.1 Passenger Show-Up Profiles – Before 9am ... 365
A.2 Passenger Show-Up Profiles – After 9am ... 366
B.1 Check-In Attributes – Europe Bound ... 369
B.2 Check-In Attributes – Latin America Bound ... 370
B.3 Check-In Attributes – Asia Bound ... 371
B.4 Check-In Attributes – Middle East Bound ... 372

Executive Summary

ES.0 Executive Summary

ES1.0 INTRODUCTION

The new Mickey Leland International Terminal (MLIT) is a capital development program designed to modernize and expand Terminal C North and Terminal D at George Bush Intercontinental Airport (IAH). The MLIT Program Definition Manual (PDM) is the culmination of planning work to modernize the terminals and contains background information and detailed project development criteria for use by designers in preparing design and construction documents for the MLIT development.

ES1.1 PROJECT PURPOSE

Terminal D is at capacity during peak hours and exceeds capacity 4-5 weeks of the year, especially during summer to winter, winter to summer months. Expansion and modernization of the facility is warranted to accommodate future international growth. In addition, the terminal building and many of its systems need to be updated to meet current building codes and operational standards. Only minor cosmetic improvements have been made to the terminal since opening in 1990. Consequently, the building has begun to show its age. The interior of the terminal is dated with inadequate seating in the holdrooms, insufficient space for new or enlarged airline clubs, inadequate restroom facilities, and concession facilities that do not meet customer expectations.

The supporting infrastructure, inventoried in detail in **Chapter 3**, is also showing signs of age with limitations in providing sufficient HVAC, water and sanitary sewer, and electrical power. Many of the building systems have not been significantly upgraded since Terminal D opened and they have reached or exceeded their lifecycle. Additionally, because of its narrow, linear design, the existing terminal space is no longer optimally configured for today's ticketing and baggage screening/handling operations.

Current customer service levels at Terminal D are no longer competitive with terminals at similarly sized airports. Total passengers for the international markets have more than quadrupled since Terminal D opened in 1990. IAH is the nation's 8th busiest international gateway and the 2nd fastest growing since the events of September 11, 2001; Terminal D requires modernization to remain competitive.

The end result is that the existing Terminal D structure now requires a major renovation or replacement to meet passenger demand, aircraft up-gauging, and current code requirements as well as the need to replace and expand the building systems to meet current demands.

The planning team generated the following list of guidelines and objectives through several sources, including interviews with HAS staff, workshops, and discussions with airport stakeholders. These sources guided the planning and subsequent design efforts for MLIT:

MLIT Planning and Design Guidelines and Objectives

1. Provide gate capacity for all aircraft types through the IAH Master Plan planning activity level (PAL33) forecast. The forecast is tied to the number of enplaning passengers (33 million) and not a specific date (approximately 2028).
2. Provide a high level of customer service.
3. Meet airline requirements for contact gates and passenger processing facilities.
4. Replace aging infrastructure that is not code compliant.
5. Develop a terminal facility that utilizes space efficiently.
6. Develop a terminal facility that maximizes concession revenue opportunities.
7. Increase opportunities for non-airline revenue sources.
8. Maximize airside envelope to establish flexible and high gate utilization.
9. Maintain existing operations and number of wide-body gates during construction phasing.

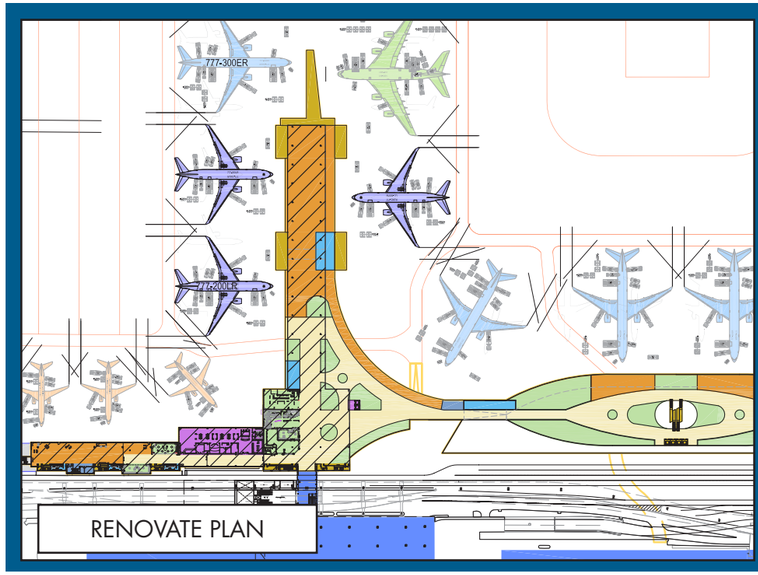
Prior planning studies for the redevelopment of Terminal D failed to meet all of the design guidelines and objectives listed above. In late December 2013, HAS and United Airlines (UA) were able to come to a design solution to accommodate these shortfalls. UA has agreed to move forward with the proposed Terminal B Phase II project that would include the construction of a two-level terminal pier on the north side of IAH. UA will vacate Terminal C North (once Terminal B Phase II is open) to ease construction phasing challenges and to increase the footprint of MLIT. Terminal B Phase II and Terminal C North proved to be the "missing link" for the MLIT development.

ES1.2 PLANNING PROCESS

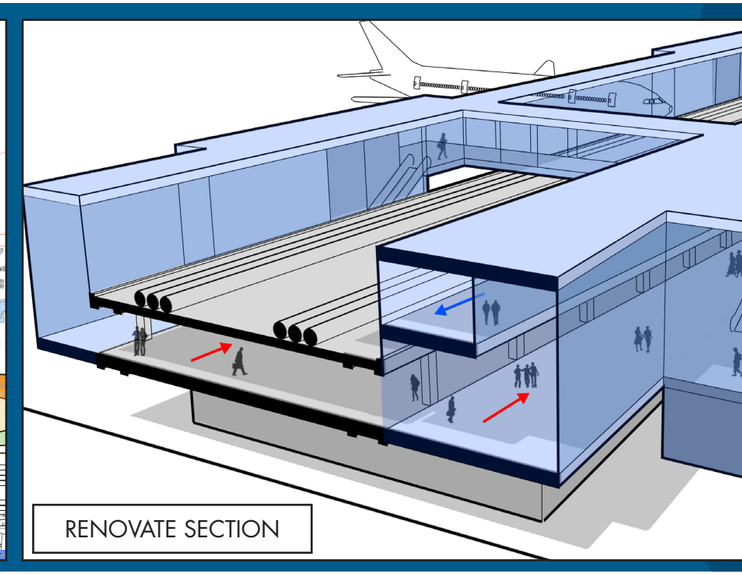
The Houston Airport System (HAS) realized the need to address issues with an aging Terminal D and the demand for increased international passenger service. Work began on the MLIT PDM in February 2014 under the HNTB On-Call Planning Services contract. The design day flight schedule described in **Chapter 2** was developed by the LeighFisher Master Plan team and used to determine program requirements (see **Chapter 4**) developed by Ricondo & Associates, Inc. Extensive collaboration and weekly workshop presentations were used to obtain input from HAS staff and airport stakeholders as the team initially evaluated plans to modify Terminal C North to accommodate arriving international passengers. The plan was to add a Sterile Corridor to the existing Pier Concourse along with a new Airline Club above the roof (see **Chapter 5**). The initial plan for Terminal D was to move forward with the "Rebuild" option developed during the Mickey Leland International Terminal (MLIT) PDM dated June 7, 2013.

During the first few weeks of MLIT planning, several terminal layout alternatives and aircraft parking combinations were evaluated. A unified MLIT terminal footprint with two pier concourses and a centralized processor became the preferred alternative. The only remaining question was whether to tear down the existing Terminal C North to the structure and "Renovate" or demolish the entire building and "Rebuild". **Figure ES.1** shows the "Rebuild" vs. "Renovate" summary. Rough Order of Magnitude (ROM) cost estimates were developed for both alternatives. In June 2014 the decision was made to "Rebuild" both Terminal C North and Terminal D within a "design to budget".

Renovate vs. Rebuild Summary



RENOVATE PLAN

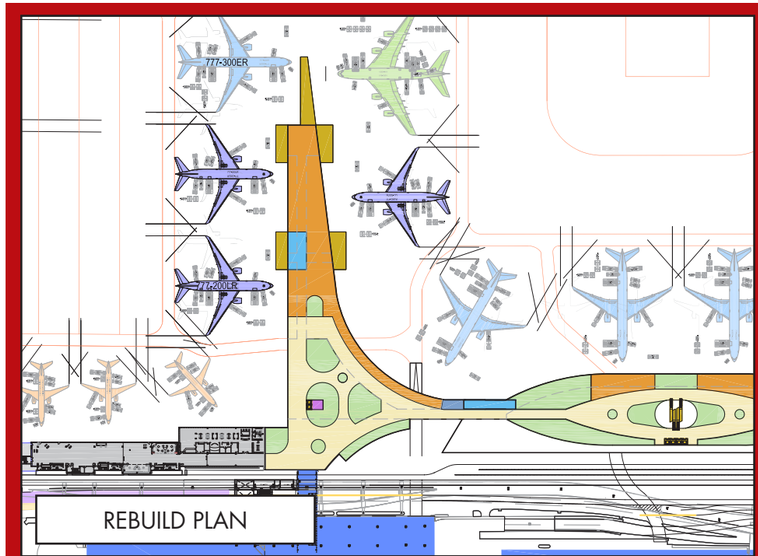


RENOVATE SECTION

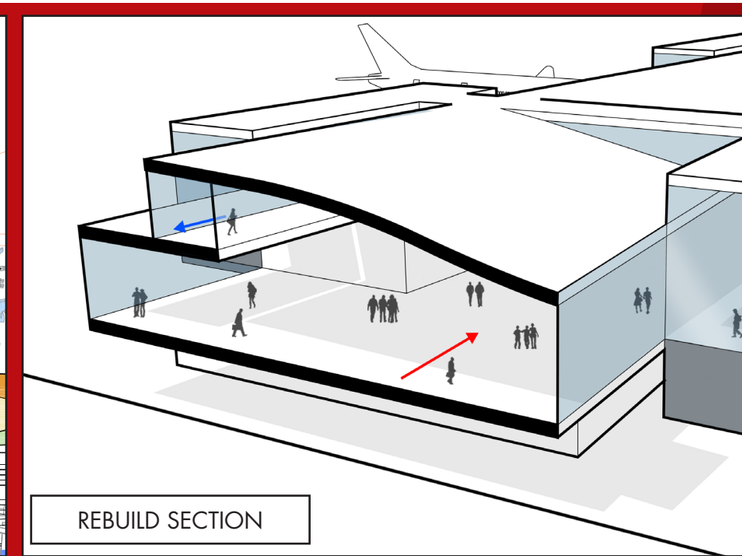
RENOVATE

NUMBER OF Int'l GATES: 14-15 (INCL. 4 A380)
NUMBER OF PROCESSORS/SSCP: 1
LANDSIDE WIDTH TO FIS: 210' (INCLUDES BYPASS)
CONCOURSE C FLOOR ELEVATION: 13' ABOVE APRON
PIER VOLUME:
EXISTING ROOF CONSTRAINTS/LESS FLEXIBLE
SSCP LANES: 8-12 @ CENTRAL PROCESSOR

WALKING DISTANCES:
STERILE C PIER (FARTHEST GATE) TO FIS: 2,500 LF
STERILE D PIER (FARTHEST GATE) TO FIS: 980 LF
SECURITY TO C PIER (FARTHEST GATE): 1,200 LF



REBUILD PLAN



REBUILD SECTION

REBUILD

NUMBER OF Int'l GATES: 14-15 (INCL. 4 A380)
NUMBER OF PROCESSORS/SSCP: 1
LANDSIDE WIDTH TO FIS: 210' (INCLUDES BYPASS)
CONCOURSE C FLOOR ELEVATION: 16' ABOVE APRON
PIER VOLUME :
OPEN/DAYLIT/FLEXIBLE/PIER UNITY
SSCP LANES: 8-12 @ CENTRAL PROCESSOR

WALKING DISTANCES:
STERILE C PIER (FARTHEST GATE) TO FIS: 2,500 LF
STERILE D PIER (FARTHEST GATE) TO FIS: 980 LF
SECURITY TO C/D PIER (FARTHEST GATE): 1,200 LF

ES1.3 FINDINGS

The Rebuild Plan consists of the reconstruction of the existing Terminal D as well as Terminal C North that together will serve up to four A380 and up to eleven wide-body aircraft for a total of fifteen gates. The reconstruction occurs in phases while maintaining operational functionality to accommodate flights and passengers during demolition and construction. Program phasing is discussed in detail in **Chapter 7**.

The program requirements, based on the PAL33 flight schedule, call for an optimized terminal building of 801,520 square feet (sf). The floor plans developed by the planning team total 801,530 sf, a difference of 10 sf. The increase in the terminal building area is attributed mostly to the geometry of the new terminal concept. The following sub-sections briefly describe each floor level and the landside components of the Rebuild Alternative (elevation above mean sea level is noted in parenthesis). More detailed information about program requirements and specific functional elements on each level may be found in **Chapters 4** and **Chapter 5**.

ES1.3.1 BAGGAGE LEVEL PLAN (74)

The Baggage Level includes elements of the Checked Baggage Inspection System (CBIS) and the subterranean tunnel that connects Terminal D with Terminal E. The Baggage Level conceptual floor plan totals approximately 43,400 sf and is illustrated in **Figure ES.2**.

ES1.3.2 TICKETING/CHECK-IN LEVEL PLAN (88)

The Ticketing/Check-In Level includes the ticket lobby, inbound and outbound baggage operations, security screening checkpoint (SSCP), and related airline and TSA support facilities. The Ticketing/Check-In Level conceptual floor plan totals approximately 171,200 sf and is illustrated in **Figure ES.3**. A conceptual rendering of the ticket lobby is shown in **Figure ES.4** and **Figure ES.5**. A conceptual rendering of the security screening checkpoint is illustrated in **Figure ES.6**.

ES1.3.3 APRON LEVEL PLAN (100)

The Apron Level includes inbound and outbound baggage operations, airline operation spaces, MEP spaces and related airport terminal facilities. The Apron Level conceptual floor plan totals approximately 105,600 sf and is illustrated in **Figure ES.7**.

ES1.3.4 DEPARTURE LEVEL PLAN (116)

The Departure Level includes holdrooms, concessions, access to the Club Level, and passenger services. The passenger services on this level are very diverse and include restrooms, chapel/meditation room, children's play area, USO space, a performance stage, nursery, and public art space. The public area includes space for the "Texas Experience", an interactive space for the international traveling public to understand more about Texas culture. This level includes support spaces such as concession storage, wheelchair storage, airport operations space, airport maintenance space, and charging and storage space for electric carts. The Departure Level conceptual floor plan totals approximately 319,700 sf and is illustrated in **Figure ES.8**. **Figure ES.9** is a conceptual rendering showing the interior of the new piers with the Sterile Corridor Level flying above. **Figure ES.10** is a conceptual rendering showing the blended holdroom in the concourse. **Figure ES.11** is a conceptual rendering of the concession core.

ES1.3.5 CLUB/STERILE CORRIDOR LEVEL PLAN (132)

The Club/Sterile Corridor Level includes airline clubs, the Diplomatic Suite, and the Sterile Corridor. The airline club space on this level will consist of six clubs of approximately 10,000 sf each. Direct aircraft boarding from airlines clubs is required for two A380 and one wide-body aircraft parking position. A conceptual rendering of the club space is shown in **Figure ES.12** and **Figure ES.13**. The Diplomatic Suite is intended to be a high-finish, secure-side space that may be used for important gatherings of HAS staff, government officials and international delegates for meetings, media events, and other engagements. The Club/Sterile Corridor Level conceptual floor plan totals approximately 161,700 sf and is illustrated in **Figure ES.14**.

ES1.3.6 LANDSIDE COMPONENTS

A major benefit of the MLIT project is the ability to improve the landside constraints that exist today in the vicinity of Terminals C, D, and E, as shown in **Figure ES.15**. The roadway adjacent to the MLIT is proposed to have four lanes providing a minimum width of 11 ft per lane to allow more space for vehicles to maneuver offering a higher level of service and more comfortable vehicle operating conditions along the roadway.

The new location of MLIT (approximately 70 ft north of its existing location) will allow for additional curb depth along the face of the building. The curb depth would increase from 15 ft to 25 ft from the face of the terminal and 20 ft from the vestibules. This will provide additional area for passengers to unload and allow better circulation of passengers, baggage, and carts along the curb. The curb is 1,060 ft long and serves private and commercial vehicles unloading along the face of the building. A conceptual rendering of the landside is shown in **Figure ES.16** and **Figure ES.17**. A conceptual rendering of the airside is shown in **Figure ES.18**.

ES1.3.7 PROGRAM PHASING

The MLIT program is broken into four main phases that span approximately six years from the initial start of design to the full build-out of the new MLIT. The program phasing was developed with the assumption that the delivery method would not be the traditional Design-Bid-Build but rather Construction Manager (CM) at Risk. The rationale behind this recommended delivery approach is the ability to design and implement enabling projects during the anticipated two year design period for the entire program. **Figure ES.19** provides a summary of the four phases, which are described below.

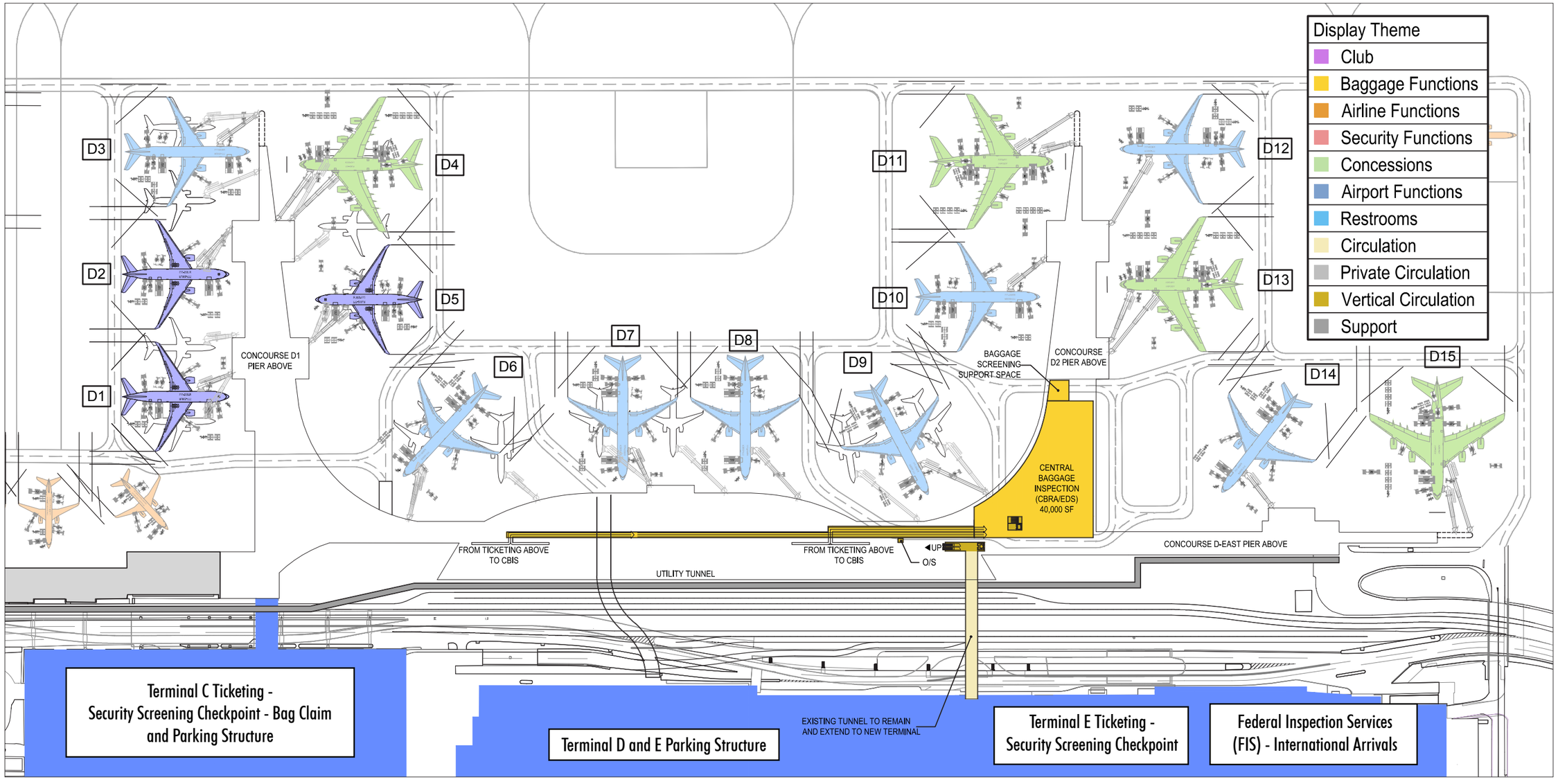
ES1.3.7.0 Phase 0 - Terminal B North Pier

A key component of the phasing of the new MLIT is the construction of the new Terminal B North Pier. This project is being completed by United Airlines and is not in the contract of the MLIT project; however, its' completion is critical to the MLIT phasing plan. At the completion of the Terminal B North Pier, United Airlines will vacate the Terminal C North Pier, which will provide the flexibility to move forward with the construction of the MLIT. The duration of Phase 0 is approximately 24 months.

ES1.3.7.1 Phase 1 - Enabling Projects

In preparation for the implementation of the new MLIT, a series of enabling projects will need to be completed. Phase 1 includes projects that need to be finished prior to the demolition of Terminal C North. These projects include: relocation of the Terminal C North Ramp Control Tower, east outbound baggage screening matrix and make-up expansion, temporary jetbridge/ walkway construction, and hydrant fueling modifications for relocated aircraft parking positions. During this enabling phase, passenger and aircraft operations generally continue to function as they do under current conditions. The duration of Phase 1 is approximately 24 months.

MLIT Rebuild Option L074 - Baggage Level



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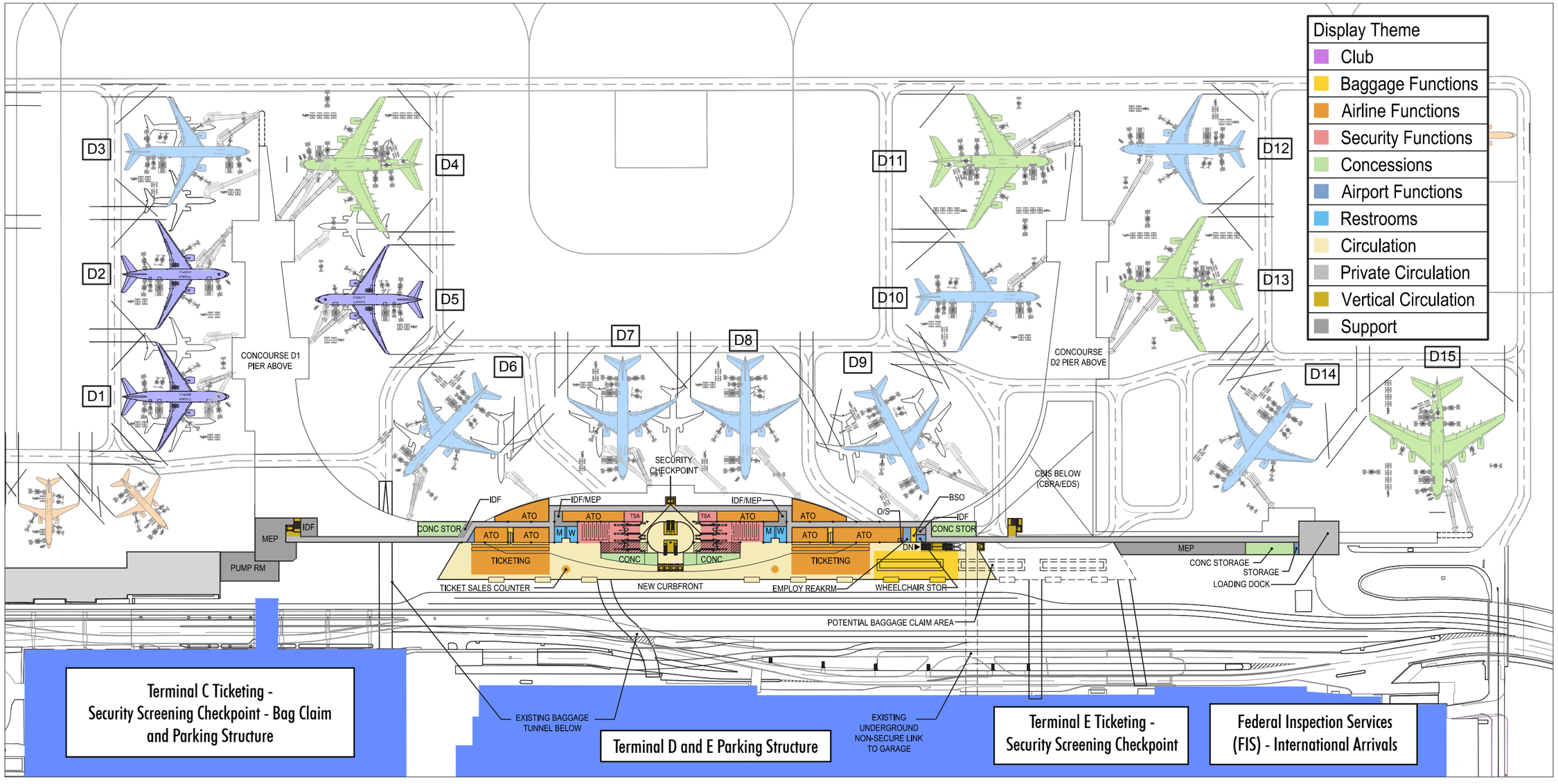
MLIT Rebuild Option L088 - Ticketing Level



0′ 200′

Central Processor - Ticketing

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent. Ticketing Hall shall be common use.

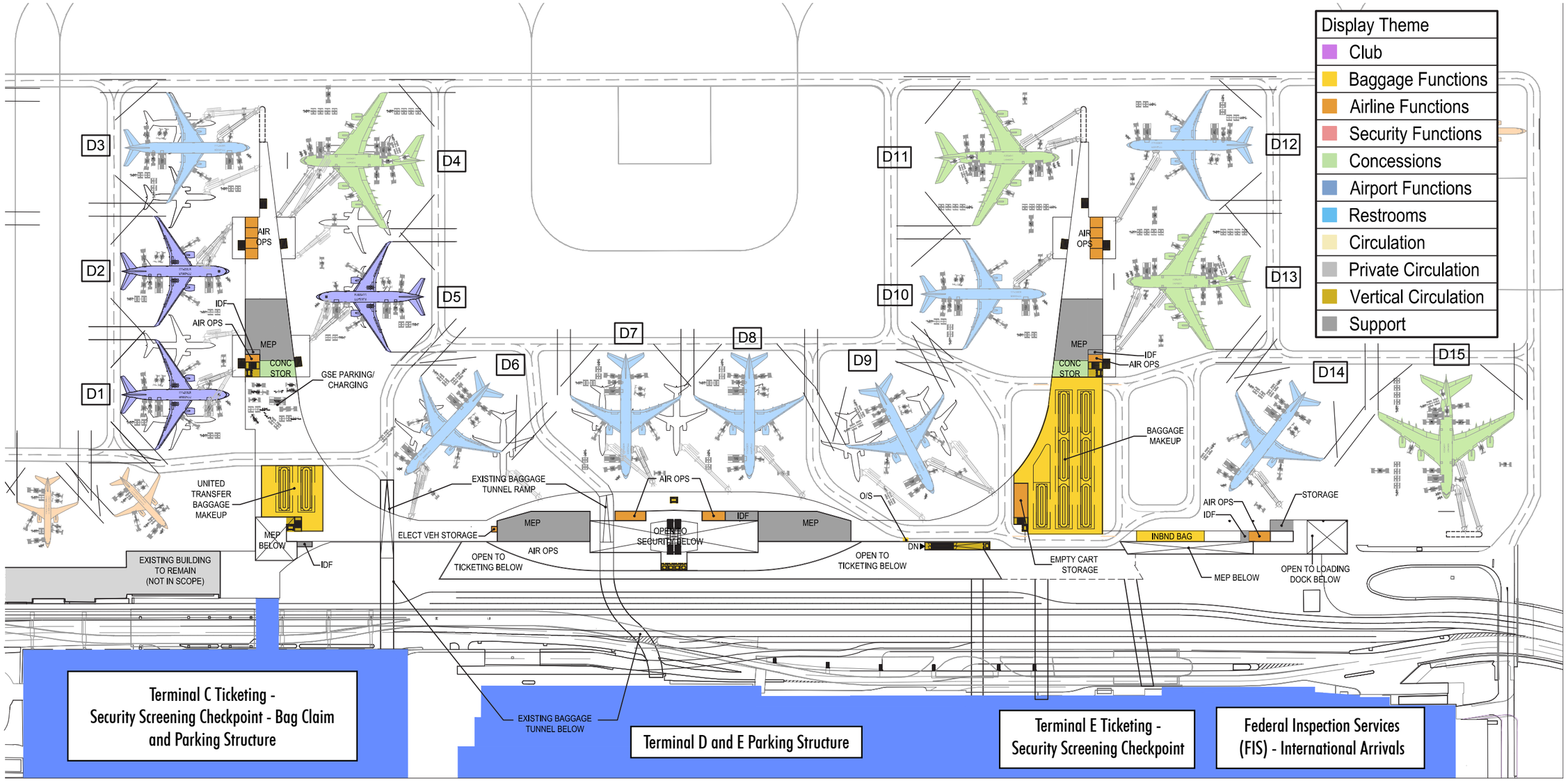
Interior View of Ticketing Hall

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent. Ticketing Hall shall be common use.

Interior View of Security

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

MLIT Rebuild Option L100 - Apron Level



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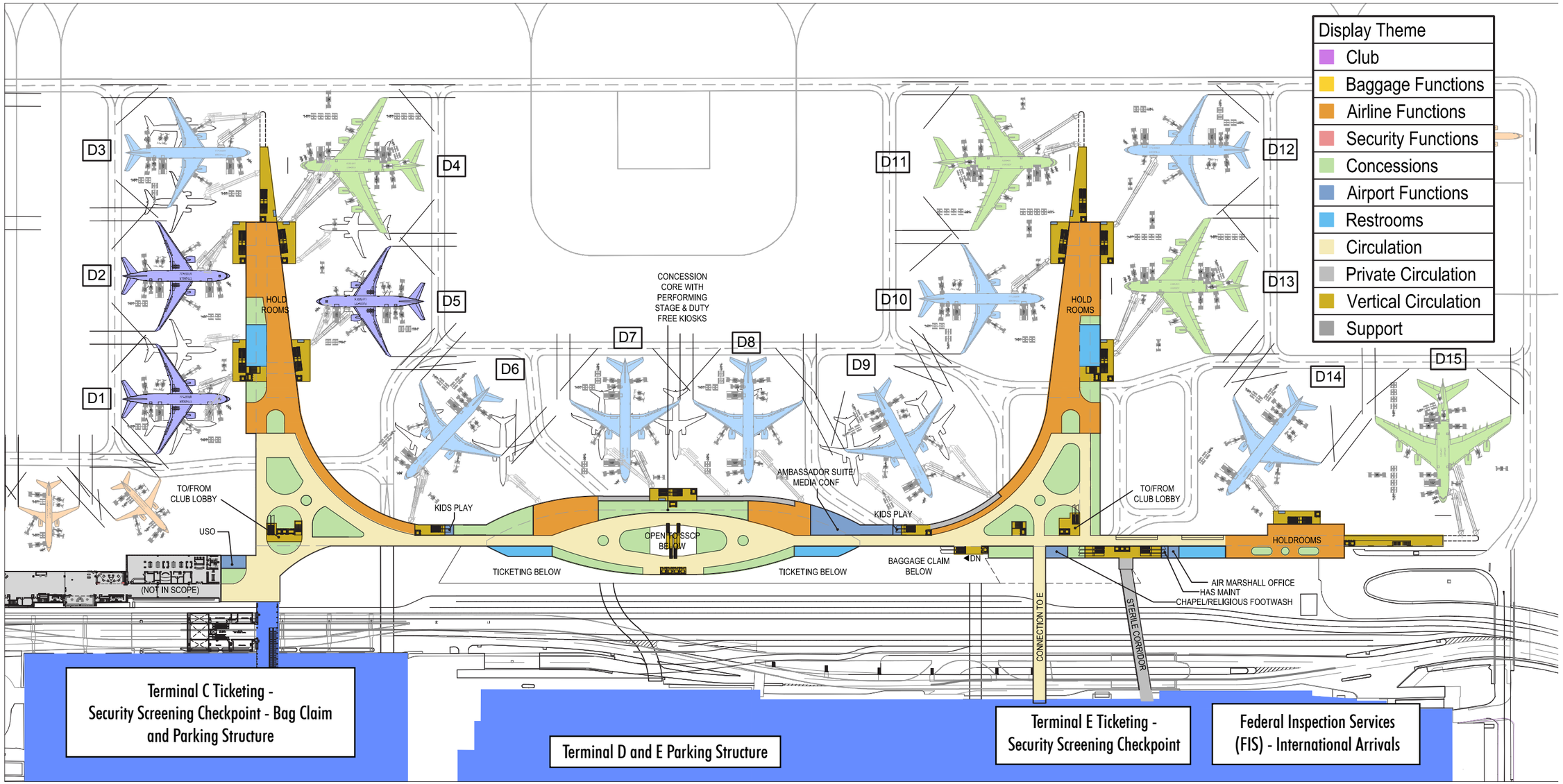
MLIT Rebuild Option L116 - Departure Level



0′ 200′

Interior View of Pier

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Concourse - Blended Holdroom

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Interior View of Concessions

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

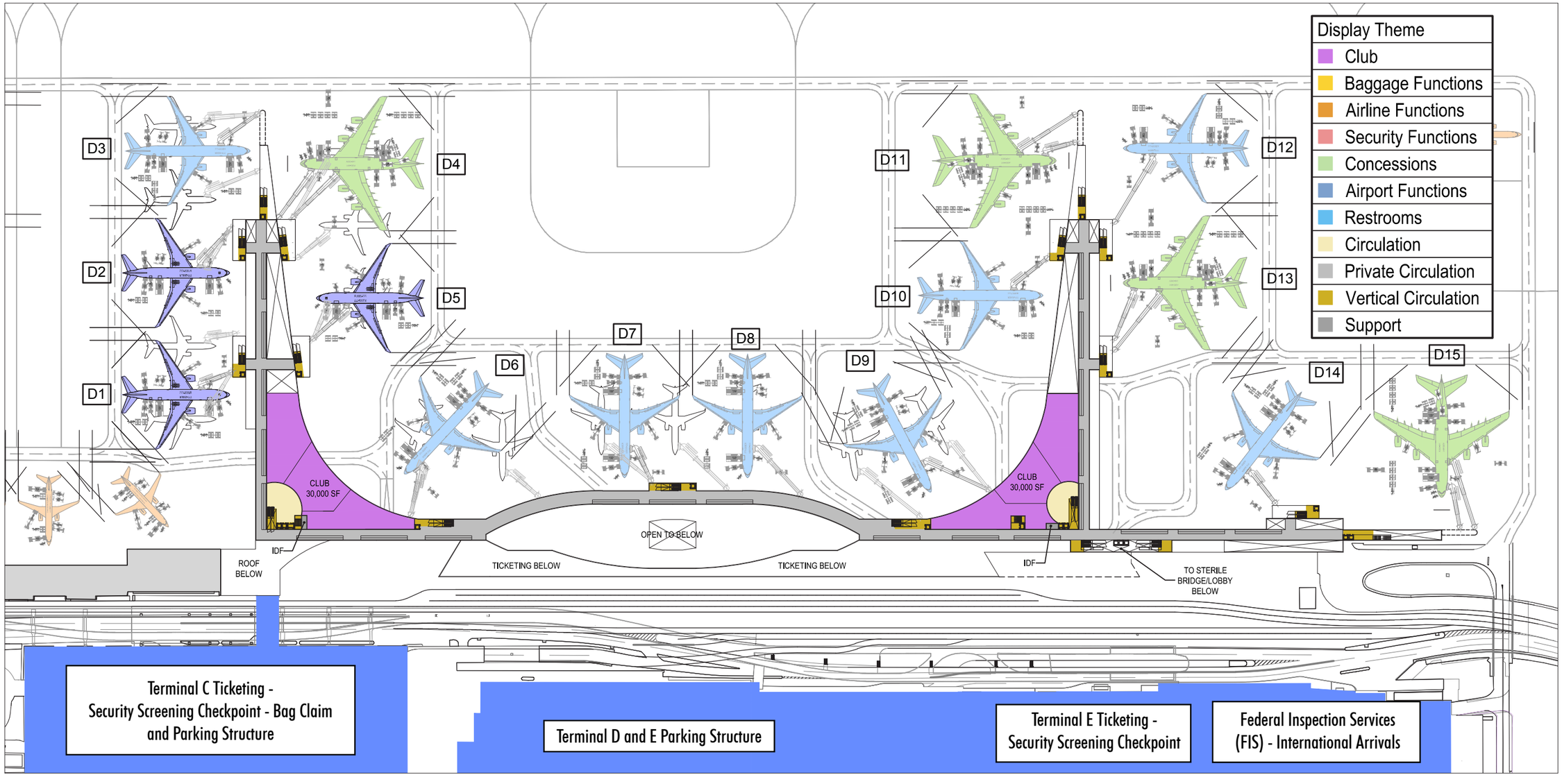
Interior View of Airline Club

NOTE: Shell only; interiors provided by Airline.

Interior View of Airline Club

NOTE: Shell only; interiors provided by Airline.

MLIT Rebuild Option L132 - Club Level



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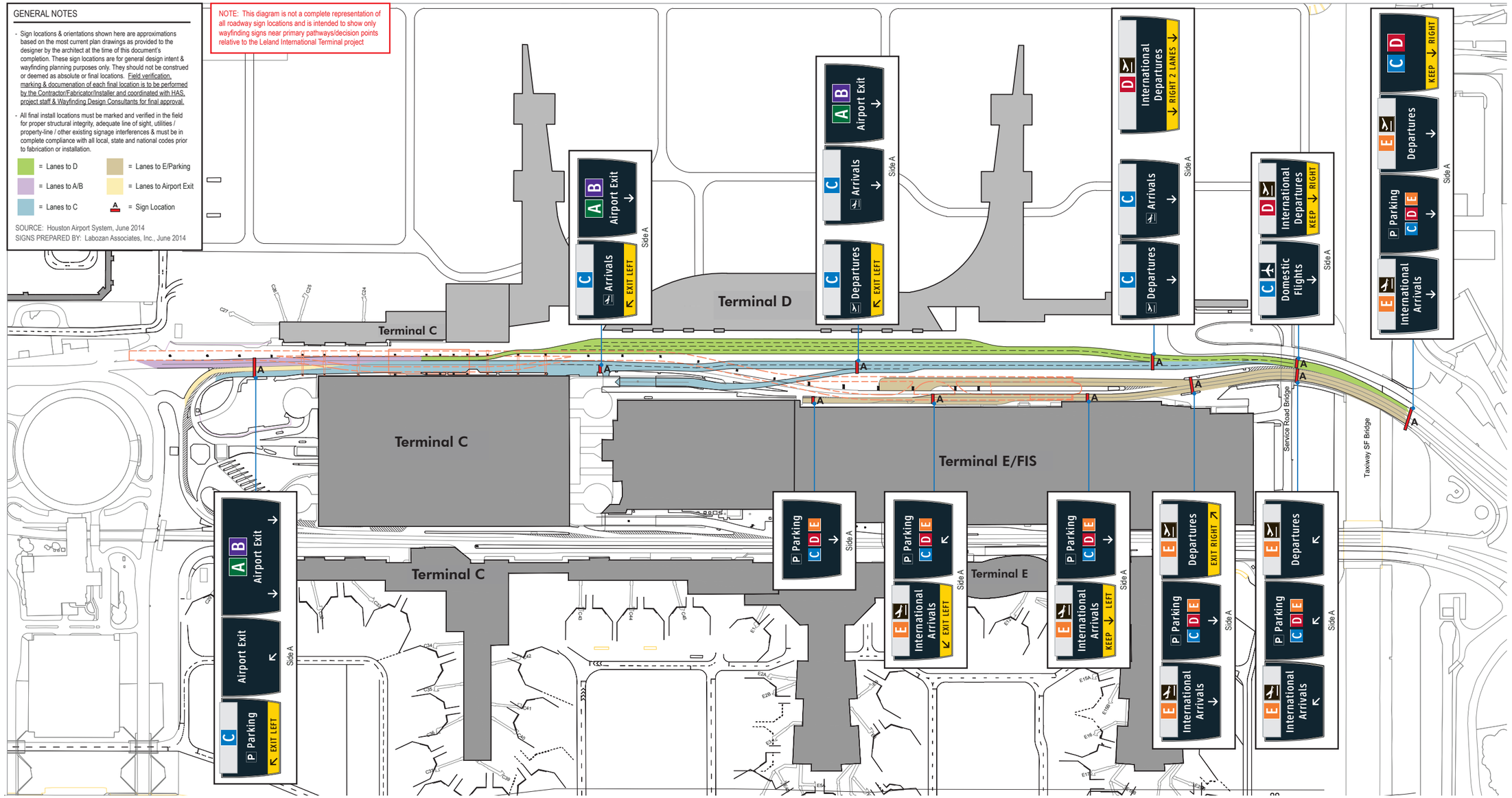
Roadway Alternative 1A (Terminal E Bypass)

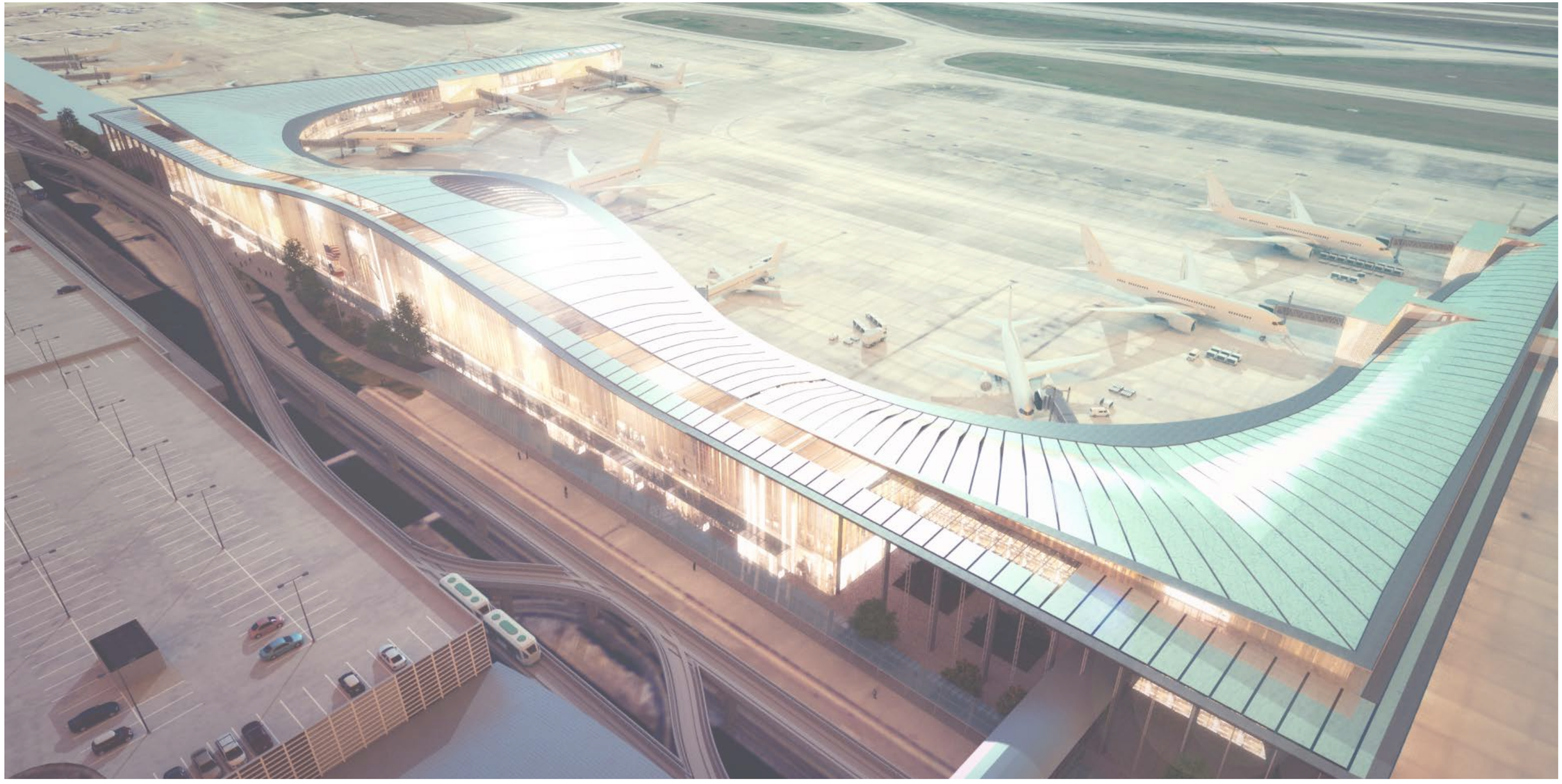


Not to Scale

Exterior Landside

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Exterior - Landside

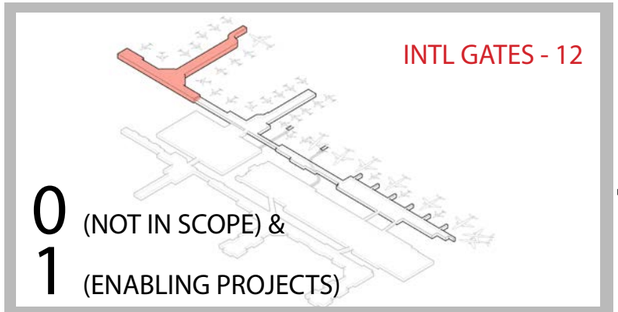


NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Exterior - Airside

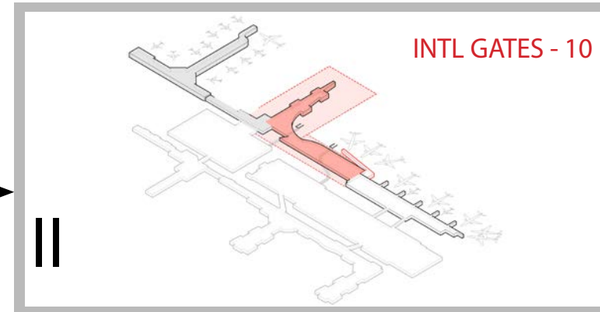
NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Phasing Summary - Rebuild



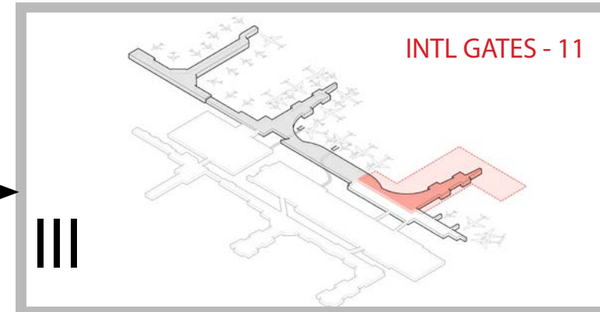
0 (NOT IN SCOPE) &
1 (ENABLING PROJECTS)

- PHASE O -
  - BUILD NEW B-NORTH PIER
- PHASE 1A -
  ENABLING UTILITIES
- PHASE 1B -
  EXISTING EAST BAGGAGE EXPANSION
- PHASE 1C -
  BUILD TEMPORARY JETBRIDGE WALKWAY



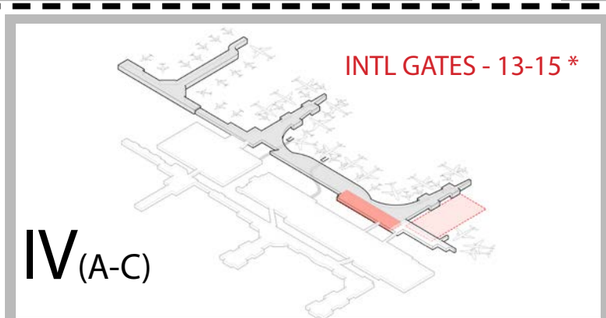
II

- PHASE 2A -
  OPEN NEW B PIER
- PHASE 2B -
  DEMO EXISTING C-PIER &C-CONNECTOR
- PHASE 2C -
  BUILD NEW D1 PIER & CENTRAL CORE



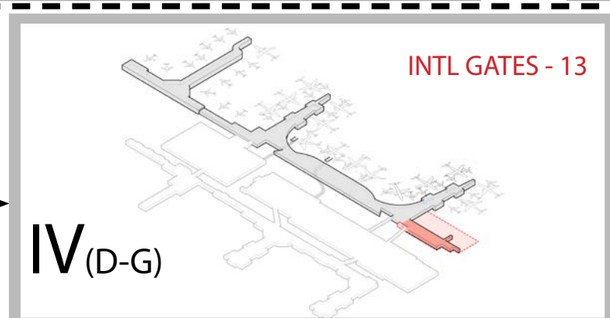
III

- PHASE 3A -
  OPEN NEW D1 PIER, CENTRAL CORE
- PHASE 3B -
  REWORK STERILE CORRIDOR THRU EXISTING D
- PHASE 3C -
  DEMO EXIST. D DEPARTURE LEVEL
- PHASE 3D -
  BUILD NEW D2 PIER



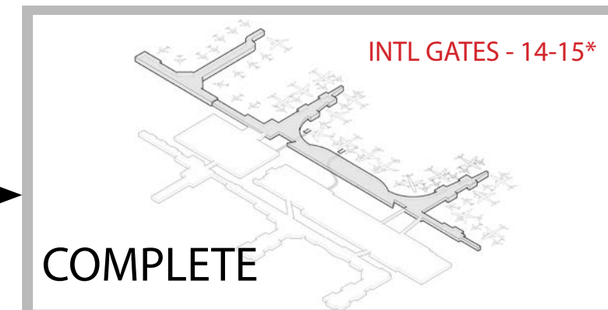
IV(A-C)

- PHASE 4A -
  OPEN D2 PIER (WEST GATES)
- PHASE 4B -
  REBUILD/OPEN D2 PIER EAST APRON
- PHASE 4C -
  DEMO EXIST. EAST LANDSIDE TICKETING



IV(D-G)

- PHASE 4D -
  BUILD TEMPORARY STERILE CONNECTOR WALKWAY
- PHASE 4E-
  OPEN NEW EAST TICKETING LANDSIDE & CURBSIDE
- PHASE 4F -
  DEMO REMAINING EX. D CONC
- PHASE 4G -
  REBUILD FIS BRIDGE & REMAINING GATES



COMPLETE

- OPEN NEW FIS BRIDGE & REMAINING GATES

COMBINED PHASE

ES1.3.7.2 Phase 2 - D1 Pier and Central Core/Processor

Phase 2 constructs the D1 Pier as well as the western portion of the new MLIT. There are three primary subphases in this portion of the construction. During this phase, operations from Terminal C North have been relocated to the new Terminal B North Pier (not in contract). Terminal D generally continues to operate as normal with the exception of the western gates which have been relocated (north) to a new temporary location (to make way for the MLIT central core/processor). The east portion of Terminal D will continue to operate as normal through this phase with 10 international gates in operation.

Within the construction zone of Phase 2 there are two existing tug drive tunnels that will be impacted. The first is to and from the Terminal C processor, while the other is to the Terminal D FIS inbound baggage delivery belts. The ongoing construction will likely constrain use of these tunnels. Additional study will be required to determine the specific impact on these tunnels and how the activity is otherwise accommodated if they are unable to remain in operation. The duration of Phase 2 is approximatley 24 months.

ES1.3.7.3 Phase 3 - D2 Pier

Phase 3 includes additional demolition of portions of the existing Terminal D as well as the construction of the D2 Pier. There are three subphases of Phase 3. At the completion of Phase 2, passenger operations have now begun in the new MLIT Terminal Processor including check in and passenger security and the new central concessions core is open. The new vehicle roadway is now open. Gate operations are in use on the D1 Pier as well as on the D frontal gates. In total, eight wide-body international gates are now operating from these new facilities along with gates D10, D11, and D12 in the existing Terminal D. The new Sterile Corridor on the upper level of the facility is in use tying into the existing Terminal D Sterile Corridor.

At this point the passenger processing functions of Terminal D, such as check-in and security screening, have been decommissioned; however, portions of Terminal D remain in use throughout Phase 3. Gates D10, D11, and D12 remain in use on the eastern portion of Terminal D, and the existing baggage screening and makeup operations continue to be in use. Portions of the building must also remain open in order to accommodate the international Sterile Corridor connection to the FIS, as well as to accommodate passenger traffic to/from the new MLIT terminal processor and existing Gates D10, D11, and D12. The duration of Phase 3 is approximately 24 months.

ES1.3.7.4 Phase 4 - Final Terminal D Demolition

Phase 4 includes the final demolition of the remaining portions of Terminal D and the completion of the MLIT and East Pier gates. There are six subphases of Phase 4. At the completion of Phase 3, passenger operations have now begun in the new D2 Pier. There are now 13 wide-body gates in operation in the new MLIT. The duration of Phase 4 is approximately 24 months.

ES1.3.7.5 Completed MLIT

When completed, modernized, and expanded Terminal D will provide IAH with a state of the art international facility able to accommodate all types of aircraft and increased passenger loads for the next 14 years or more (PAL33 2028).

ES1.3.8 ROUGH ORDER OF MAGNITUDE COST ESTIMATES

A high-level Rough Order of Magnitude (ROM) Cost Estimate was developed for the Renovate and Rebuild alternatives, which are summarized in **Table ES.1**. The basis of the ROM is discussed in **Chapter 8** and the full cost estimates are provided in **Appendix C**.

Table ES.1 MLIT Cost Estimate Comparison

CATEGORY	LOW*	HIGH*
New Terminal	$438,298,483	$502,400,637
Air Side Sitework	$94,881,902	$108,758,597
Land Side Improvements	$5,172,543	$5,929,039
Utility Enabling Projects	$142,241,383	$163,044,510
Other Enabling Projects	$85,789,534	$98,336,449
MLIT Program Cost	**$766,383,844**	**$878,469,232**

**Including Owner's Soft Costs*

*** The above table reflects the latest draft cost estimates. Finalized revisions will be included in the completed RFQ.*

ES1.4 RECOMMENDATION

The Rebuild Alternative plans and cost estimates were presented side by side with the Renovate Alternative plans and costs to HAS and the stakeholders. Advantages and disadvantages of each plan were also presented. Each plan meets the same program requirements. However, by rebuilding Terminal D and Terminal C North, a unified, consistent terminal building could be constructed. In June 2014, the decision was made to "rebuild" both Terminal C North and Terminal D within a "design to budget". This Program Definition Manual presents the MLIT planning criteria, floor plans, phasing approach, and costs based upon that June 2014 decision. The preferred plan herein is intended to serve as a guide to the selected A/E for developing design and construction documents.

Chapter 1 | Introduction

1.0 Introduction

1.1 Background

The Mickey Leland International Terminal (MLIT) is a Capital Development Program designed to modernize and expand Terminal C North and Terminal D at George Bush Intercontinental Airport (IAH). The MLIT Program Definition Manual (PDM) is the culmination of planning work containing background information and program development criteria for use by designers in preparing construction drawings for the reconstruction of Terminal C North and Terminal D. Terminal D is at capacity during peak hours and an expansion and modernization of Terminal D is warranted to accommodate future growth. In addition, the terminal building and many of its systems need to be updated to meet current building codes and operational standards. The primary users of Terminal D are the Foreign Flag (FF) international airlines. United Airlines (UA) also uses the facility to accommodate some international arrivals. UA is the exclusive operator in Terminal C North.

UA and the FF airlines are in need of more international arrival capable gates to accommodate future growth. The Houston Airport System (HAS), the FF airlines, UA, and the non-UA domestic airlines have worked in a collaborative planning effort over the past year to realize this recommended solution for all parties.

Terminal D opened in 1990 as the International Airlines Building (IAB) serving the FF airlines as well as Continental Airlines (now UA) with 12 gates serving a mix of narrow-body and wide-body aircraft. The wide-body design aircraft at that time was the Douglas Aircraft Company DC-10, an Airplane Design Group (ADG) IV aircraft. In 2014 the FF airlines are operating larger ADG VI aircraft such as the Airbus Industries A380 and Boeing Company B747-800.

The following is a timeline of key dates for Terminal D:

- 1990 – Opened as the International Airlines Building.
- 1998 – Renamed Terminal D, Mickey Leland International Terminal.
- 2001 – Continental Airlines expanded international service out of Terminal D.
- 2003 – Continental Airlines opened Terminal E and Terminal D became home to the FF airlines.
- 2005 – The new Federal Inspection Services (FIS) facility was completed and all international operations were transferred to the FIS.
- 2007 – Emirates Airlines, Singapore Airlines, and Qatar Airlines began scheduled wide-body service to Terminal D.
- 2011 – The Refresh Project was initiated to prepare for arrival of Lufthansa scheduled A380 flights.
- 2012 – First A380 flight begins service out of Terminal D.
- 2013 – Turkish Airlines and Air China begin operation out of Terminal D with new non-stop service to Istanbul, Turkey and Beijing, China respectively.
- 2014 – Korean Airlines starts non-stop service to Seoul, South Korea and Scandinavian Airlines (SAS) is scheduled to start non-stop service to Stavanger, Norway in August. A second A380 flight is schedule to begin service out of Terminal D by the end of the year.

Terminal C opened in 1981; it was and remains the largest terminal at IAH accommodating the facilities and operations of United Airlines exclusively. Terminal C consists of three separate buildings: an eight-level central building at landside and two, two-level concourse buildings at airside. The Central Building accommodates all terminal-access and passenger processing functions. Pedestrian bridges at the north and south sides of the main building connect to the concourse buildings at the adjacent north and south airside areas for aircraft boarding. Other pedestrian bridges and walkways on the east and west sides connect to adjacent parking garages.

Terminal C North is currently served by 13 aircraft contact parking positions, Gates C14 through C26. These positions allow parking for 13 narrow-body (Group III or smaller) aircraft. In addition, there are three positions capable of accommodating wide-body (Group V) aircraft if operations at adjacent gates are restricted.

1.2 Process

Planning for the MLIT has taken place over the past several years (2010-2014). Each successive stage in the evolution of the program has further clarified the vision for a new International Terminal to replace Terminal D. This section chronicles the stages in the evolution of the MLIT and how they shaped the program that is emerging today.

1.2.1 TERMINAL ASSESSMENT

In early 2011, the Houston Airport System (HAS) assessed Terminal D and began a process for determining how to make improvements. Only minor cosmetic improvements have been made to the terminal since opening in 1990, consequently, the building has begun to show its age. A plan developed in 2010, known as the Terminal D "Refresh," was under consideration but the concept addressed interior finishes and upgrades to systems and did not provide additional capacity to accommodate additional wide-body aircraft. The interior of the terminal is dated with inadequate seating in the holdrooms, insufficient space for airline clubs, inadequate restroom facilities, and inadequate concession facilities that do not meet customer expectations or demands. The supporting infrastructure is also showing signs of age and limitations in providing HVAC, water pressure, sanitary sewer capacity, and electrical power. Because of its narrow design, the existing terminal space is no longer used in an optimum manner for ticketing and baggage handling. Finally, the airside is constricted and unable to accommodate larger aircraft such as the Airbus A380. At peak operational times, typically midday to late afternoon, all of the gates are occupied, which limits space to accommodate new FF carriers.

Other hubs across the United States have been upgrading their international facilities in response to the increasing number of international passengers passing through those hubs. The growing impact of airline alliances has also influenced how modern international terminals function. HAS realized the need to address these issues within the aging Terminal D and the demand for increased international passenger service.

1.2.2 STRATEGIC PLAN

In the summer of 2011, the HAS initiated the first step in addressing the issues with Terminal D. The Planning and Programming Division of HAS tasked CH2M Hill with the preparation of a strategic plan addressing three

pressing issues at IAH. These were the Terminal B Expansion Program, George Bush Intercontinental Airport (IAH) Master Plan, and Terminal D (with a focus on Terminal D). HAS was already in the early planning stages for a new A380 gate at Terminal D and the objective of the strategic plan was to identify a general program to address the overall needs of Terminal D. This was to be done in concert with the Terminal B program and the IAH Master Plan, which was in the preliminary scoping phase. The consultant team tasked with the preparation of the strategic plan prepared a timeline and objectives for HAS to achieve. **Figure 1.1** is an excerpt from the Strategic Plan. It shows the planning timeline for addressing the immediate Terminal D issues and the IAH Master Plan. Since the Terminal B Expansion Program was being managed by United Airlines and had already started, the Strategic Plan only looked at where conflicts might arise between the Terminal B Expansion Program, the IAH Master Plan, and Terminal D plans.

Figure 1.1 – Strategic Plan Timeline

Department	60 Days	6 months	12 months	30 months
Planning	• Terminal D 2012 PDD • Master Plan Framework/NTP	• Terminal D Decision Point	• Complete Master Plan	• Provide ongoing support to capital program

One of the key directives for Terminal D that emanated from the Strategic Plan was to prepare a Project Development Document (PDD) for interim projects to accommodate an A380 aircraft and make minor cosmetic improvements to Terminal D while new plans were being prepared and implemented. Another key directive was to prepare a Decision Point Document that would accomplish the following objectives:

- Determine if Terminal D should be renovated or completely replaced.
- Establish near-term development and enabling projects.
- Establish the near-term development and enabling foundation for remaining master plan elements.

The Strategic Plan was presented to HAS in August 2011.

1.2.3 TERMINAL D A380 PROJECT DEVELOPMENT DOCUMENT

Once the Strategic Plan was completed, the Planning and Programming Division focused on getting Terminal D ready to accept the first scheduled service of an A380 to IAH. The Terminal D A380 Project Development Document (PDD) was initiated to make all of the preparations needed for Lufthansa Airlines' inaugural A380 flight to Houston in the summer of 2012. These preparations were intended to be temporary while plans were put in place to either refurbish Terminal D, renovate it, or completely replace it. The common term for this project was the "Refresh Project". The Terminal D A380 PDD contained all of the plans, directives, schedules, and cost data to complete those necessary activities. The activities included the following:

- Converting Gate D12 to a dual-passenger loading bridge gate to accommodate the A380. A new passenger loading bridge was added to reach the upper level of the A380.
- Providing gate power and pre-conditioned air (PCA) to Gate D12 to supply the A380 with power and air conditioning without the aircraft using its auxiliary power unit (APU).
- Re-aligning the fuel pits, lead-in lines, and other parking position changes for Gates D12 and D11.
- Cosmetic changes to the holdroom, gate check-in, and walkways for Gate D12 such as replacing carpeting, repairing gate check-in positions, and repainting.

The changes to Gate D12 were originally envisioned to be just the first phase of changes to Terminal D. The PDD also reviewed the existing utilities servicing Terminal D as well as interior conditions such as restrooms, signage, club space, seating, carpeting, and lighting. A second phase was envisioned to refresh the entire terminal and all of that information was included in the PDD as well. The final draft of the PDD was submitted in November 2011, but the second phase of work was deferred by HAS while other options were considered.

1.2.4 DECISION POINT STUDY

As the A380 Gate PDD was nearing completion, the Planning and Programming Division tasked the CH2M Hill team with preparing a Decision Point Study to evaluate the current Terminal D program. The HAS leadership had been working on an overall program to improve the system for several months prior. Out of this program came four initiatives to guide the Decision Point Study:

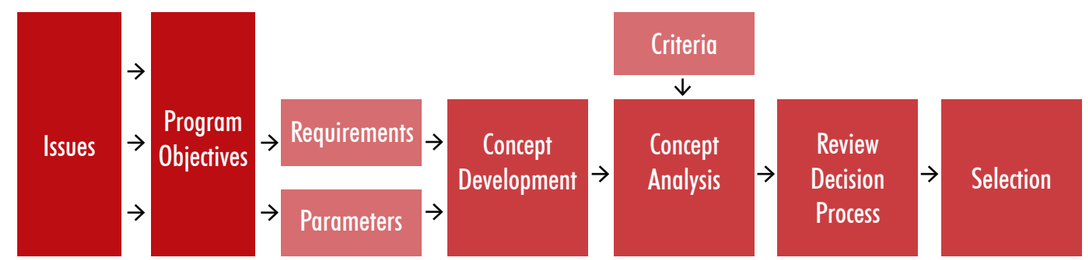
1. Creating high performance organization by maximizing HAS staff involvement in the planning process.
2. Creating a development plan that meets the growing international demand in a manner that strengthened IAH's role as a preeminent U.S. gateway.
3. Strengthen the addressing of the aging infrastructure by creating a facility plan that can be more easily maintained in order to sustain an opening day fresh feeling into the future.
4. Providing a plan that is financially sound and thereby funded into the future.

Using these four initiatives, the CH2M Hill team began work on the Decision Point Study with the following objectives in mind:

- Determine if Terminal D should be renovated or completely replaced.
- Identify near-term development and enabling projects.
- Establish the near-term development and enabling foundation for remaining master plan elements.

As the study progressed the focus became whether or not the existing terminal structure was capable of handling new construction or if it needed to be totally demolished. The answer to this question determines how to proceed with adding international capacity and creating a modern international terminal. **Figure 1.2** provides an illustration of the Decision Point Study process as it was first initiated. **Table 1.1** summarizes the preliminary Decision Point development options for Terminal D.

Figure 1.2 – Decision Point Study Process



Six concept alternatives were developed through initial workshops leading to the central question of whether the Terminal D structure (the steel frame) has the ability to handle additional loads, and if the foundation is capable of accepting additional weight. A structural engineering review determined that the existing structural components were sound and capable of handling the loads for which they were designed; however, they could not handle any additional loads such as building an additional level. The foundation was determined to be capable of handling the designed loads. The structural components would have to be isolated structurally from any new construction.

Based upon the structural report, HAS directed the consultant team to focus on renovation-in-place options. With input from the final workshop, the consultant team identified two alternatives for comment and further refinement. Those options were to build a structurally independent East Pier onto the existing Terminal D structure or build a structurally independent west pier onto the existing Terminal D structure. After further refinement by the consultant team, HAS senior leadership decided in February 2012 to proceed with implementing the West Pier alternative, citing speed of delivery and ability to increase capacity, without having to relocate Taxiway SF at a cost no greater than that of the East Pier option. The refined West Pier alternative was refined and submitted along with a draft Decision Point Document to HAS in May 2011.

Table 1.1 – Preliminary Decision Point Development Options for Terminal D

Concept	Description
Option 1	A multi-pier configuration utilizing the existing terminal structure with options to extend the terminal east. This concept envisioned renovating the existing structure and building new piers connected to the existing structure.
Option 2	A multi-pier configuration utilizing the existing terminal structure but adding space to the existing terminal on the ramp side. This concept envisioned renovating the existing structure and expanding it to incorporate a better holdroom/concession area mix. This concept also included options to extend the terminal east.
Option 3	This concept proposed building a new processor and pier east of the existing facility with options to eventually renovate or replace the existing Terminal D structure.
Option 4	A multi-pier configuration that radically renovates and possibly replaces the existing facility. This concept has a more angular gate and holdroom layout. Also this concept provided options for extending the terminal to the east.
Option 5	A multi-pier configuration similar to Option 1, but expanding the concession and holdroom space at the base of the pier to improve concession revenue. This concept also includes options for expansion of the terminal to the east. It could also be a renovation or complete replacement project.
Option 6	This concept proposed constructing a new holdroom/concourse in front of the existing terminal structure. This new concourse would house upgraded concessions and permit the renovation or replacement of the existing terminal facility at a future date.

1.2.5 TERMINAL D MODERNIZATION PROGRAM - PROGRAM DEFINITION MANUAL

Work began on the Terminal D Modernization Program Definition Manual in August 2012 under HNTB. The original assignment was to prepare an in-depth program definition manual to be provided to the Terminal D design consultant(s) that would outline all of the planning decisions. The PDM was intended to provide detailed criteria for developing the design for the Terminal D West Pier and renovations to the existing Terminal D facility as decided in the Decision Point Study. The consultant team proceeded with refining the general layout of the West Pier and Terminal D, including presentations at workshops to obtain input from HAS staff and airport stakeholders. PDM draft sections were written which included the following information:

- Project Description – background, objectives, planning approach
- Gate Utilization – how to utilize the number of gates identified in the new design
- Space Planning – the amount of space needed for various terminal functions
- Physical Facility Planning – creating a physical layout of the required terminal spaces
- Systems and Utilities Planning – determining the capacity of existing terminal systems and what is required to support the physical layout of the terminal space

Work proceeded until December 2012. As a result of comments received during the workshops, work was suspended while HAS reconsidered the renovation option versus building a completely new terminal on the same site. Concerns were raised about the inability to reuse the intermediate space (old Federal Inspection Services (FIS) space) and the overall cost of the renovation versus rebuilding the structure. Comments centered on the life-cycle costs and benefits of a completely new structure compared to a renovated facility. In December 2012, the consultant team was directed to modify the PDM to describe how to demolish Terminal D completely and replace it with a new Terminal D facility. The TDMP PDM for the rebuild of Terminal D was completed in June 2013.

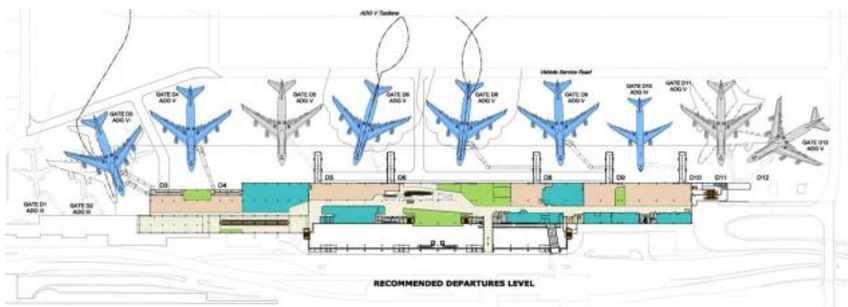
1.2.6 EAST TERMINAL

In the spring of 2013, , while evaluating long-term concerns in the Central Terminal Area, the LeighFisher Master Plan team developed an East Terminal concept. This alternative would have been the new home, a consolidated terminal complex, for the foreign flag carriers that operate out of Terminal D as well as the non-United domestic airlines that operate out of Terminal A. The East Terminal concept was studied in detail and would have provided a "greenfield" site to the east of the existing Central Terminal Area (CTA). The East Terminal concept provided some relief for long-term Master Plan issues such as additional gates, landside relief and international-domestic carrier synergies. However, during the planning phase and after stakeholder engagement it was determined that the connectivity of passengers and baggage to/from the East Terminal and the CTA would not be acceptable.

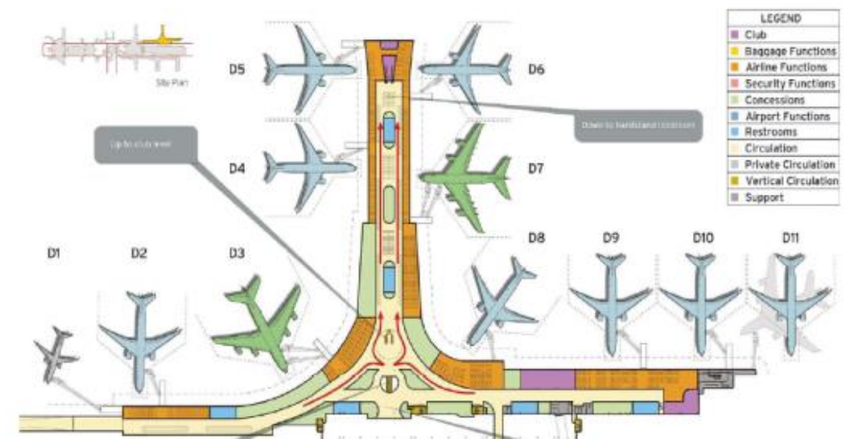
1.2.7 MICKEY LELAND INTERNATIONAL TERMINAL – PROGRAM DEFINITION MANUAL

In late December 2013, HAS and United Airlines (UA) were able to come to a design solution to accommodate phasing challenges identified during the June 2013 TDMP PDM and the East Terminal Concept. UA agreed in principle to move forward with the proposed Terminal B Phase II project that would include the construction of a two-level terminal pier on the north side of IAH. UA would relinquish its exclusive rights to Terminal C North and HAS would be able to increase the footprint of Terminal D. The HNTB team was tasked with updating the TDMP PDM to include both Terminal D and Terminal C North. Stakeholder meetings with the HNTB team, HAS, UA, FF carriers, and the non-United domestic airlines were conducted regularly starting in February 2014 through June 2014 to develop a solution that would be acceptable to all stakeholders at IAH. The contents of the MLIT PDM outline the program defined during this stakeholder engagement process. **Figure 1.3** illustrates the international terminal planning alternatives considered in the previous studies for the modernization and expansion of Terminal D.

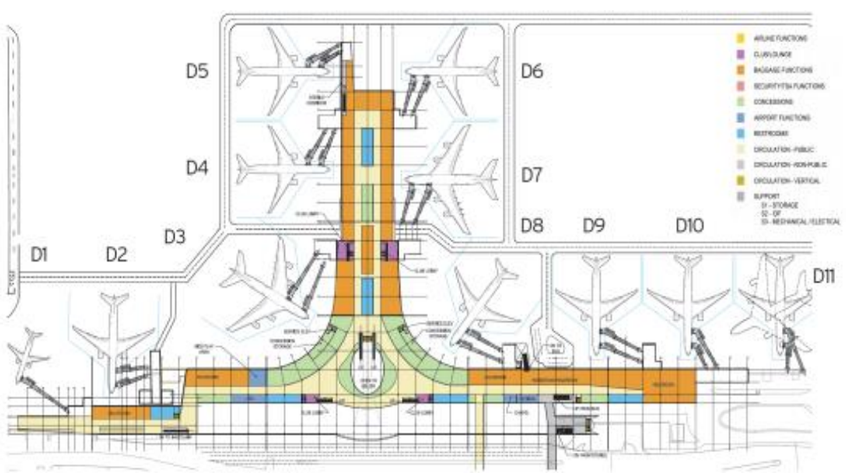
Previous Terminal D Replacement Alternatives



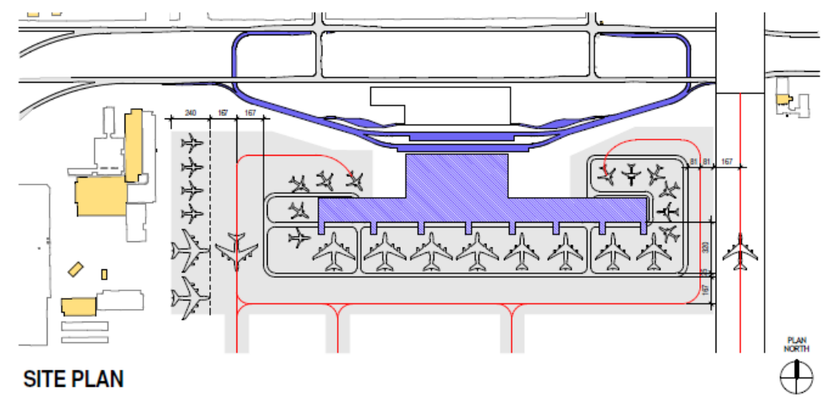
Refresh – 2010



Renovate – 2012



Rebuild – 2012



East Terminal – 2013

1.3 Project Purpose

Terminal D is currently at capacity during peak hours and an expansion is warranted to accommodate future growth in the number of passengers, and the increase in wide-body and super-wide-body aircraft using the facility. The current airline trend is to up-gauge the size of aircraft rather than adding additional flights, therefore terminal facilities are reaching and exceeding their capacities while the airfield capacity remains fairly constant. For example, there are no available contact gates during the daily peak period for new entrant airlines or additional flights by existing airlines at the airport.

In addition, the 2011 Decision Point Study determined that Terminal D's building systems are in need of updating and in some instances the building systems are approaching failure. Many of the building systems have not been significantly upgraded since Terminal D opened in 1990 and they have reached or exceeded their life cycle. Furthermore, due to the age of many of the building systems, they do not meet current code requirements and any major renovation to the facility would trigger complete code non-compliance for all building systems. The end result is that the existing structure now requires a major renovation to meet passenger demand, aircraft up-gauging, and the need to replace and expand the building systems to meet current demands and bring them into code compliance.

The physical needs of Terminal D are not the only needs that must be addressed. The Airport's international facility must also provide a high level of customer service throughout its life cycle. Currently customer service levels at Terminal D are no longer competitive with terminals at similarly sized airports. Total passengers for the international markets have more than quadrupled since Terminal D opened in 1990 (illustrated in **Figure 1.4**). IAH is the nation's 8th busiest international gateway and the 2nd fastest growing since the events of September 11, 2001 (illustrated in **Figure 1.5**). Terminal D requires modernization to remain competitive.

Figure 1.4 IAH Historical and Forecast International Passengers

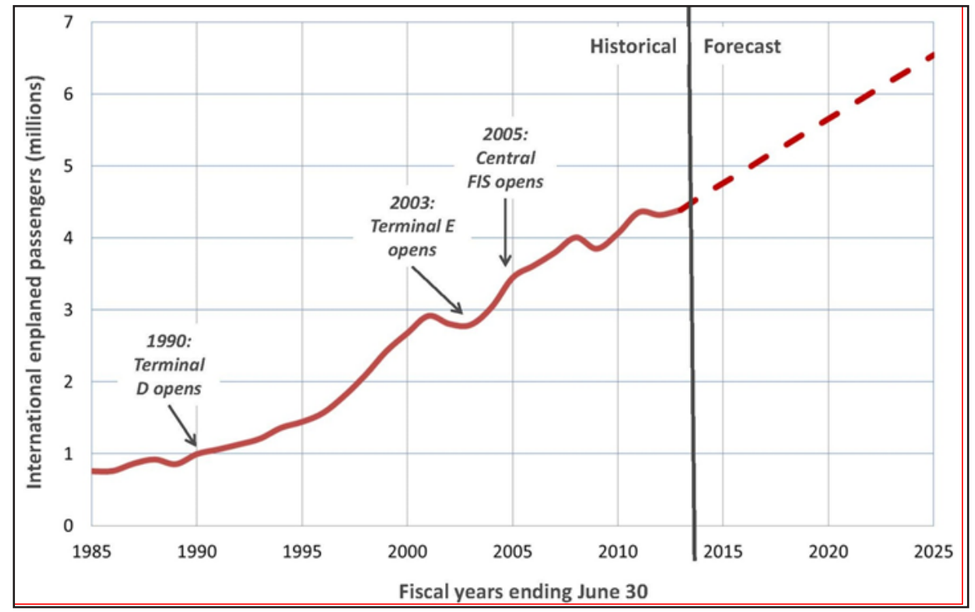
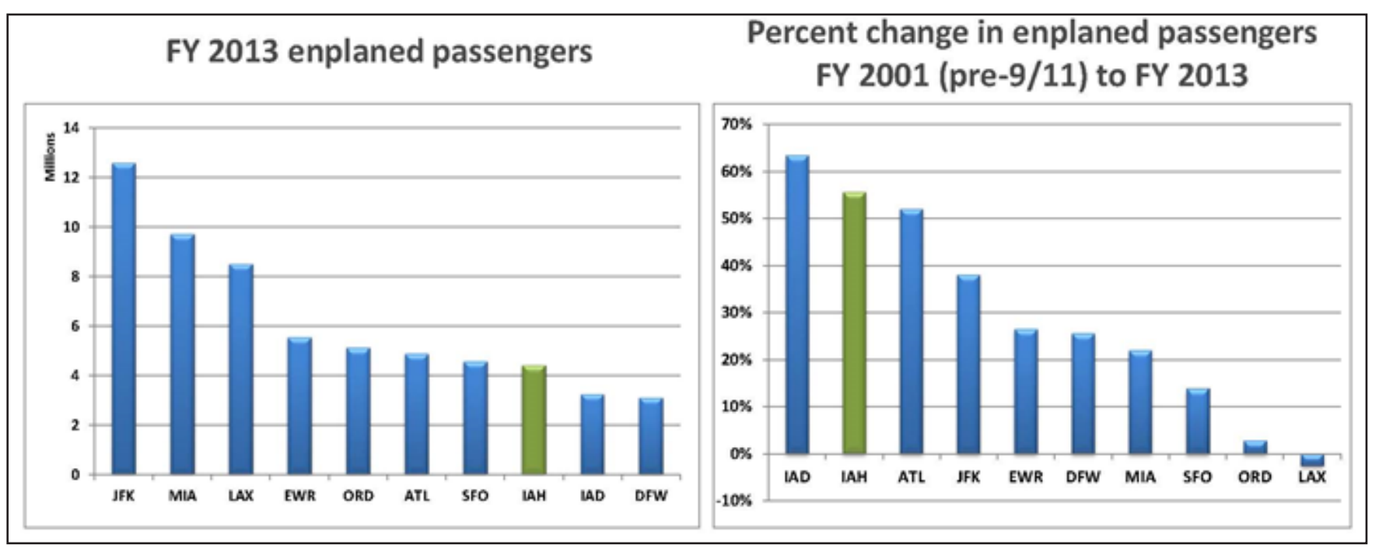


Figure 1.5 Busiest U.S. International Gateways



1.4 PDM Objectives

Planning documents, even one as focused as this PDM, require a set of guidelines by which to evaluate progress, express expectations, guide decision-making, and measure success. The guidelines are typically developed by the entity for which the plan is being prepared since it is that entity that will own and implement the plan.

The following set of guidelines and objectives were developed based on statements obtained from several sources including interviews with HAS staff, workshops, discussions with airport stakeholders, and reviews of written materials. Each of the objectives meets all of the characteristics mentioned earlier. They provide a way for the HAS staff and airport stakeholders to evaluate progress, express expectations, guide decision-making, and measure success.

1. Provide gate capacity for all aircraft types.
2. Provide a high level of customer service.
3. Meet airline requirements for contact gates and passenger processing facilities.
4. Replace aging infrastructure that is not code compliant.
5. Develop a terminal facility that utilizes space efficiently.
6. Develop a terminal facility that maximizes concession revenue opportunities.
7. Increase opportunities for non-airline revenue sources.
8. Maximize airside envelope to establish flexible and high gate utilization.
9. Maintain existing operations and number of wide-body gates during construction phasing.

Chapter 2 | Design Day Schedule

2.0 Design Day Schedule

There are two primary locations for international flight arrivals at George Bush Intercontinental Airport (IAH), Terminals D and E, which are jointly served by a centrally located U.S. Customs and Border Protection (CBP) Federal Inspection Services (FIS) facility. Terminal E exclusively accommodates hub-carrier United Airlines. Terminal D accommodates the majority of foreign flag carriers, with the exception of Air Canada which operates out of Terminal A, and select United Airlines international arrivals. All gates in Terminal D are common use and use is governed by the International Facilities Policy (IFP).

Carriers currently utilizing Terminal D and their destinations include:

- Aeromexico: Villahermosa and Mexico City, Mexico
- Air China: Beijing, China
- Air France: Paris, France
- Atlas Air: Luanda, Angola
- British Airways: London, England
- Emirates: Dubai, United Arab Emirates
- Korean Air: Seoul, South Korea
- KLM: Amsterdam, Netherlands
- Lufthansa: Frankfurt, Germany
- Qatar Airways: Doha, Qatar
- Scandinavian Airlines (SAS): Stavanger, Norway (starts August 20, 2014)
- Singapore Airlines: Moscow, Russia with continuing service to Singapore
- TACA Airlines: San Salvador, El Salvador
- Turkish Airlines: Istanbul, Turkey
- United Airlines: Arrivals only from various destinations
- VivaAerobus: Monterrey, Mexico

The following sections review the existing Terminal D flight schedule and the future Mickey Leland International Terminal (MLIT) Design Day Flight Schedule (DDFS). The MLIT DDFS is the basis for the future MLIT facility requirements presented in **Chapter 4**.

2.1 Terminal D Summer 2014 Foreign Flag Flight Schedule

The existing flight demand profile for international traffic at Terminal D is primarily compressed into two peaks, afternoon and evening, with minimal activity outside of the peaks. **Table 2.1** presents the existing foreign flag carrier flight schedule at Terminal D. All of the flights from/to Europe and the Middle East (all wide-body aircraft) arrive and depart between 13:10 and 20:40 resulting in demand for up to six simultaneous wide-body international aircraft operations at Terminal D. In its existing configuration Terminal D can accommodate a maximum of seven wide-body aircraft simultaneously. However, if one of the aircraft is an Airbus A380 this is reduced to six simultaneous operations. In the winter, when the flight schedules are adjusted for daylight saving time, the peaking becomes more pronounced. Terminal D lacks the capability to accommodate additional wide-body aircraft during the peak time of the day; however, outside of the peak gate occupancy period, Terminal D has available gate capacity.

Korean Air initiated service to Houston from Seoul, South Korea May 2, 2014, with daily flights using a Boeing 777-200 aircraft. The flight is scheduled to arrive in Houston at 08:30 and depart at 10:40. Scandinavian Airlines (SAS) also recently announced their intention to serve Houston from Stavanger, Norway beginning August 20, 2014, with six weekly flights using a special business version Boeing 737-700 aircraft. SAS is scheduled to arrive in Houston at 19:40 and depart at 21:35. These new flights are reflected in the 2014 summer flight schedule presented in **Table 2.1**. HAS is currently in discussions with additional South American, European, Asian, and African airlines to begin and/or increase service to Houston. However, until additional wide-body gates can be constructed, new wide-body flights will have to be scheduled outside of the existing peak gate occupancy period.

Table 2.1 – Summer 2014 Terminal D Foreign Flag Carrier Flight Schedules

CARRIER	ARRIVAL/DEPARTURE DESTINATION	ARRIVAL TIME	DEPARTURE TIME	AIRCRAFT MODEL	FREQUENCY
Atlas Air	Luanda	06:35	10:45	Boeing 747-400	357
Korean Air	Seoul	08:30	10:40	Boeing 777-200	1234567
Aeromexico	Mexico City	12:24	13:27	Embraer E190	1234567
TACA Airlines	San Salvador	13:10	17:32	Airbus A319	1234567
KLM	Amsterdam	13:10	15:15	Boeing 747-400C	1234567
Lufthansa	Frankfurt	13:45	15:50	Airbus A380-800	1234567
Singapore	Moscow/Singapore	13:55	17:45	Boeing 777-300ER	24567
Air France	Paris	14:00	16:00	Boeing 777-300	1234567
British Airways	London	14:30	16:30	Boeing 747-400	1234567
Air China	Beijing	15:40	01:00	Boeing 777-300	1234567
Emirates	Dubai	16:25	18:50	Boeing 777-300ER	1234567
Qatar Airways	Doha	16:40	19:50	Boeing 777-200LR	1234567
Aeromexico	Mexico City	16:56	18:06	Embraer E190	1234567
Turkish Airlines	Istanbul	18:05	19:50	Boeing 777-300ER	1234567
KLM	Amsterdam	18:10	20:10	Boeing 747-400C	46
British Airways	London	18:30	20:40	Boeing 777-200	1234567
Viva Aerobus	Monterrey	18:30-21:20	19:40-22:30	Boeing 737-300	1357
Scandinavian	Stavanger	19:40	21:35	Boeing 737-700	123457
Aeromexico	Mexico City	20:13	21:15	Embraer E190	1234567
Aeromexico	Mexico City	22:45	06:30	Embraer E190	1234567

Source: Houston Airport System August 13 to August 18, 2014 Summer Schedule; SAS added to schedule, starts service August 20, 2014. Note: 1 Monday 2 Tuesday 3 Wednesday 4 Thursday 5 Friday 6 Saturday 7 Sunday

In addition to the current scheduled mix of aircraft arriving and departing Terminal D, some United Airlines international regional jets (RJs) and mainline aircraft utilize Terminal D for arrivals. These flights do not use Terminal D for departures. In terms of flights and arriving passengers, United Airlines is the largest single operator at Terminal D. On average, United Airlines operates approximately 40 arriving RJ flights at Terminal D per day.

A maximum of six RJs can be accommodated on existing Terminal D gates except when Gate D2W is in use by a wide-body aircraft causing the RJ gate capacity to drop to three. The remaining United international flights use the Terminal D hardstand. In the past United has had other flights assigned to Terminal D including wide-body aircraft. Terminal D is also used by United Airlines for gate relief when flight schedules become disrupted. Gate use for these flights is on an "as available basis".

2.2 Mickey Leland International Terminal Design Day Flight Schedule

HAS requested that the LeighFisher Master Plan team produce a future gated flight schedule to serve as the basis for the MLIT facility (existing Terminal D and the north concourse of Terminal C). For the purposes of this chapter, the western pier (formerly the north concourse of Terminal C) is designated as D1 and the eastern pier as D2.

2.2.1 Flight Schedule Development

A flight schedule representing forecast passenger airline activity on an average day in the peak month associated with 33 million annual enplanements was developed. Consistent with LeighFisher's baseline forecast of aviation activity, this activity level, referred to as Planning Activity Level 33 (PAL33), is anticipated to occur in the year 2028.

2.2.2 Gating Analysis

Flights in the future schedule were allocated to gates using LeighFisher's Gate Model. For purposes of this analysis, gates at the MLIT were based on **Figure 2.1**. These gates were assumed to serve a mix of activity that would include (1) all flights by foreign flag airlines, and (2) a subset of United Airlines' flights; i.e., those flights that could not be accommodated on United's other gates. Estimating United's share of activity that would use gates at the MLIT therefore required gating all of United Airlines' flights on a future inventory of gates.

2.2.3 United Airlines Future Gate Inventory

- Domestic Gates
  - Existing Terminal B South
  - Proposed Terminal B North
    - Including Phase 2 and Phase 3, note that Phase 3 was assumed to be a domestic facility without second FIS in place.
  - Existing Terminal C South
- International Gates
  - Existing Terminal E
  - Proposed MLIT
    - D1 Pier (West)
      - Gates C25, C24, and C23 would not accommodate international arrivals.
    - D Front (gates between D1 and D2)
    - D2 Pier (East)

2.2.4 Allocation Rules

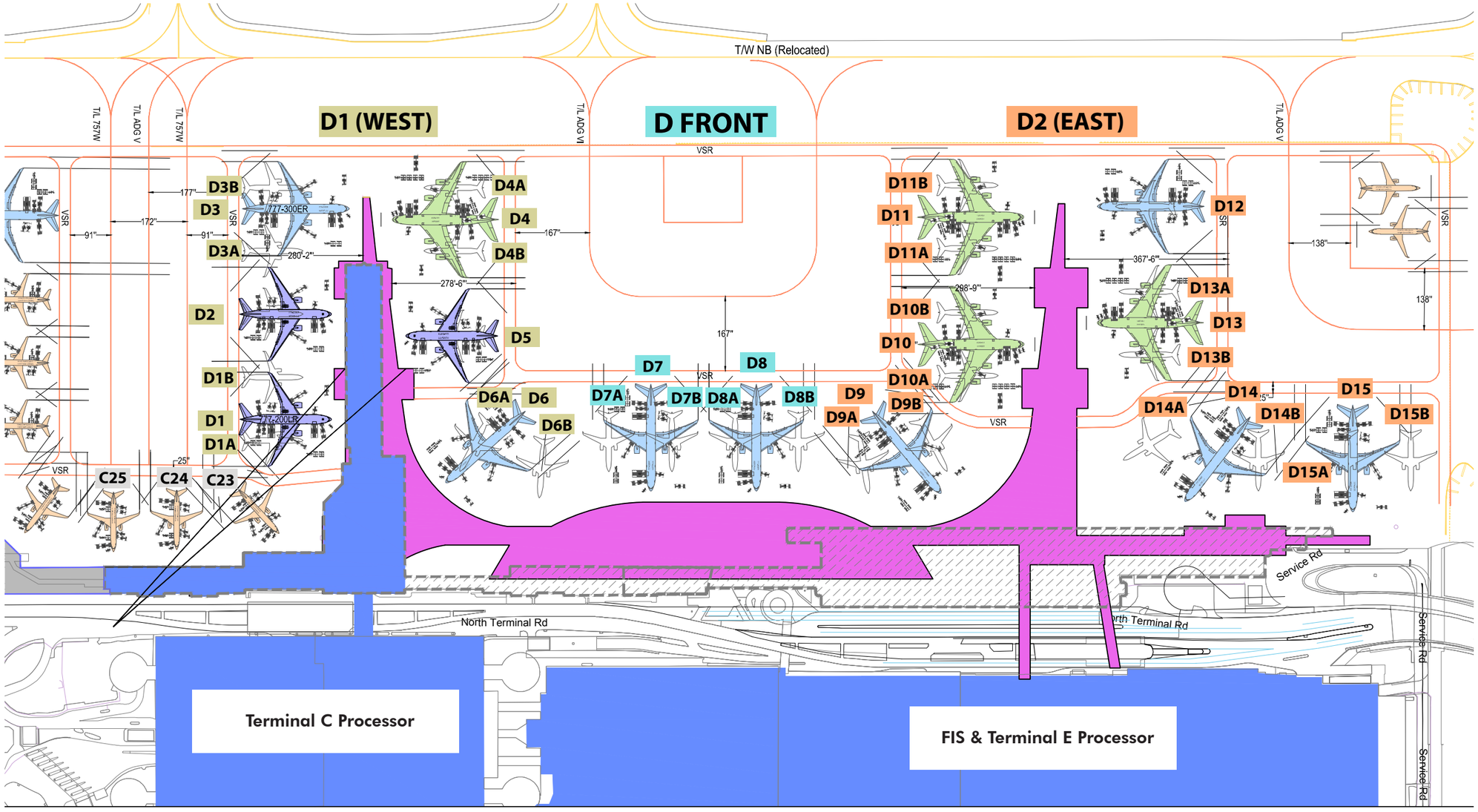
Allocating flights to individual gates was based on a hierarchy of rules. The rules specify (1) the order in which flight groups were gated and (2) for each group, the set of gates the group was allowed to use in order of preference. Any flights that could not be gated on the inventory of permissible gates were left un-gated. A list of any un-gated flights was generated at the completion of the model run. The rules hierarchy assumed in the analysis is generally summarized in the following outline:

1. Foreign Flag Flights
   1.1. D2 Pier (East)
   1.2. D Front
   1.3. D1 Pier (West)

2. United International Flights (Wide-body and Narrow-body Aircraft)
   2.1. Terminal E
   2.2. D1 Pier (West)
   2.3. D Front
   2.4. D2 Pier (East)

3. United International Flights (Regional Jets)
   If turn time is sufficient:
   3.1. Arrive Terminal E; tow-off; depart Terminal B South
   3.2. Arrive D1 (West); tow-off; depart Terminal B North
   3.3. Arrive D Front; tow-off; depart Terminal B North
   3.4. Arrive D2 (East); tow-off; depart Terminal B North
   Else:
   3.5. Arrive & depart Terminal E
   3.6. Arrive & depart D1 (West)
   3.7. Arrive & depart D Front
   3.8. Arrive & depart D2 (East)

MLIT Gate Numbers



Not to Scale

4. United Domestic Flights (Wide-body Aircraft)
    4.1. Terminal C South
    4.2. Terminal E
    4.3. D1 (West)
    4.4. D Front
    4.5. D2 (East)

5. United Domestic Flights (Narrow-body Aircraft)
    5.1. Terminal B North
    5.2. Terminal C South
    5.3. Terminal E
    5.4. D1 (West)
    5.5. D Front
    5.6. D2 (East)

6. United Domestic Flights (Regional Jets)
    6.1. Terminal B South
    6.2. Terminal B North
    6.3. Terminal C South
    6.4. Terminal E
    6.5. D1 (West)
    6.6. D Front
    6.7. D2 (East)

2.2.5 Findings

The key findings of the gating analysis for the MLIT at PAL33 are summarized as:

- The D1 (West) pier is anticipated to be used solely by United Airlines.
- All PAL33 projected activity by foreign flag airlines could be accommodated on the D2 Pier (East) and D Front gates.
- The proposed D2 (East) and D Front gates may also be used by United but only (1) after all foreign flag activity is accommodated, and (2) if no other United gates or gates on D1 (West) are available.
- The proposed D1 (West) pier would likely accommodate a mix of United Airlines activity including narrow-body, wide-body, and regional jets, with the majority of this activity comprised of narrow-body and regional jets.
- Nearly all of United Airlines' anticipated PAL33 international flights could be accommodated on the proposed D1 (West) pier and existing Terminal E gates. However, this finding assumes that gates C25, C24, and C23 would be part of the MLIT project and could accommodate international arrivals. HAS subsequently indicated that these gates would not be part of MLIT and would not accommodate international arrivals.
- Given that all PAL 33 forecast activity by foreign flag airlines can be accommodated on the proposed D2 Pier (East) and D Front gates, facilities for processing originating passengers at the MLIT, such as the ticketing lobby, should be planned to initially accommodate passenger flows to these gates.
- Provision of additional capacity to process originating passengers departing from proposed D1 Pier (West) should be considered as part of a future phase, if possible. It is expected that United Airlines will continue to process passengers at facilities in existing Terminals C and E through, and likely beyond, the PAL33 forecast period. This includes any passengers that enplane or deplane at gates in the MLIT. However, should this change, or should foreign flag activity increase significantly more than forecast, additional processing capacity could be needed.
- Seven (7) Foreign Flag carrier gates are required at the MLIT to accommodate the PAL 33 DDFS. HAS indicated the desire to maximize the terminal footprint and construct one (1) additional gate for a total of 15 wide-body gate at the MLIT.

2.2.6 MLIT Gating Analysis Gantt Charts

Figure 2.2 is a gantt chart showing the proposed aircraft activity on the D1 pier (gates D1-D6), **Figure 2.3** shows the D "front" gates (D7 and D8) and **Figure 2.4** shows the D2 pier (gates D9-D15). Select gates have "A" and "B" designations to indicate two for one and three for two narrow-body aircraft flexibility.

The gantt chart legend is:

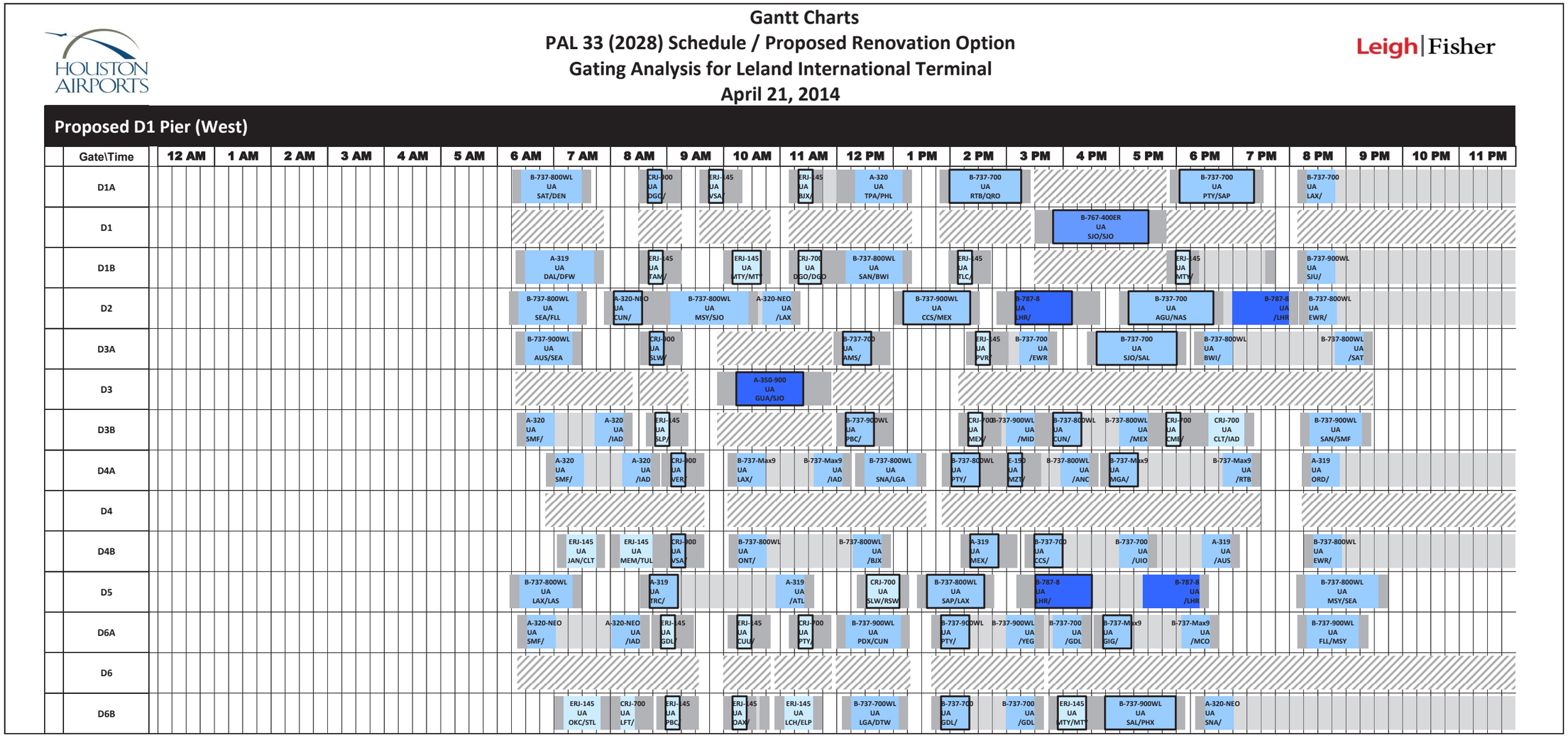
- Red block flights are operated by foreign flag airlines; blue block flights are operated by United Airlines and their regional affiliates.
- The darker the shade of red or blue, the larger the aircraft.
- A heavy black outline around the flight block indicates the flight arrived from an international origin and requires a gate linked to the FIS.

2.3 Summary

The MLIT DDFS was reviewed by the MLIT stakeholder team to ensure that the planned gate count for the MLIT will accommodate the updated flight schedule. With the assumption that there would be at least four Airbus A380 capable gate positions, the MLIT Team determined that the planned gate count will accommodate the MLIT DDFS. The MLIT planning team used the MLIT DDFS to estimate peak hour arriving and departing passenger demand in **Chapter 4, Program Requirements**.

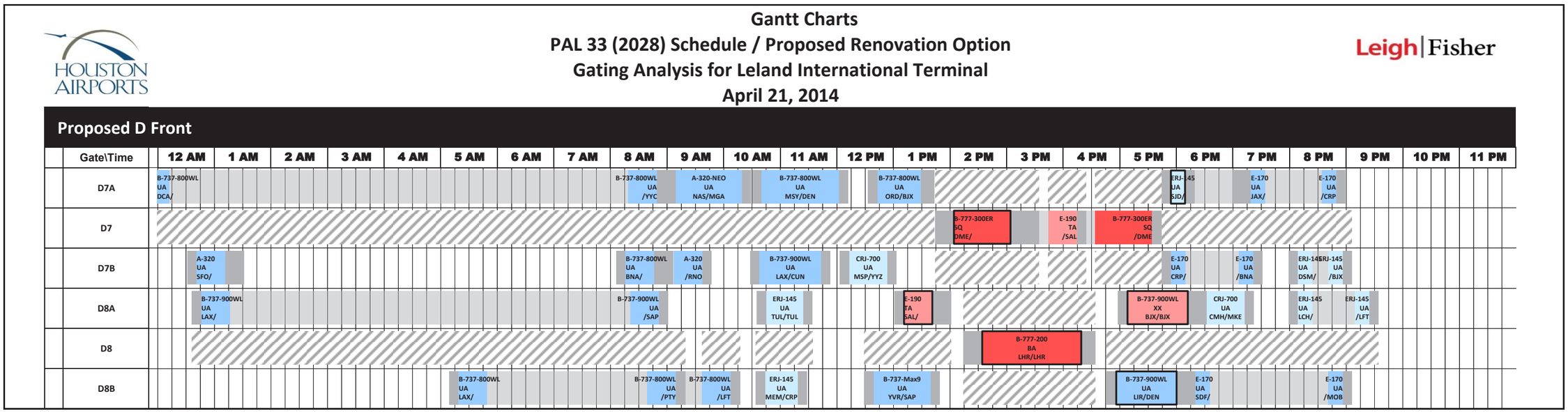
Table 2.2 lists the PAL 33 foreign flag carrier international arrivals and **Table 2.3** lists the international departures to/from the MLIT.

MLIT D1 Pier (West) Gates Design Day Flight Schedule - PAL 33



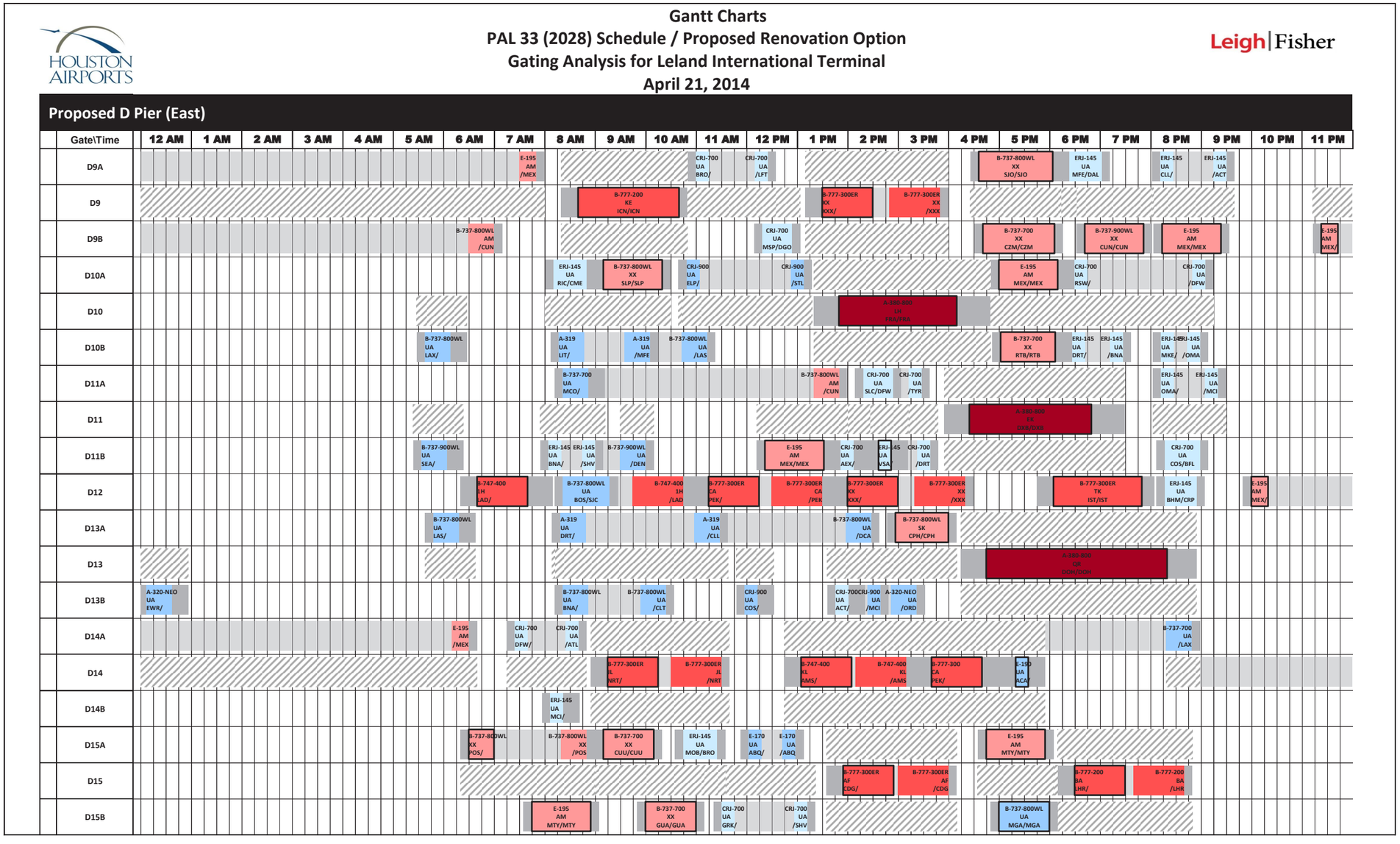
Source:
1: LeighFisher Inc., April, 2014

MLIT D Front Gates (Design Day Flight Schedule) - PAL 33



Source:
1: LeighFisher Inc., April, 2014

MLIT D2 Pier (East) Gates - Design Day Flight Schedule - PAL 33



Source:
1: LeighFisher Inc., April, 2014

MLIT Foreign Flag Carrier - Design Day Flight Schedule - International Departures

DEPARTURES		
OP	**DESTINATION**	**STD**
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	6:30
AeroMexico	CANCUN	7:00
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	7:50
TBD	PORT OF SPAIN	8:50
AeroMexico	MONTERREY GENERAL MARIANO ESCOBEDO APT	8:55
TBD	CHIHUAHUA	10:10
TBD	SAN LUIS POTOSI	10:20
Korean Air	SEOUL INCHEON INTERNATIONAL APT	10:40
Atlas Air	LUANDA	10:45
TBD	GUATEMALA CITY	11:00
Japan Airlines	TOKYO NARITA APT	11:30
Air China	BEIJING CAPITAL APT	13:30
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	13:32
AeroMexico	CANCUN	13:50
KLM	AMSTERDAM	15:10
TBD	LONDON HEATHROW APT	15:50
Air France	PARIS CHARLES DE GAULLE APT	16:00
Scandinavian	COPENHAGEN APT	16:00
Lufthansa	FRANKFURT INTERNATIONAL APT	16:10
TACA Airlines	SAN SALVADOR	16:15
TBD	TOKYO NARITA APT	16:20
British Airways	LONDON HEATHROW APT	16:20
Singapore	MOSCOW DOMODEDOVO APT	17:35
AeroMexico	MONTERREY GENERAL MARIANO ESCOBEDO APT	17:55
TBD	SAN JOSE	18:04
TBD	COZUMEL	18:06
TBD	ROATAN	18:07
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	18:10
TBD	LEON-GUANAJUATO	18:13
Emirates	DUBAI	18:50
Turkish Airlines	ISTANBUL	19:50
TBD	CANCUN	19:52
Qatar Airways	DOHA	20:20
British Airways	LONDON HEATHROW APT	20:40
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	21:24

Source: LeighFisher Inc., April, 2014

MLIT Foreign Flag Carrier - Design Day Flight Schedule - International Arrivals

ARRIVALS		
OP	**DESTINATION**	**STA**
TBD	PORT OF SPAIN	6:30
Atlas Air	LUANDA	6:40
AeroMexico	MONTERREY GENERAL MARIANO ESCOBEDO APT	7:45
Korean Air	SEOUL INCHEON INTERNATIONAL APT	8:40
TBD	CHIHUAHUA	9:10
TBD	SAN LUIS POTOSI	9:10
Japan Airlines	TOKYO NARITA APT	9:15
TBD	GUATEMALA CITY	10:00
Air China	BEIJING CAPITAL APT	11:15
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	12:22
KLM	AMSTERDAM	13:05
TACA Airlines	SAN SALVADOR	13:12
TBD	LONDON HEATHROW APT	13:30
Lufthansa	FRANKFURT INTERNATIONAL APT	13:50
Air France	PARIS CHARLES DE GAULLE APT	13:55
TBD	TOKYO NARITA APT	14:00
Singapore	MOSCOW DOMODEDOVO APT	14:05
British Airways	LONDON HEATHROW APT	14:35
Scandinavian	COPENHAGEN APT	14:57
Air China	BEIJING CAPITAL APT	15:40
Emirates (Pre-Cleared)	DUBAI	16:25
TBD	SAN JOSE	16:36
TBD	COZUMEL	16:41
Qatar Airways (Pre-Cleared)	DOHA	16:45
AeroMexico	MONTERREY GENERAL MARIANO ESCOBEDO APT	16:45
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	17:00
TBD	ROATAN	17:02
TBD	LEON-GUANAJUATO	17:09
Turkish Airways	ISTANBUL	18:05
British Airways	LONDON HEATHROW APT	18:30
TBD	CANCUN	18:42
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	20:14
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	22:00
AeroMexico	MEXICO CITY BENITO JUAREZ INT'L APT	23:23

Source: Leigh Fisher Inc., April, 2014

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Chapter 3 | Existing Conditions

3.0 Existing Conditions

This chapter summarizes existing conditions for Terminals C and D and different areas of the terminals by function. For the purposes of this chapter, existing conditions and functional usage of the terminals are subdivided into four topical areas: Terminal Building, Airside, Site Utilities, and Landside.

3.1 Terminal Building

Terminal D opened in 1990 as the International Airlines Building (IAB) serving foreign flag carriers as well as Continental Airlines (now United Airlines) with 12 gates serving a mix of narrow-body and wide-body aircraft. In 1998, the IAB was renamed Terminal D - Mickey Leland International Terminal. Starting in 2001, Continental Airlines expanded international service from IAH and saturated the inbound international arrival facilities including the gates. Due to the amount of new international operations, Continental Airlines embarked upon the construction of a new international terminal (Terminal E) for their growing international flights and the Houston Airport System (HAS) embarked upon the construction of a new Federal Inspection Service (FIS) facility to serve the expanded international service. With the completion of Terminal E construction in 2003, Continental Airlines moved the majority of its international flights to that facility leaving the foreign flag carriers and Continental Airlines' international regional jet (RJ) arrival flights in Terminal D.

Terminal D has 12 gates (D1-D12) and one super wide-body capable gate (Airbus A380) that also serves as a wide-body gate (D12). There are seven wide-body gates (Boeing 777-300ER and smaller); D2, D4, D5, D7, D9, D11, D12, plus D12A that takes D11 and D12 out when under A380 Operations. D1, D6, D8, and D10 are narrow-body (Boeing 737-900W and smaller) gates. During the afternoon peak Terminal D is at 100% capacity. Originally, Terminal D was developed to handle all inbound international passengers. Outbound international passengers were handled at Terminals C and D. After Continental Airlines (now United Airlines) relocated its international operations to Terminal E and after HAS developed the Central FIS, Terminal D evolved into its current role. Terminal D is used almost exclusively for FF departures and UA RJ arrivals. The 12 gates are no longer split between the FF carriers and UA. The original agreement gave CO preferential rights on gates 1-6, but that has long since expired. Now, a majority of the terminal space formerly used for the original FIS is vacant. Before 2007, Continental Airlines' RJ flights used the Terminal D hardstand and passengers were bussed to an FIS entrance at Gate D12 ground level. The foreign flag carrier service required only two-thirds of the gate capacity available at that time. After 2007, Emirates Airlines, Singapore Airlines, and Qatar Airlines initiated new wide-body flight services and capacity limitations began to emerge in Terminal D. Wide-body gate capacity has since reached 100% during the peak period. To accommodate growth, a new west ticket and airline ticketing office (ATO) area was constructed along with a new west baggage screening and make-up area. An in-line baggage screening area was completed along with a relocation and expansion of the passenger security screening area. New passenger boarding bridges (PBBs) were installed in 2010 to minimize the passenger bussing for United Airlines' RJ flights. In 2012 a refresh project was initiated by HAS to upgrade portions of the terminal and create space for Lufthansa Airlines' A380 flights that started in July 2012. New boarding bridges were also installed at Gate D12 to accommodate the A380.

The following sub-sections describe the existing conditions and functions of the terminal building in greater detail.

3.1.1 SPACE UTILIZATION

The existing Terminal D is a five-level terminal and concourse building. Each level name corresponds to the level's height above sea level (e.g., Level 74 is 74 feet above mean sea level). Following are the names of the five levels in Terminal D today:

- Basement Level (74)
- Ticketing Level (88)
- Apron Level (100)
- Intermediate/Sterile Corridor Level (106/110)
- Departures Level (121)

The total building area is approximately 417,156 sf, of which 11% consists of unused area and vacated FIS space. **Table 3.1** contains a detailed listing of the area and function for each level. **Table 3.2** lists additional facts about the space utilization in Terminal D.

3.1.1.1 Basement Level (74)

The basement level houses mechanical equipment, electrical equipment, battery room, electrical service cabinets, service tunnels, and communications equipment space (PABX and CCTV). The communication equipment serves the entire terminal area and is a crucial part of the overall communications infrastructure in the terminal area and the entire IAH property. The basement level also contains the glycol-cooling system that is being phased out in favor of gate pre-conditioned air units. The entire level contains approximately 26,000 sf.

3.1.1.2 Ticketing Level (88)

The Ticketing Level is bound on the south by North Terminal Road and by a retaining wall on the north. This level is at a similar grade to the access roadway system serving it, which is a single level roadway for Terminal D. The Ticketing Level contains public circulation space, ticketing and check-in counters, airline ticket offices, restrooms, a four-lane security screening checkpoint, TSA break room, HAS offices, and a baggage claim unit used primarily for irregular aircraft operations, in particular domestic charter flights. Currently there are 62 ticket positions split between two ticketing areas as well as six Electronic Data Systems (EDS) units on this level. All TSA checked baggage screening occurs on this level. Refer to **Figure 3.1** for a detailed layout of the Ticketing Level. This level contains approximately 136,000 sf.

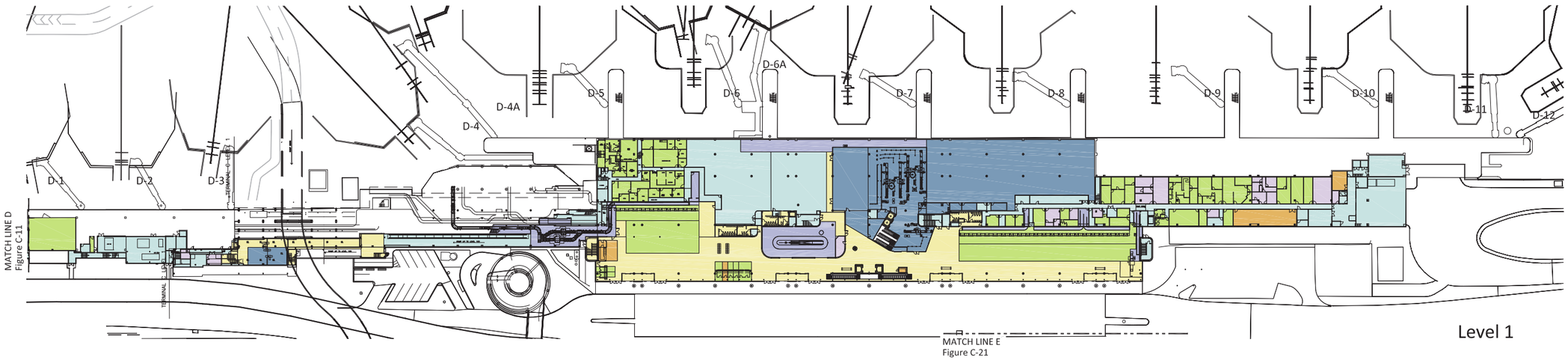
There are water leaks at the airline ticket offices at the ticketing level at British Airways, Korean Air, Avianca/TACA and HAS office. Leaks are coming from the ramp area level.

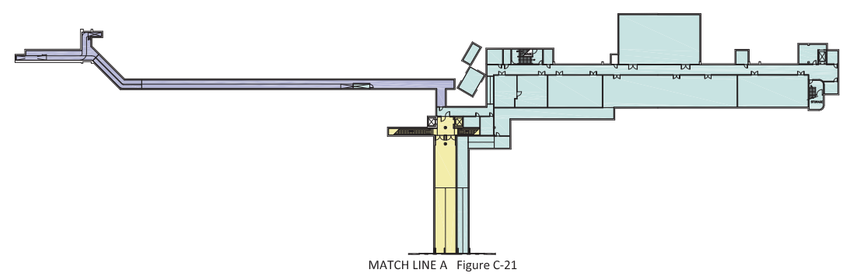
3.1.1.3 Apron Level (100)

The Apron Level, as shown in **Figure 3.2**, is dedicated to outbound baggage handling facilities, airline operations and maintenance spaces, and mechanical/electrical/plumbing (MEP) utility rooms. There are six existing baggage make-up devices on this level. This level accounts for approximately 47,500 sf.

Existing Terminal D Ticketing Level (88)

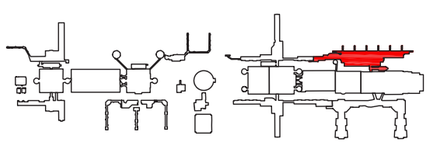
Level 88





Level - LL1

KEY MAP



Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdlR Architects, Inc., December 21, 2012

Leigh|Fisher

0 62.5' 125'

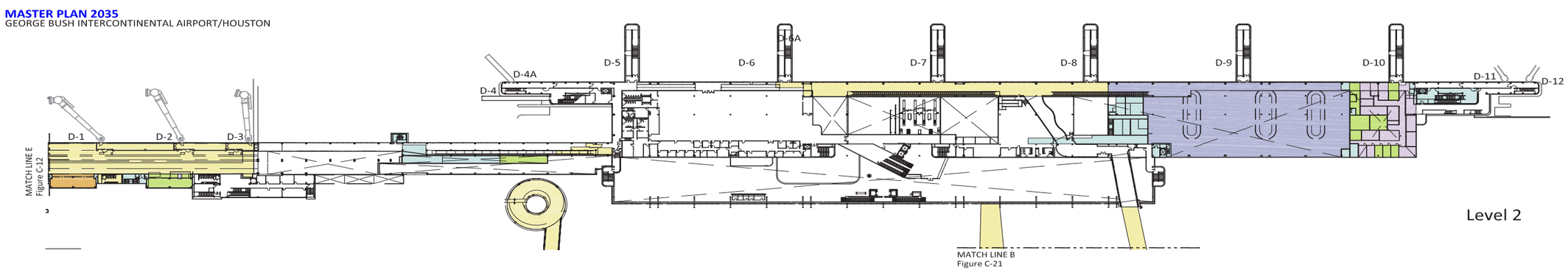
N

LEGEND

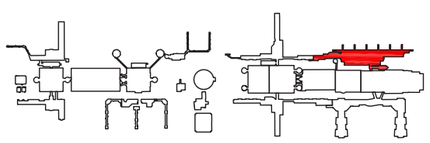
- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

Existing Terminal D Apron Level (100)

Level 100



KEY MAP



Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdlR Architects, Inc., December 21, 2012

Leigh|Fisher

0 62.5' 125'

N

LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

3.1.1.4 Intermediate/Sterile Corridor Level (106/110)

This level is sometimes called the Intermediate Level since it is located between the Ticketing and Departure Levels (refer to **Figure 3.3**). In the 1990s this level was also called the Mezzanine Level and contained the original Immigration Hall (now Customs and Boarder Protection (CBP) primary inspection) for Terminal D. The Intermediate Level includes the existing Sterile Corridor system for arriving international passenger access to the CBP primary in the new FIS Building (located between Terminal D and Terminal E). The original Terminal D FIS bag claim and U.S. Customs (now CBP secondary inspection) was on the Ticketing Level (100 below). The level contains approximately 60,000 sf of space, most of it unused.

3.1.1.5 Departure Level (121)

The Departure Level is arranged as a single-loaded, linear concourse serving 12 aircraft gates. The linear gate frontage on this level is 2,260 ft. This level primarily contains passenger holdrooms, circulation space, restrooms, concessions, and airline/common-use club space encompassing approximately 129,000 sf. Refer to **Figure 3.4** for a detailed layout of the Departures Level.

Terminal D is connected to Terminal C on its west end via the C Connector, also known as the C-Link. The connector is a long corridor that provides passenger movement between the two terminals. It also serves three gates that have historically been used to accommodate United Airlines (UA) RJ international arrivals, but recently were modified to accommodate a wide-body aircraft at Gate D2 (referred to as Gate D2A when used for a wide-body).

Terminal D is also connected to the FIS building and Terminal E via a connector that is opposite of Gate D8.

3.1.1.6 Existing Terminal D Wayfinding

The existing wayfinding signage conditions found within Terminal D (as of 2011-2012) were briefly surveyed and documented by Labozan Associates, Inc. (LAI) with the assistance of CH2MHill, Bradlink, LLC, and IAH's in-house Sign Shop. Photos were taken of existing wayfinding sign locations found within typical priority public accessible areas across predetermined areas of the main terminal facility (excluding FIS areas). Typical pathways for wayfinding processes were captured in progression with photos of existing wayfinding signage that travelers would likely interact with during the course of their journey through Terminal D. These pathways included processes for Departing (e.g., Ticketing Curbside to Gate D9) and Arriving (Gate D3 to Underground Tunnel Area) traffic. Note: see **Figure 3.5** Terminal D – Existing Wayfinding Conditions for additional details. The photos were used within presentations to HAS during early existing condition wayfinding analysis and conceptual exploration processes.

Table 3.1 – Existing Terminal D Functional Space Allocation (sf)

SPACE CATEGORY	DEPARTURE LEVEL (121)	INTERMEDIATE/ STERILE LEVEL (106/110)	APRON LEVEL (100)	TICKETING LEVEL (88)	BASEMENT LEVEL (74)	TOTAL
Ticketing	NA	NA	NA	4,094	NA	4,094
Queuing	NA	NA		7,932	NA	7,932
ATO	NA	NA	9,160	16,400	NA	25,560
Holdrooms	39,046	NA		NA	NA	39,046
Baggage	NA	NA	35,262	23,698	NA	58,960
Clubs	21,935	NA	NA		NA	21,935
Airport Space	3,745	2,761	262	15,692	NA	22,460
Circulation	49,381	NA	NA	41,247	12,009	102,637
FIS Areas	69	26,129	74	776	NA	27,048
Old FIS	NA	29,158	NA	NA	NA	29,158
Concessions	9,941	NA	NA	6,902	NA	16,843
MEP	4,610	1,839	567	4,750	11,792	23,558
Other	NA	NA	2,196	13,978	1,886	18,060
Terminal Area	128,727	59,887	47,521	135,469	25,687	397,291
Gross Mark Up (5%)						19,865
Gross Building Area						**417,156**

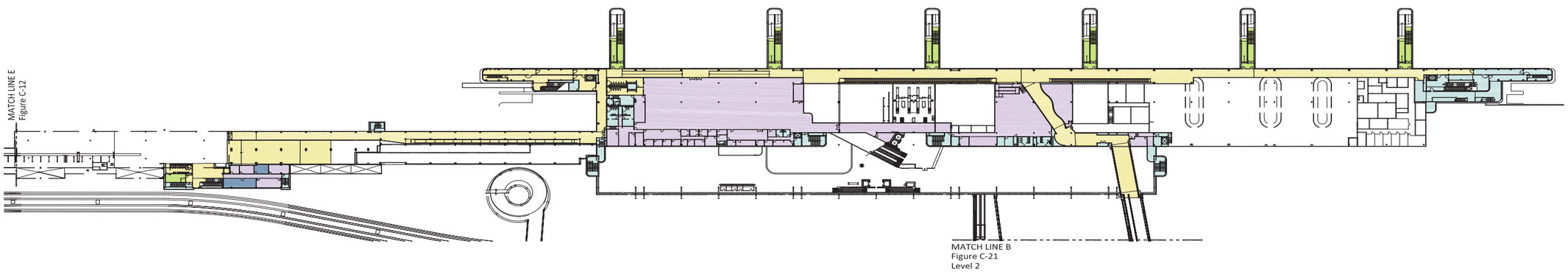
Source: Terminal D Improvements – Program Definition Manual; Gensler Team

Table 3.2 – Terminal Space Facts Summary

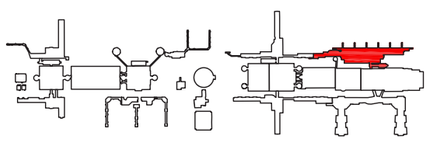
COMPONENT	EXISTING
Ticket Counters	62
Bag Make-Up Devices	5
EDS Units	6
A380/ADG VI Holdroom	1
Wide-Body Holdroom	4
Narrow-Body Holdroom	7
Airline Clubs	3
Security Checkpoint Lanes	4
Concessions	16,843 sf

Source: HNTB Corporation

Existing Terminal D Intermediate/Sterile Corridor Level (106/110) Level 110



KEY MAP



Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdlR Architects, Inc., December 21, 2012

Leigh|Fisher

0 62.5' 125'

N

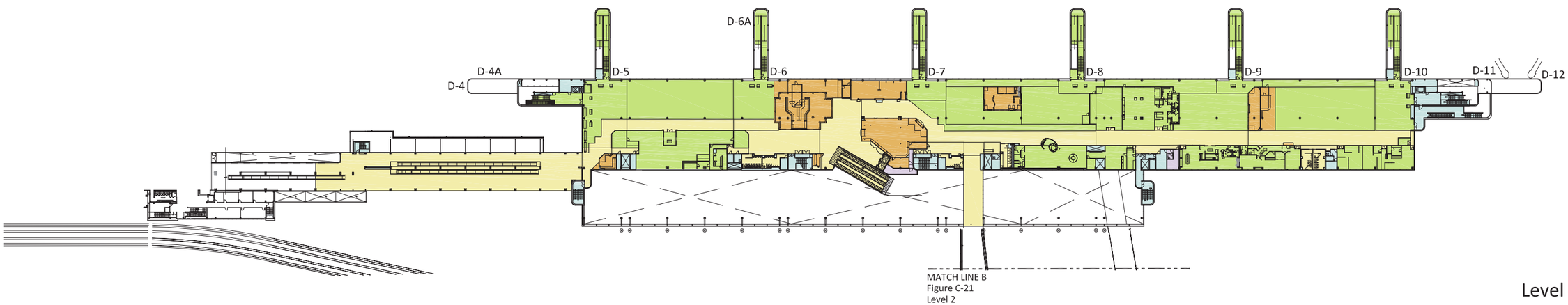
LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

Existing Terminal D Departure Level (121)

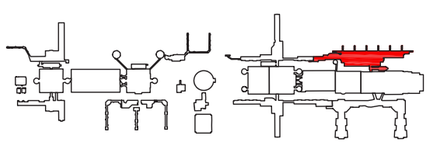
Level 121

MASTER PLAN 2035
GEORGE BUSH INTERCONTINENTAL AIRPORT/HOUSTON



Level 4

KEY MAP



Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdlR Architects, Inc., December 21, 2012

Leigh|Fisher

0 62.5' 125'

N

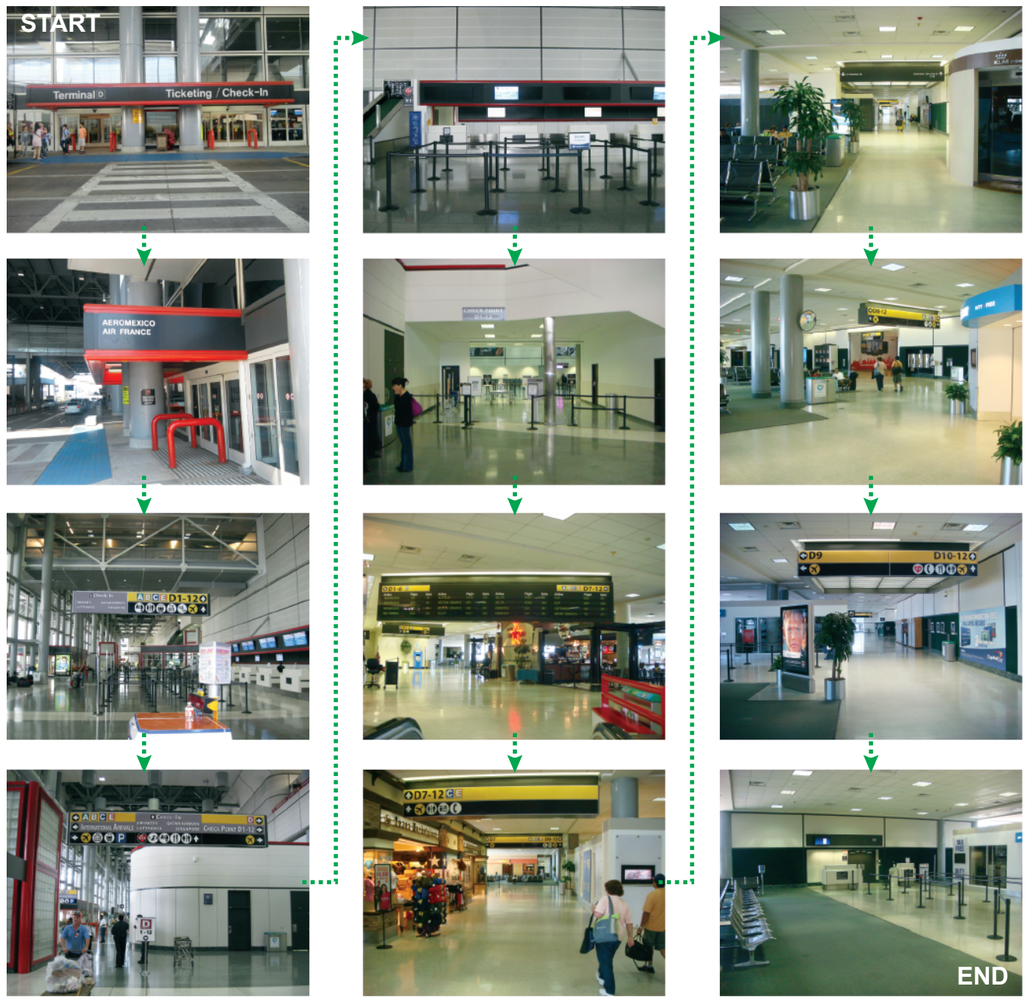
LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

Terminal D Existing Wayfinding Signage Conditions Example

Terminal D - Existing Wayfinding Signage Conditions Example (as of 2011-2012)

TYPICAL DEPARTING PROCESS EXAMPLE: Ticketing Curbside to Gate D9



TYPICAL ARRIVING PROCESS EXAMPLE: Gate D3 to Underground Tunnel Area

SOURCE: Houston Airport System, May 2014
PREPARED BY: Labozan Associates, Inc., May 2014

3.1.2 TERMINAL MECHANICAL/ELECTRICAL/PLUMBING (MEP) SYSTEMS

The existing condition of the basic utility and engineering systems serving Terminal D were well documented in the IAH Terminal D International Facility Improvements and Additions Program Definition Manual (PDM) document prepared by the Gensler Team in May 2010. This information was updated in the 2011 A380 Gate Project Development Document prepared by CH2M Hill and further refined and updated by the TDMP Team. In some cases the data may be two to three years old, but it is still accurate for determining capacity. All of the systems have aged since detailed inspections took place, thus it can be assumed that the systems have deteriorated further, even with aggressive maintenance. It is anticipated that most, if not all, of the systems will need to be replaced if the building is reconstructed.

The main mechanical room is located at Basement Level (74). The room currently houses a dual compartment surge tank, electric fire and jockey pump, domestic water pumps, and dewatering system composed of two primary and two back-up pumps. It also contains the electrical service connections, communications equipment, and access to service tunnels. Refer to **Figure 3.6** for a composite overview of the building systems in the Basement Level (74).

3.1.2.1 Chilled Water

Terminal D, along with the other IAH terminals, receives its chilled water directly from the airport Central Plant distribution system located by the Central Cargo Area. Water is treated at the plant and sent through the distribution system at a temperature of 40° F. The water travels along the main distribution header and delivers the chilled water into Terminal D via a 16 inch line, and exits through a 16 inch line back into the main distribution header, returning to the Central Plant. Terminal D has two 2,100 gpm centrifugal pumps located on the Basement Level (74) in the main mechanical room. These pumps provide chilled water circulation throughout Terminal D.

In general, the chilled water systems appear in good condition. No major discrepancies were noted by building maintenance staff and all observed piping and insulation systems for chilled water appear to be in good condition.

3.1.2.2 Hot Water System

Hot water for Terminal D is supplied by two hot water heat exchangers located on the Basement Level (74) in the main mechanical room. Airport high temperature hot water is brought to the shell and tube heat exchangers and heat is transferred to the closed-loop building hot water system. Two building hot water pumps (830 gpm each) circulate the water through the building to air handlers and terminal units. The entire building's hot water system is in poor condition. Maintenance personnel have reported numerous leaks (most notably on the Departure Level and in the Sterile Corridor), major clogging of smaller pipes, and instances where entire pipe sections have been removed due to scale build-up and pipe deterioration. Problems appear to stem from lack of water treatment of the building water. Maintenance personnel stated that to their knowledge, the system has not been treated in years. Original design documents indicate a water treatment unit, but it cannot be located. Maintenance personnel have delayed starting treatment on the system because introduction of treating and cleaning compounds at this point, after so many years of deterioration, could cause holes to open up in piping previously clogged, potentially causing flooding conditions, personnel injury, and furnishings damage.

If the system remains unimproved, pipes will continue to clog and to deteriorate, eventually moving from the smaller pipes to the larger pipes, decreasing flow, putting more strain on the pumping systems and finally affecting the coils of the air handling units and terminal units. Refer to **Figures 3.7** for a photograph of the pumps.

3.1.2.3 Temperature Control

Maintenance staff has noted a few areas that get unreasonably cold at times. The loading dock service corridor on the east side of the Ticketing Level is one of the cool spots. This area is served by ductwork taps to the interior zone single duct terminal units. These units have no heating coils. Another cool spot is the area around Gates D11 and D12 (Departure Level). This area is served by a single-zone, constant volume air-handling unit with hot water heat; but the piping/coils may be clogged or the controls may not be operating properly. At this time, Terminal D and the connector corridor between Terminal D and Terminal C suffer from uncontrolled temperature, back offices, as well as holdrooms at gates D1, D2, and D3. The entire Terminal D arrival Sterile Corridor also suffers from inefficient temperature control.

At the Ticket Counter Area on the Ticketing Level (88), airflow comes from sidewall linear bar air grilles with zero degree deflection that blow directly from the panels above the front of ticket counters. Cold air hits the panels and is directed down towards the ticket agent positions below.

Figure 3.7 – Water System Pumps (Basement Level)

Existing Terminal D Basement Level (74)

Level 74

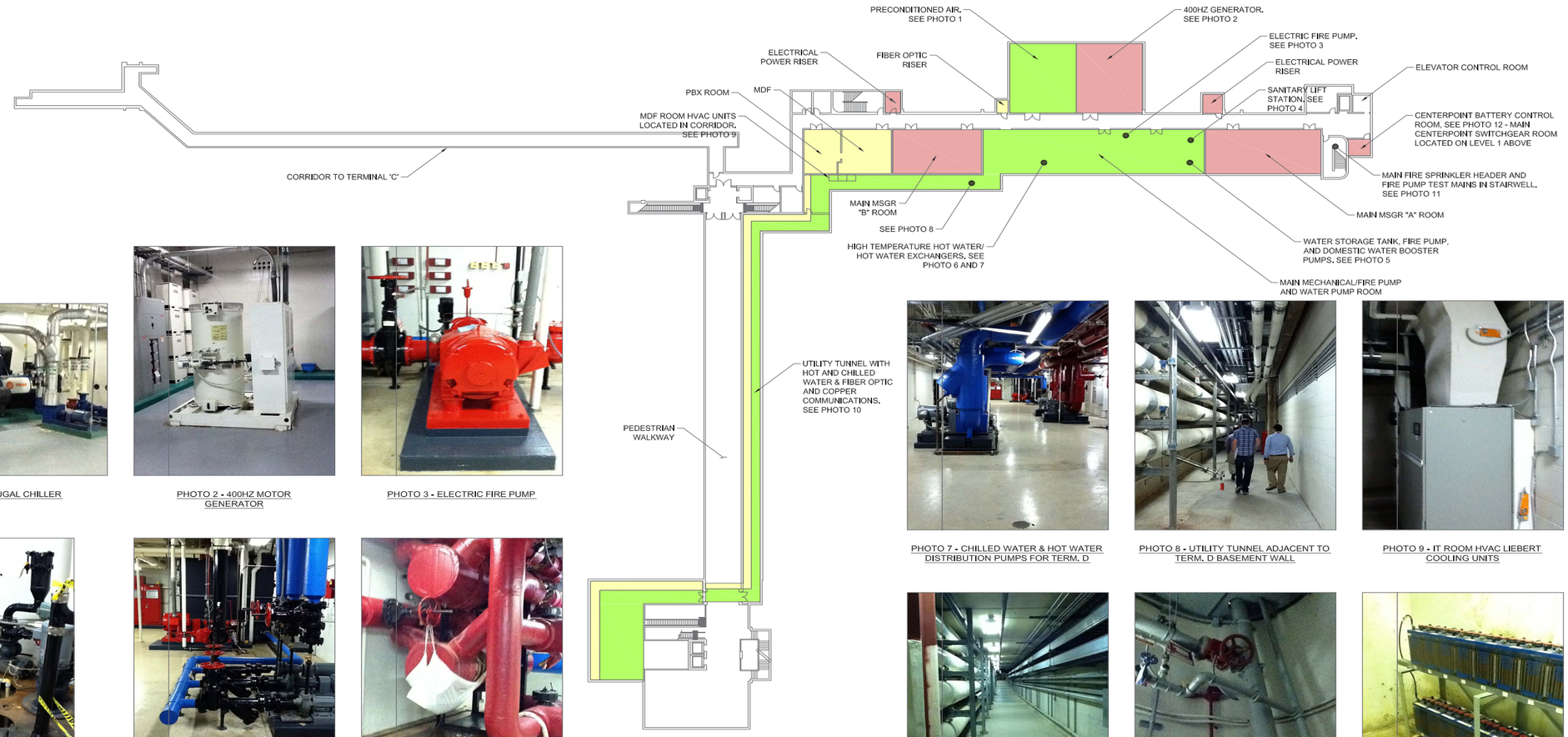


PHOTO 1 - PCA CENTRIFUGAL CHILLER

PHOTO 2 - 400HZ MOTOR GENERATOR

PHOTO 3 - ELECTRIC FIRE PUMP

PHOTO 4 - SANITARY LIFT STATION

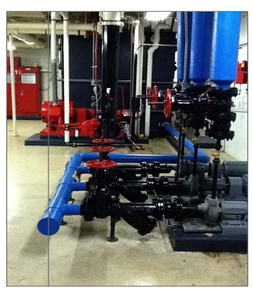


PHOTO 5 - DOMESTIC WATER BOOSTER PUMPS AND WATER STORAGE TANK

PHOTO 6 - HIGH TEMP HW HEAT EXCHANGERS

PHOTO 7 - CHILLED WATER & HOT WATER DISTRIBUTION PUMPS FOR TERM. D

PHOTO 8 - UTILITY TUNNEL ADJACENT TO TERM. D BASEMENT WALL

PHOTO 9 - IT ROOM HVAC LIEBERT COOLING UNITS

PHOTO 10 - UTILITY TUNNEL PARALLELING THE PASSENGER BRIDGE

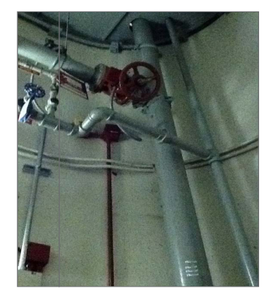


PHOTO 11 - FIRE PROTECTION HEADER AND FIRE PUMP TEST MAIN LOCATED INSIDE STAIRWELL AT BASEMENT LEVEL

PHOTO 12 - BATTERY ROOM

Not to Scale

3.1.2.4 Air Handling Units

Terminal D consists of a mixture of single-zone, variable air volume air handling units and single-zone, constant volume units. The single-zone variable air volume units deliver air to fan-powered terminal units and single-duct terminal units. The majority of air handling units is located in two mechanical penthouses on the roof of the building. Most areas in the terminal are served by single-zone variable air volume (VAV) air handling units with fan-powered constant volume terminal units. The areas served by this method include the Ticketing Level (Inspection, Baggage Claim, Airline Offices), Apron Level (100) offices, Intermediate Level (Inspection, Arrivals, Baggage Sorting), and Departure Level (Holdrooms, Concessions, Clubs). The Ticketing Level is served by single-zone constant volume systems, as are the rooms on the Basement Level and the fixed loading bridges that serve the Departure Level and Intermediate Level. Generally, the air handling systems are in fair condition. The air handlers are beginning to show some aging but still have 10 to 15 years of useful life if aggressively maintained.

3.1.2.5 Electrical System

The following section outlines the existing electrical system in Terminal D. Background information was obtained from the Gensler IAH Terminal D Renovation – 500 N & 500 R drawing set dated 08-27-2010 (E 7.01, 7.02, 7.03, 7.04, 7.05, 7.06, 7.07, and 7.08).

CenterPoint Energy provides power to the building at 12.47 kV from a single utility vault located at the east end of the building on the Ticketing Level. Terminal D is fed from dual 15 kV 3#500 kcmil and 1#3 ground, utility feeders sourced from two separate CenterPoint Energy circuits, GR3 and IT6, each with an automatic primary selector switch for redundant service to the facility. Peak utility demand is 2,278 kVA. Each supply line feeds a distribution panel through a breaker of 1,200 amps each, for a total capacity of 11,000 kVA. All switchgear is 480/277 volt (V), three-phase, four-wire.

Utility 12.47 kV power is delivered to 1,200 A, 15 kV, metal-clad switchgear with main-tie-main arrangement. Space is available on each end of the switchgear to add two additional cubicles. However, any addition must be in compliance with the minimum clear working space requirements per the NFPA 70E and the National Electrical Code; taking into consideration the front and rear accesses on those main switchgears and the Flash Protection Boundaries. A 6 inch conduit is stubbed up in a future space on each end to feed the future north pier. The 6 inch conduit's route is through the basement to a pull room and underground to a manhole on the apron. The 15 kV switchgear currently feeds three double-ended unit substations. Two unit substations consist of 2,500 kVA, 12.47 kV, 277/480 volt (V) transformers, and secondary 4,000 amp (A) main-tie-main switchgear. Each switchgear lineup feeds two 4,000 amp switchboards that distribute power to building loads. Refer to **Figure 3.8** and **Figure 3.9** for illustrations of the lineup feeds.

The 4,000 A switchboard SWBD-A2 peak loading demand is around 765 kVA (i.e., around 920 A) with six (800 A) breaker spaces available. Similarly, the peak loading demand in SWBD B1 is 724 kVA (i.e., around 870 A) with three 800 A spaces and one 800 A spare available. These spaces are suitable only for maximum 800 A breakers and cannot be upgraded to accommodate larger breakers. Switchboards SWBD-A1 and SWBD-B2 have no spaces available for future use.

Information obtained from HAS shows that no spaces remain on switchboard-A1. Six 800 A spaces remain on switchboard-A2. The third unit substation consists of 1000 kVA, 12.47 kV, 277/480 volt (V) transformers and secondary 1,600 A main-tie-main switchgear. The switchgear feeds two 1,600 A switchboards that distribute power to building loads at the Inter-Terminal Train (ITT) level.

Spaces are available in these switchboards, but it is anticipated that loads are already near the maximum switchboard capacity. All building load feeders consist of cable in conduit. All power distribution equipment is General Electric. The estimated installed load is 7,700 kVA and the estimated maximum demand is 6,335 kVA. Refer to **Figure 3.10** for a diagram of the existing electrical system.

Figure 3.8 – Switchgear Line-Up

3.1.2.6 Standby Power Distribution

Standby power is provided by a Stewart and Stevenson 1,050 kW/1,312 kVA natural gas generator at the east end of the building on the Ticketing Level (illustrated in **Figure 3.11**). It is reported that the generator is in poor condition. The standby generator feeds a 1,600 A switchboard ESWB in the generator room. This switchboard feeds multiple automatic transfer switches and distribution panels serving elevators, fire pump, lift stations, exit/egress lights, card readers, security doors, CCTV, radio equipment and fire alarm system (Refer to **Figure 3.12** and **Figure 3.13** for standby power distribution single line diagrams). Switchboard ESWB currently has two 800 A spare breakers and one 800 A space available for future use. Existing peak demand load is unknown. Distribution panels EDP1 and EDP2 have no spaces available for future use. Distribution panels EDP3 and EDP4 each have one 100/3 and one 30/3 spare breaker available. All building load feeders consist of cable in conduit. All power distribution equipment is General Electric.

Figure 3.9 – Typical Secondary Switchboard

3.1.2.7 Lighting

General purpose lighting consists of fluorescent troffers in public areas and strip fluorescent fixtures in mechanical spaces. These fixtures appear to have energy saving ballasts and T-12 warm white lamps. High bay interior areas consist of metal halide High Intensity Discharge (HID) fixtures. Egress lighting is connected to generator power. HID egress fixtures also contain quartz restrike.

Exit lighting is connected to generator power and consists of cast aluminum exit signs with fluorescent lamps. Exterior lighting is generally high pressure sodium HID. Lighting control for back-of-house, toilets, offices, and other small spaces is locally switched. Lighting control for large spaces and public areas is controlled by Lutron relay or dimming panels. It is reported that the dimming system has never worked correctly and is currently bypassed.

3.1.2.8 Natural Gas

The existing structure is served with a 4 inch natural gas line. The natural gas meter/regulator is located at Level 88 on the east end of the terminal. Natural gas is primarily used for cooking appliances at food concessions.

3.1.2.9 Fire Suppression and Life Safety

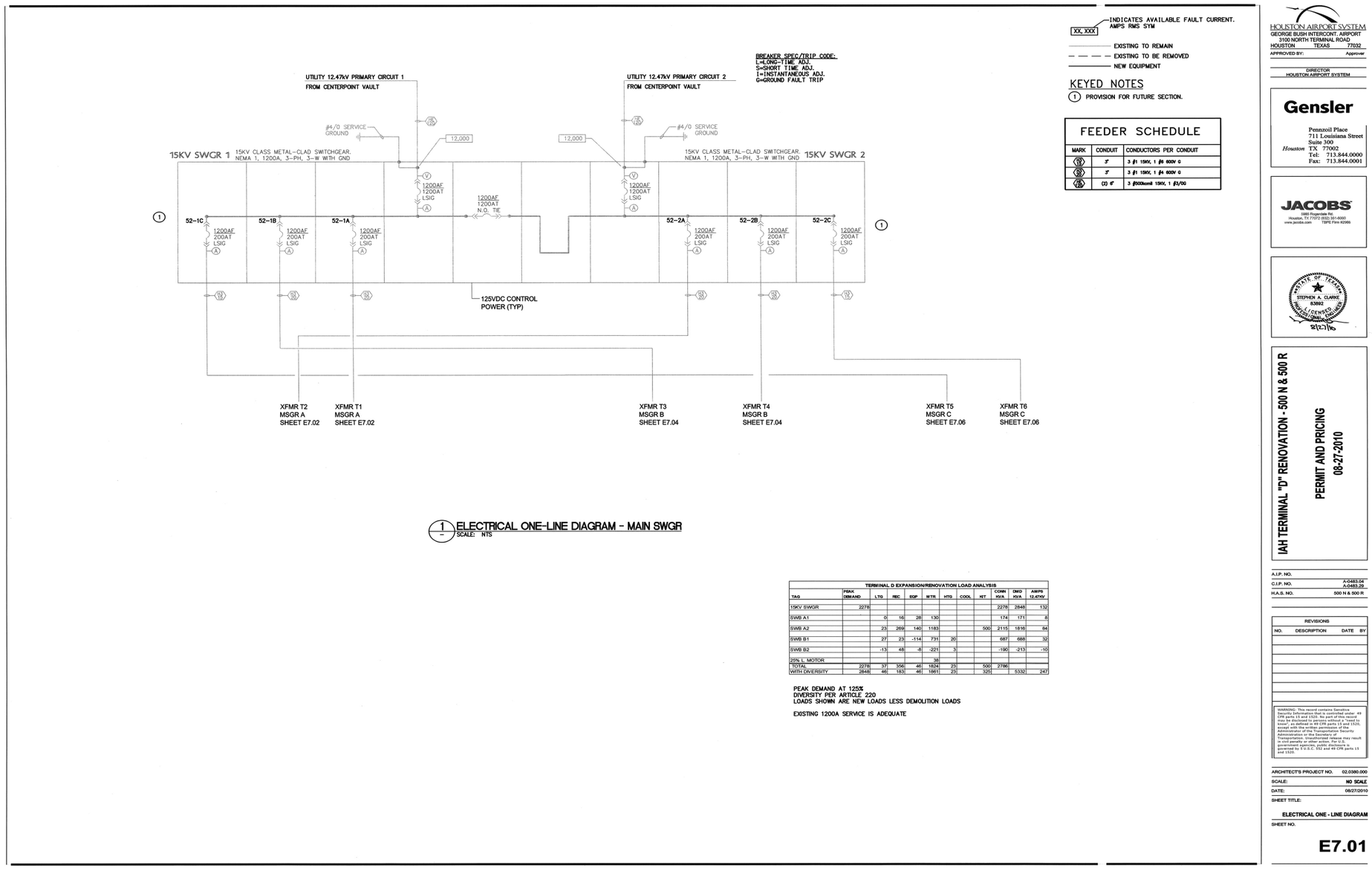
A new fire alarm system was installed in 2004/2005 under HAS Project 500Q. This system complies with current HAS standards. The existing building is completely protected with an automatic wet sprinkler system. It has been reported by HAS personnel that the existing sprinkler heads are under a manufacturer's recall and need to be replaced. No documentation has been provided at this time to support this claim. The existing structure has an electrically driven (200 hp) 1,500 gpm (140 psi) fire pump and a 15 gpm jockey pump and provides firewater to a complete standpipe and automatic sprinkler system. The existing building is equipped with a Class III standpipe system with 2.5 inch fire hose valves and automatic sprinkler floor control valves at each level and off of each standpipe. There are a few small Halon systems within the building. These should be removed, as Halon is no longer suitable for commercial fire protection applications.

The existing fire protection tank has a metal nameplate which shows the tank was made by United Fabrication, built in December 1988, with overall dimensions of nine feet (length) x nine feet (width) x nine feet (height) and contains 5,000 gallons (refer to **Figure 3.14**). The fire system inspection report, dated April 22, 2010, lists the tank dimensions as nine feet x six feet, seven inches x eight feet, one inch and contains 3,582 gallons (refer to **Figure 3.15**). This information points to a tank that has a partition. The partition divides the tank so that 3,582 gallons are available for fire protection and about 1,400 gallons are available for the potable water system (5,000 gallons – 3,582 gallons = 1,418 gallons). Refer to **Figure 3.16** Water/Fire Protection System valves for a photograph of the surge tank and fire pump isolation valve.

Following is additional information on the existing Terminal D fire protection system:

- There is a 10 inch suction line from the tank to the fire pump.
- The city water main fill line is 6 inches to the tank.
- The water tank needs to be relined.
- The tank suction anti-vortex plate is not per NFPA 22 standards.
- Per the fire system inspection report, the tank water capacity is adequate for a 1,500 gpm flow for 30 minutes using city water pressure to refill the tank. However, the existing tank will not be adequate to meet 2012 IFC, which requires a flow rate equal to 1,500 gpm for four hours (1,500 gpm x 60 min/hr x 4 hours = 360,000 gallons).
- City water test pressure: no hydrant static or residual pressure and flow test data was available from the City Fire Prevention Chief Inspector or the IAH ARFF Fire Station Chiefs. HAS staff provided verbal information that the city water pressure fluctuates and has been recorded at 33 psi.
- Per the fire system inspection report, the pump suction pressure from the tank that was measured at the 10 inch suction line was one psi at 1,500 gpm flow.
- The April 22, 2010, fire pump inspection report includes a list of non-compliant items regarding the existing system.
- Three aircraft rescue and fire fighting (ARFF) stations exist at IAH. Those are Stations #92, #54, and #99. Station #92 is nearest to Terminal D. ARFF stations are used to fight aircraft jet fuel fires. Each ARFF station has two 3,000 gallon crash fire trucks with aircraft fire fighting foam (AFFF). They have one 5,000 gallon structural fire truck that can assist the city in fighting a building fire.
- There is one Fire Department Connection (FDC) for Terminal D and it is located landside at the building's southeast front entrance. City fire trucks access the FDC via a parking lot off the main landside road to the airport.
- Multiple fire hydrants are located landside along the public road that serves Terminal D. One hydrant is located within 100 feet of the FDC per NFPA standards. No airside fire hydrants currently exist.

Electrical One-Line Diagram - Main SWGR



TERMINAL D EXPANSION/RENOVATION LOAD ANALYSIS

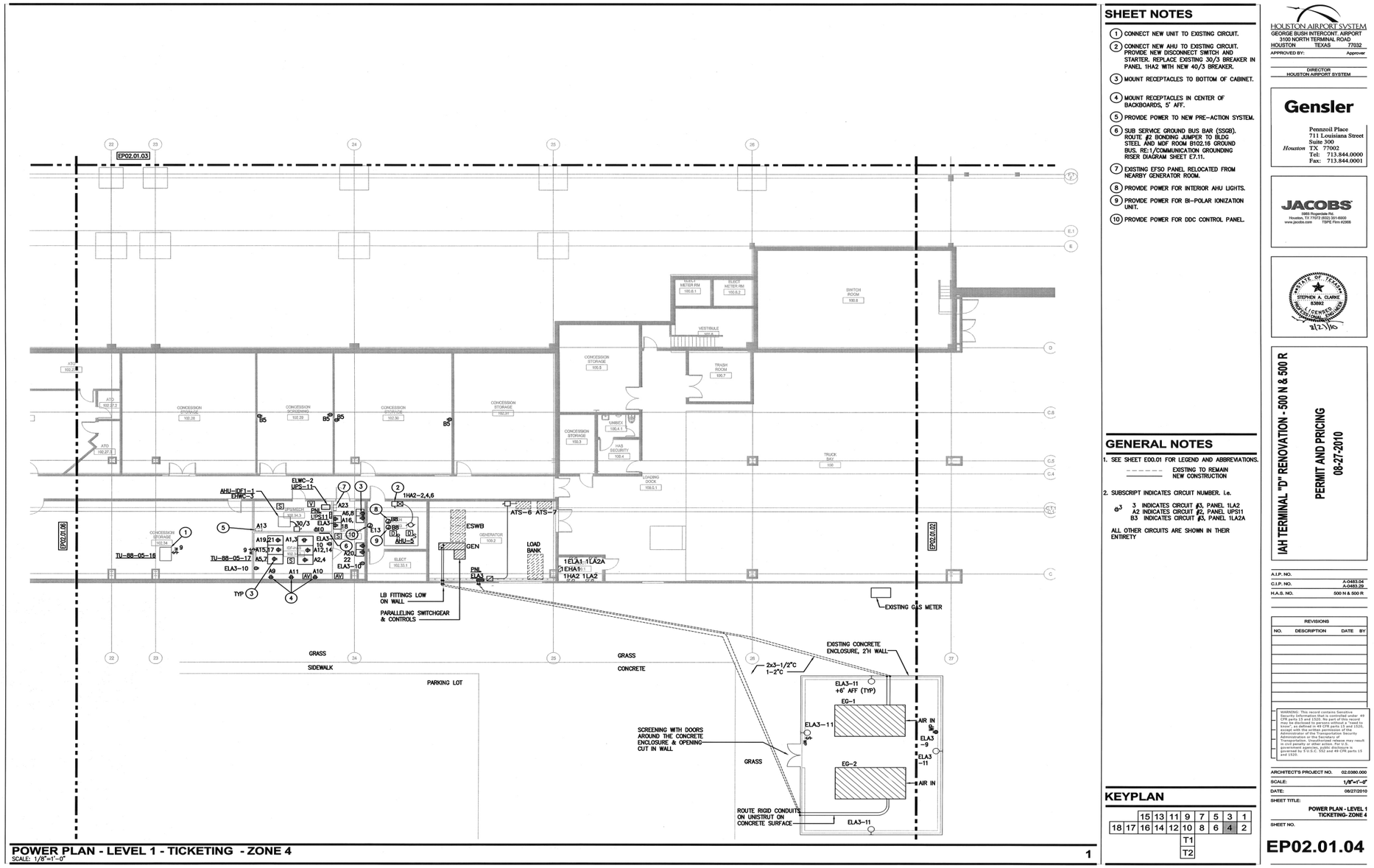
TAG	PEAK DEMAND	LTG	REC	EQP	M'TR	HTG	COOL	HT	CONN KVA	DMD KVA	AMPS 12.47KV
15KV SWGR	2278								2278	2848	132
SWB A1		0	16	28	130				174	171	8
SWB A2		23	269	140	1183			500	2115	1816	84
SWB B1		27	23	-114	731	20			687	688	32
SWB B2		-13	48	-8	-221	3			-190	-213	-10
20% L. MOTOR					38						
TOTAL	2278	37	356	46	1824	23		500	2786		
WITH DIVERSITY	2848	46	183	46	1861	23		325		5332	247

PEAK DEMAND AT 125%
DIVERSITY PER ARTICLE 220
LOADS SHOWN ARE NEW LOADS LESS DEMOLITION LOADS

EXISTING 1200A SERVICE IS ADEQUATE

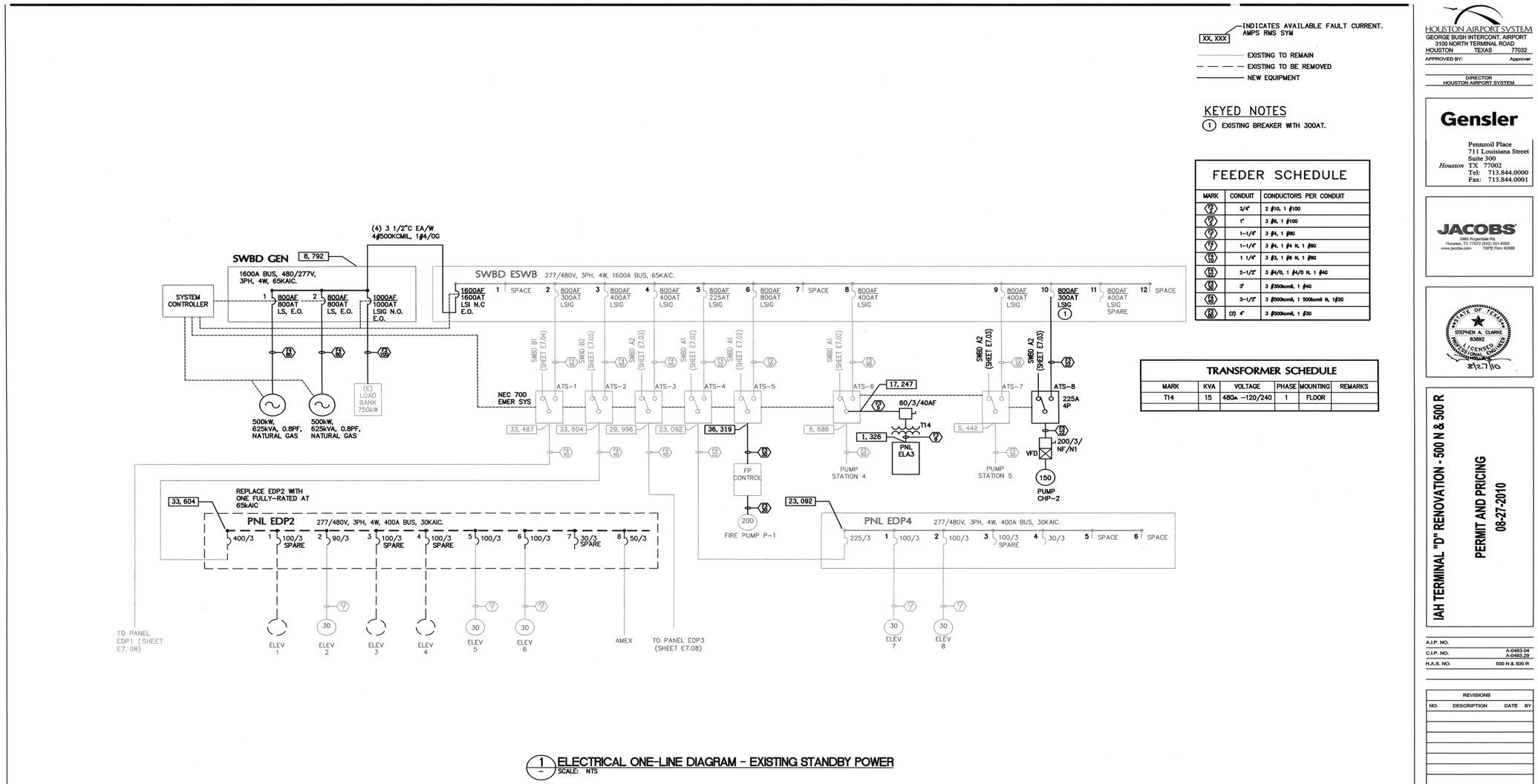
Not to Scale

Existing Generator



Not to Scale

Electrical One-Line Diagram - Existing Standby Power

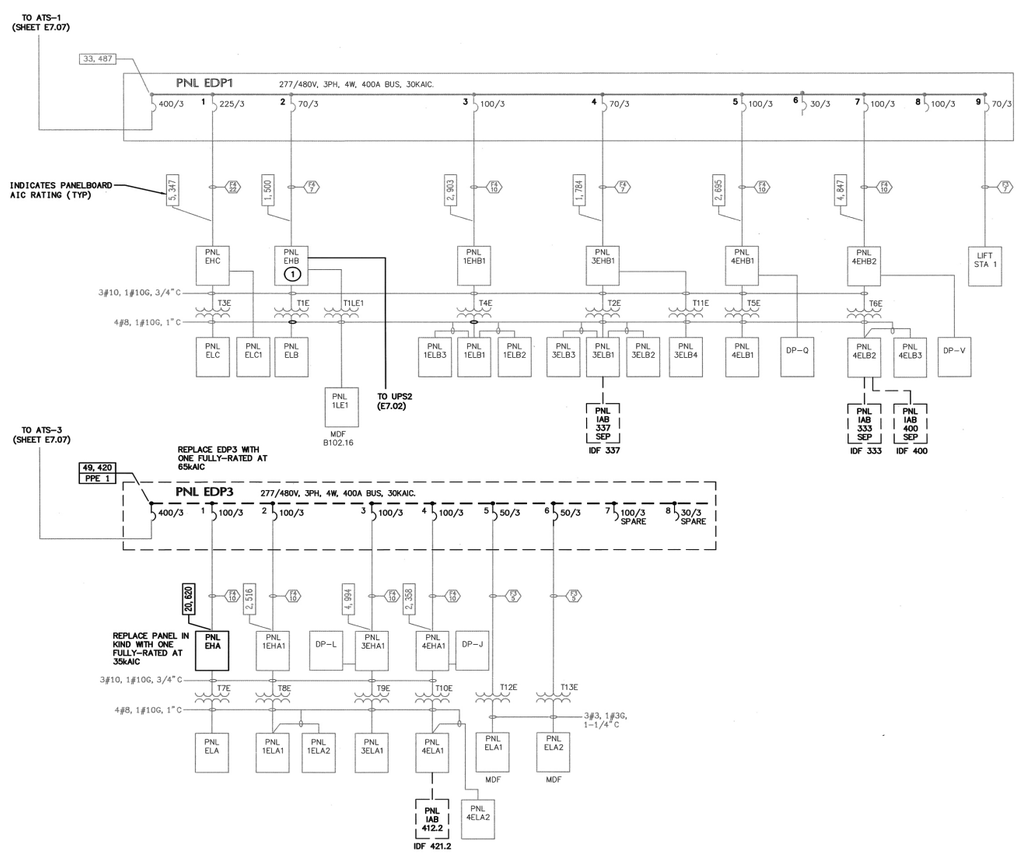


1 ELECTRICAL ONE-LINE DIAGRAM - EXISTING STANDBY POWER
SCALE: NTS

Not to Scale

Electrical One-Line Diagram - Existing Standby Power

Level 74



1 ELECTRICAL ONE-LINE DIAGRAM - EXISTING STANDBY POWER
SCALE: NTS

XX, XXX — INDICATES AVAILABLE FAULT CURRENT. AMPS RMS SYM

EXISTING TO REMAIN
EXISTING TO BE REMOVED
NEW EQUIPMENT

KEYED NOTES

1. PROVIDE UPDATED PANEL INDEX FOR MODIFIED PANEL.

FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
12	3/4"	2 #10, 1 #10G
9	1"	3 #6, 1 #10G
9	1-1/4"	3 #4, 1 #8G
9	1-1/4"	3 #4, 1 #8 N, 1 #10G
10	1 1/4"	3 #3, 1 #6 N, 1 #8G
13	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
14	3"	3 #300kcmil, 1 #4G
14	3-1/2"	3 #500kcmil, 1 500kcmil N, 1#2G
14	(2) 4"	3 #500kcmil, 1 #3G

TRANSFORMER SCHEDULE

MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T1E	15	480 Δ – 208/120Y	3	FLOOR	
T2E	15	480 Δ – 208/120Y	3	FLOOR	
T3E	15	480 Δ – 208/120Y	3	FLOOR	
T4E	15	480 Δ – 208/120Y	3	FLOOR	
T5E	15	480 Δ – 208/120Y	3	FLOOR	
T6E	15	480 Δ – 208/120Y	3	FLOOR	
T7E	15	480 Δ – 208/120Y	3	FLOOR	
T8E	15	480 Δ – 208/120Y	3	FLOOR	
T9E	15	480 Δ – 208/120Y	3	FLOOR	
T10E	15	480 Δ – 208/120Y	3	FLOOR	
T11E	10	480Δ – 120/240	1	FLOOR	
T12E	15	480 Δ – 208/120Y	3	FLOOR	
T13E	15	480 Δ – 208/120Y	3	FLOOR	

HOUSTON AIRPORT SYSTEM
GEORGE BUSH INTERCONT. AIRPORT
3100 NORTH TERMINAL ROAD
HOUSTON TEXAS 77032
APPROVED BY: Approver
DIRECTOR
HOUSTON AIRPORT SYSTEM

Gensler
Pennzoil Place
711 Louisiana Street
Suite 300
Houston TX 77002
Tel: 713.844.0000
Fax: 713.844.0001

JACOBS
9393 Priorities Rd.
Houston, TX 77072 (832) 351-6000
www.jacobs.com TBPE Firm #2966

STATE OF TEXAS
STEPHEN A. CLARKE
63992
LICENSED
PROFESSIONAL ENGINEER
8/27/10

IAH TERMINAL "D" RENOVATION - 500 N & 500 R
PERMIT AND PRICING
08-27-2010

A.I.P. NO.
C.I.P. NO. A-0483.04 A-0483.29
H.A.S. NO. 500 N & 500 R

REVISIONS

NO.	DESCRIPTION	DATE	BY

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ARCHITECT'S PROJECT NO. 02.0380.000
SCALE: NO SCALE
DATE: 08/27/2010
SHEET TITLE:
ELECTRICAL ONE - LINE DIAGRAM
SHEET NO.
E7.08

Not to Scale

Figure 3.14 – Water Tank Name Plate

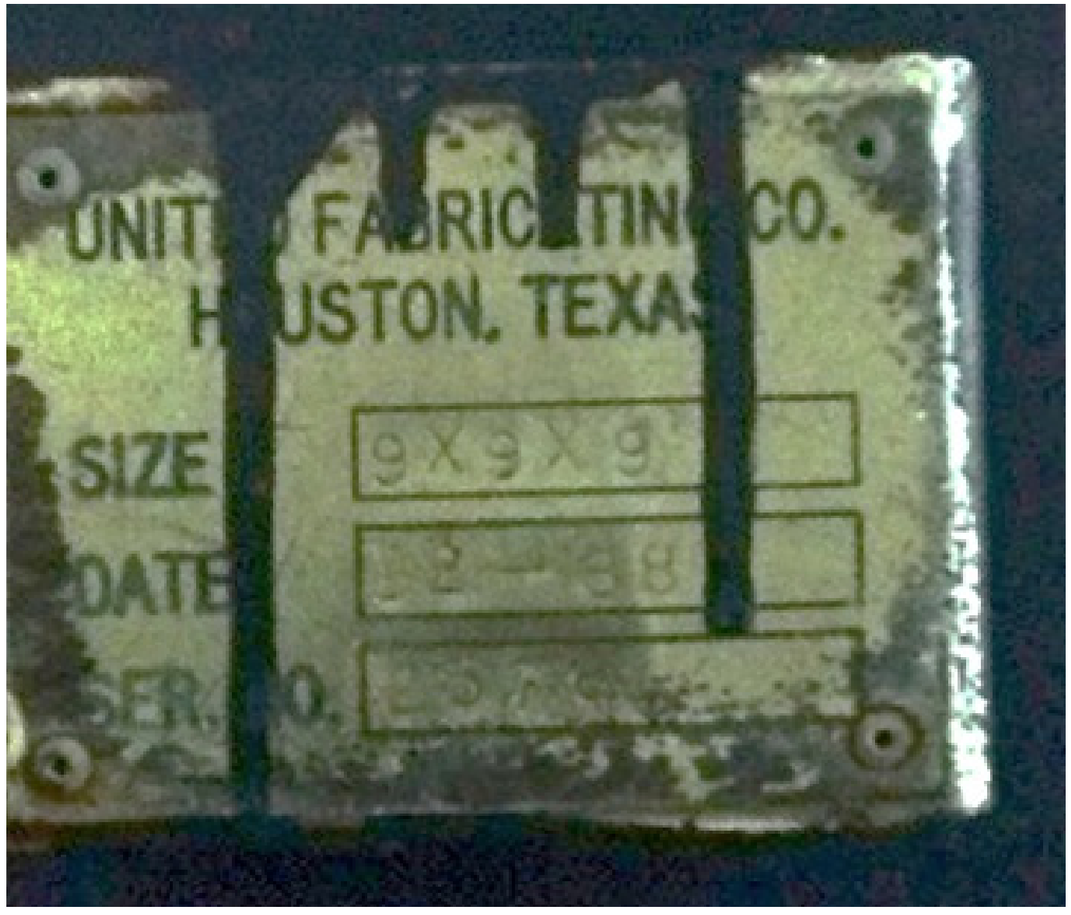


Figure 3.15 – Fire System Inspection Report

FireWater SERVICES, INC.
SCR-0792 TX

ANNUAL WATER STORAGE TANK INSPECTION

BUILDING NAME: IAH-Terminal D Garage
BUILDING ADDRESS: 3500 North Terminal Road
INSPECTION DATE: 04-22-2010
INSPECTOR: Minter/ Angeles

TYPE OF TANK:	Rectangle
DIMENSIONS OF TANK:	9'-0" X 6'-7" X 8'-1" 3,582 Gallons
SIZE OF MAIN FILL VALVE:	6"
CITY WATER SUPPLY PRESSURE:	Unknown
NUMBER OF FLOAT VALVES:	2
SIZE OF FLOAT VALVES:	1 – 4" 1 – 6"
FLOAT VALVES OPERATIONAL?	Yes
CONDITION OF VALVES:	Good
CONDITION OF PIPING:	Good
CONDITION OF EXTERIOR TANK:	Good
CONDITION OF INTERIOR TANK:	Needs to be relined
TANK ROOM HEATED?	Yes
CORRECT WATER LEVEL?	Yes
LOW WATER ALARM?	Yes
HIGH WATER ALARM?	Yes
LEVEL INDICATOR OPERATIONAL?	Yes
ANTI-VORTEX PLATE INSTALLED?	Not per NFPA
OVERFLOW PIPE INSTALLED & SIZE:	Yes – 8"
WILL THE WATER SUPPLY KEEP UP FOR 30 MINUTES WHILE THE PUMP IS FLOWING 100% OF RATED CAPACITY?	Yes
OTHER:	

P.O. Box 840249 • Houston, TX 77284-0249
(281) 855-1970 • FAX (281) 858-8278
www.firewaterservices.com

Figure 3.16 – Water/Fire Protection System Valves (Basement Level)

3.1.2.10 Dewatering System

There is a dewatering system located in the Main Mechanical Room that empties into a tank located below floor level. During the construction of Terminal D an artesian spring was encountered; the dewatering system prevents the basement from flooding. A photograph of the dewatering system is included as **Figure 3.17**.

Figure 3.17 – Dewatering System (Basement Level)

3.1.2.11 Life Safety System

The life safety systems are operational and are currently code compliant. There are no known deficiencies with the life safety systems in Terminal D. The current life safety system code requirements are grandfathered in for the Terminal D area. Any future upgrades to the system will require the system to be brought up to full code compliance. The scansion plates for the sprinklers are obsolete and cannot be replaced.

3.1.2.12 Information Technology

The existing Terminal D Information Technology (IT) system is set up in a traditional "Hub and Spoke" arrangement with the central Main Distribution Frame (MDF) hub, feeding Individual Distribution Frame (IDF) spokes via fiber optic and copper connections (refer to **Figure 3.18** for a schematic of the "Hub and Spoke" distribution). The existing MDF is in the basement of Terminal D. (The MDF room has a new fire suppression system that was installed June 2011.) In addition to the IT infrastructure for the existing terminal, the basement houses the PBX system for the entire airport. The main airport fiber optic (FO) loop also utilizes the Terminal D MDF as a go-between when routed between terminals and other ancillary buildings, which means that almost all airport-wide FO pathways land on Terminal D, MDF, patch panels, or are routed through Terminal D, MDF raceways.

The majority of the existing IDF rooms are served off of central air systems with some rooms having temperature control and some rooms not having control. Most of the IDF rooms with the exception of the SITA room and MDF room do not have dedicated air handling systems meeting current HAS requirements. None of the existing IDF rooms meet current HAS requirements. See **Figure 3.19** and **Figure 3.20** for locations of existing Terminal D IDF, IT, telecom and electrical rooms.

The existing access control system uses a distributed architecture consisting of redundant head-end servers with automated fall over, intelligent field panels (IFP), and contactless smart card readers and access media. The existing access control software application is ProWatch by Honeywell. The head end system is currently in place and operates on redundant servers located in the Terminal A MDF.

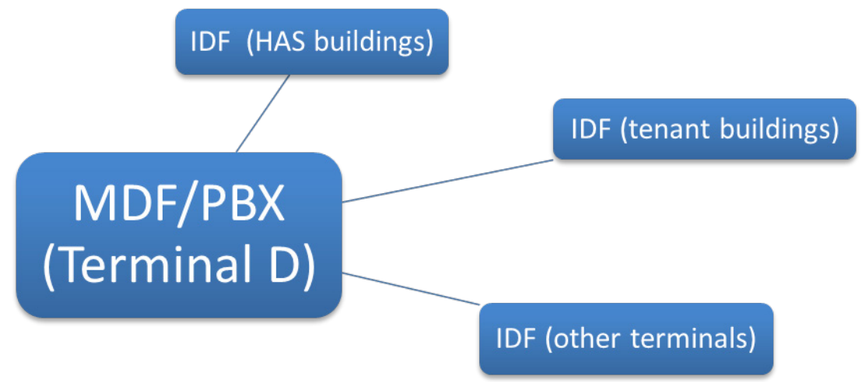
Communication between head-end and IFPs is via network switches on a secure VLAN across the common HAS LAN.

Standard cardreaders and access media are iCLASS contactless by HID. HAS utilizes a secure iCLASS Elite key managed by HID to ensure a unique security format. Current iCLASS products in use include model R10 for mullions, R40, RK40 (with keypad) card readers and 16k smart card credentials.

Existing distributed video surveillance system architecture utilizes redundant head-end database servers at the Terminal A MDF and Administration Building, with camera servers and storage arrays located in the respective facility (Terminal D) MDF. HAS holds a DVM site license.

The following are existing technology systems in Terminal D: Public Address (PA), Master Antenna Television (MATV), Passenger Tracking for checkpoint wait times, Flight Information Display System (FIDS), and Common Use Terminal Equipment (CUTE).

Figure 3.18 – IT "Hub and Spoke" Distribution



3.1.2.13 Building Automation System (BAS)

The existing Terminal D BAS master controller is located in the Central Utility Plant (CUP). It monitors and controls HVAC systems in the terminal buildings including Terminal D. Fiber communication cable runs between the CUP and terminal buildings. Pneumatic controllers that are used leak and have poor accuracy regarding measuring key performance indicators including pressure, temperature, flow, and position. No measurement and verification is used to trend energy consumption and alert maintenance staff to problems in the HVAC system.

3.2 Airside

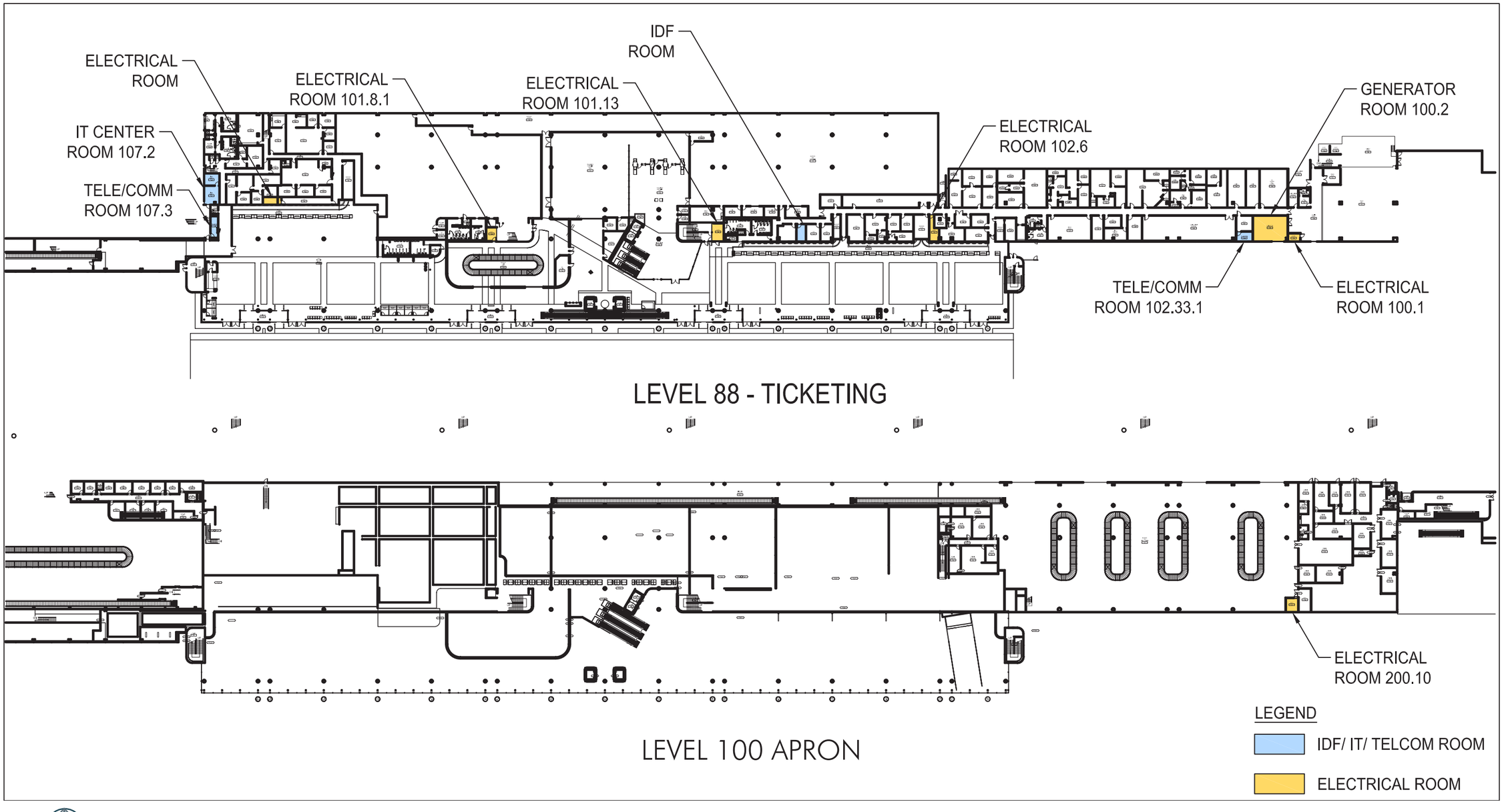
The following subsections describe the current gating capabilities at Terminal D as well as information on aircraft gates, aircraft circulation, ground service vehicle roads, and aircraft specialty services.

3.2.1 GATE LAYOUT

Terminal D is currently served by 12 aircraft contact parking positions, Gates D1 through D12. These positions allow parking for six narrow-body aircraft, five wide-body aircraft, and one super-body aircraft, as shown on **Figure 3.21**. A Visual Docking Guidance System (VDGS) provides aircraft with precision parking guidance to the appropriate nose-wheel stop bar at the majority of the gates at Terminal D.

The Terminal D apron also provides off-gate aircraft parking approximately 700 feet north of the terminal building between Taxiway NC and the taxilane servicing the terminal gates (refer to **Figure 3.21**). This area is primarily used for hardstand operations and remain-overnight (RON) aircraft parking. The parking area dimensions are approximately 300 feet (depth) by 1,700 feet (length). The hardstand can accommodate regional aircraft and wide-body aircraft in various combinations. The existing terminal apron is served by an east-west ADG V taxilane north of the aircraft parking positions and dual ADG IV and ADG V taxilanes oriented north-south and positioned between Terminal C and the hardstand parking area.

Terminal D - Existing Floor Plans



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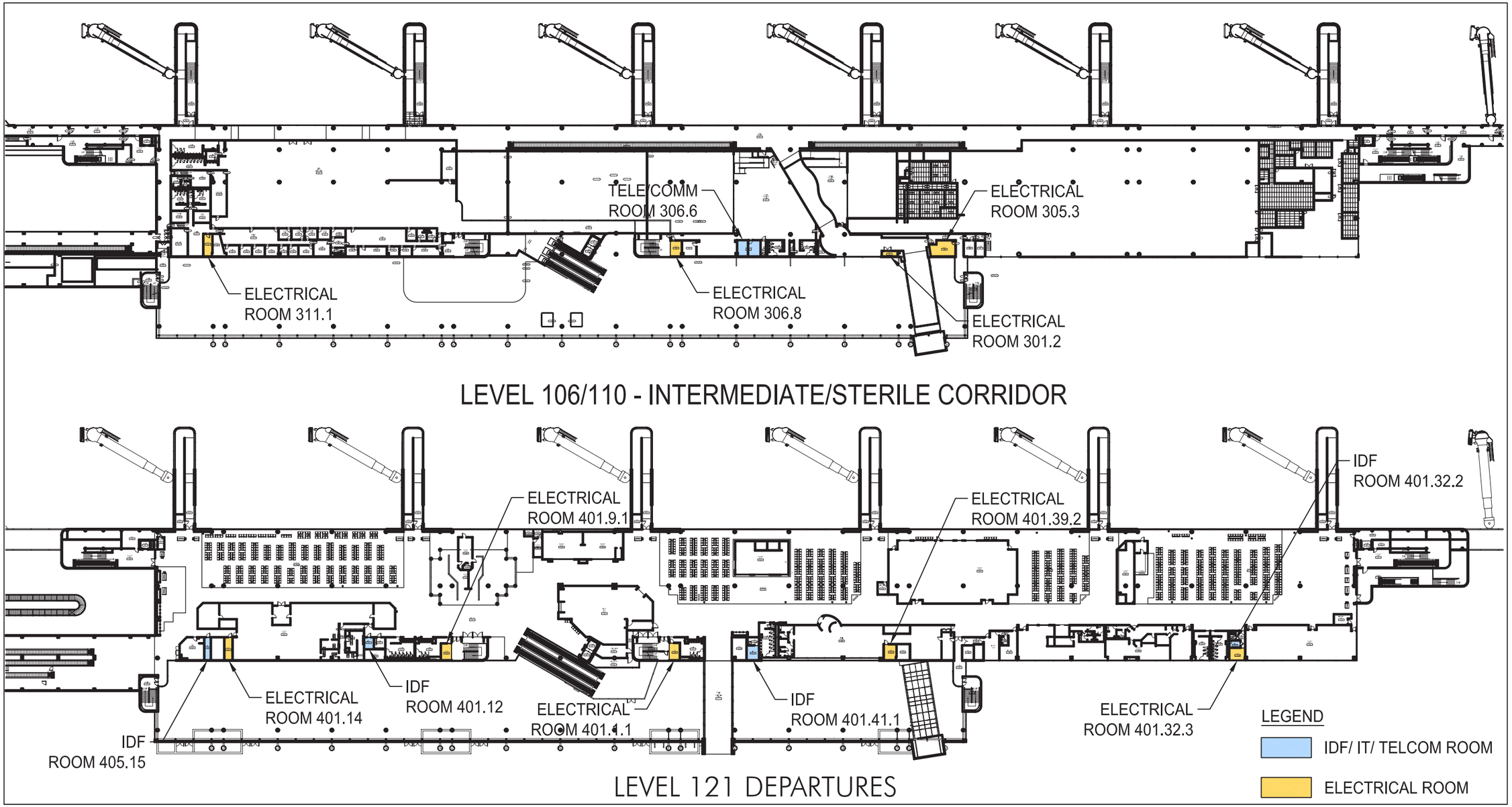
Terminal D - Existing Floor Plans



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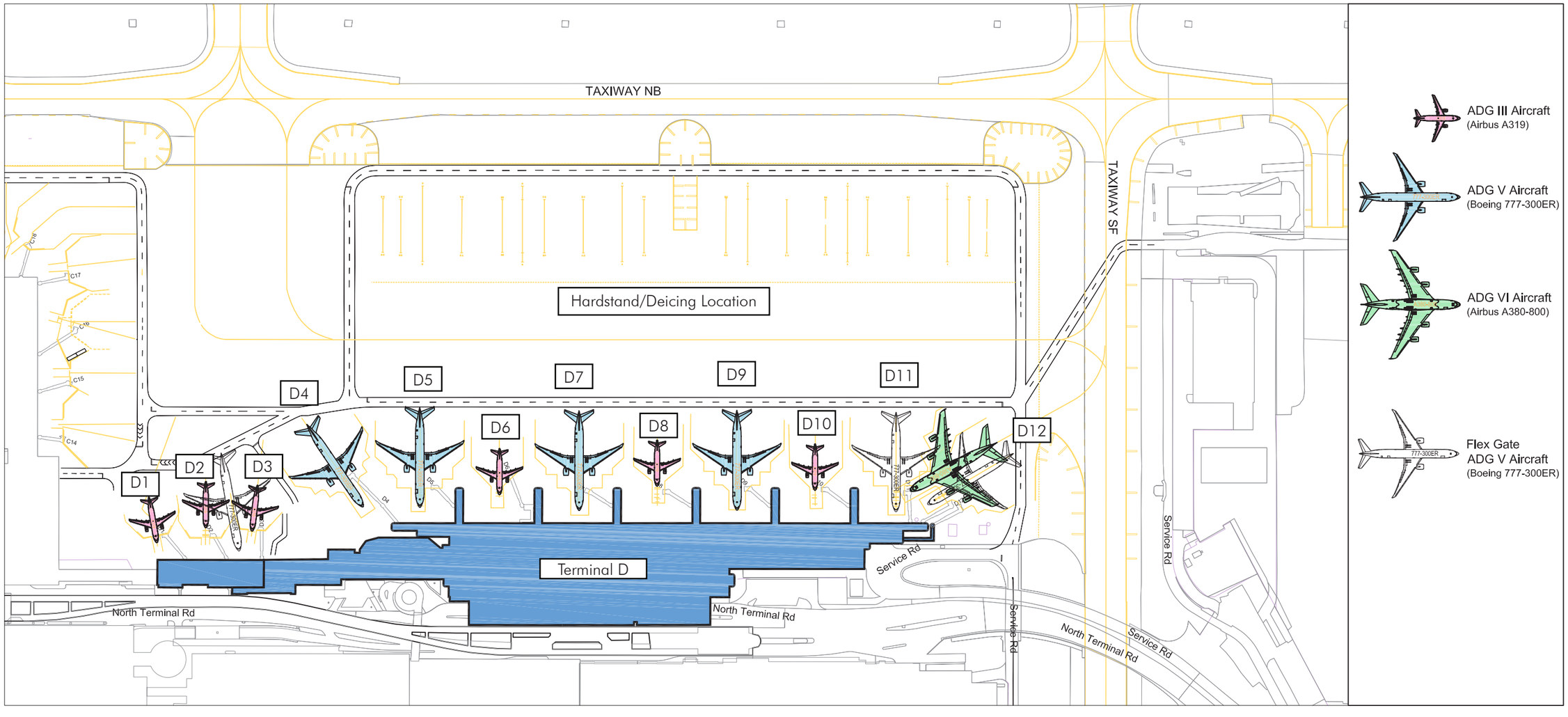
Terminal D - Existing Gate Layout



Note: Gate D9 is being modified to accommodate an A380; project completion estimated November 2014

0′ 1000′

3.2.2 GATING CAPABILITIES

In its current configuration, Terminal D has a total of 12 common-use gates (D1-D12). One gate serves super-body (ADG VI) and smaller aircraft, five gates can accommodate wide-body aircraft (ADG V), and six gates can accommodate narrow-body aircraft (ADG III and smaller). With the recent up-gauge of equipment by Lufthansa to an A380, one gate was modified to accommodate a super wide-body aircraft (Airbus A380; ADG VI). This was accomplished by converting two wide-body gates (D11 and D12) into an A380 gate designated Gate D12A. Since Gate D12A reduced the number of wide-body gates from six to five when in use by an A380, an additional wide-body gate was needed to serve the current wide-body flight demand. Gate D2W was created such that all airlines with wide-body gates today could continue to have access to such gates. Gate tradeoffs such as accommodating a single A380 but losing two wide-body gates and adding Gate D2W and losing three narrow-body gates reflects decisions made to maximize use of the existing gate areas.

The Terminal D hardstand was developed in 1998 to provide additional aircraft storage and commercial use opportunities. The pavement area can accommodate six ADG V aircraft or various combinations of smaller aircraft. Current hardstand uses include United Airlines international RJs on the west portion of the ramp and large aircraft on the east portion. The hardstand is designed to accommodate as many as seven RJ aircraft and three to four larger aircraft on the east. United Airlines routinely uses the hardstand for ADG III and ADG IV aircraft. The hardstand is also used as a deicing location when needed and a parking location for irregular operations. The Terminal D hardstand has also been used for deplaning large inbound aircraft when necessary. The hardstand is not currently used for enplaning large aircraft since there is sufficient space available in Terminal D.

Since the Terminal D gates are common-use gates, each gate is designed to accommodate all certain classes of aircraft so that there is flexibility in assigning gates. Gate classes are defined for Terminal D to reflect FAA aircraft classifications as described in FAA Advisory Circulars 150/5300-13A, Airport Design. **Table 3.3** summarizes the existing gate capabilities of each of Terminal D's existing gates. The six aircraft groupings and their associated wingspan ranges are provided for reference below.

- ADG VI = wingspan of 214 feet up to but not including 262 feet (Airbus A380)
- ADG V = wingspan of 171 feet up to but not including 214 feet (Boeing 777)
- ADG IV = wingspan of 118 feet up to but not including 171 feet (Boeing 757)
- ADG III = wingspan of 79 feet up to but not including 118 feet (Boeing 737)
- ADG II = wingspan of 49 feet up to but not including 79 feet (ERJ-145)
- ADG I = wingspan less than 49 feet (small general aviation aircraft)

Table 3.3 – Existing Terminal D Gate Inventory

GATE	MAXIMUM ADG	REPRESENTATIVE AIRCRAFT	DEPENDENCIES
D1	ADG III	Boeing 737-700W	Gate D1 is closed if ADG V is at D2W
D2	ADG III	Boeing 737-800W	Gate D2 is closed if Gate D2W is occupied
D2W	ADG V	Boeing 777-200ER	Used for Singapore Boeing 777-300ER Group V aircraft
D3	ADG V	Boeing 737-800W	Gate D3 is closed if ADG IV or V is at D2W
D4	ADG V	Boeing 777-300ER	N/A
D5	ADG V	Boeing 777-300ER	N/A
D6	ADG III	Boeing 737-800W	N/A
D7	ADG V	Boeing 777-300ER	N/A
D8	ADG III	Boeing 737-800W	N/A
D9	ADG V	Boeing 777-300ER	N/A
D10	ADG III	Boeing 737-800W	N/A
D11	ADG V	Boeing 777-300ER	Gate D11 is closed if Gate D12A is occupied by an ADG-VI aircraft
D12	ADG V	Boeing 777-300ER	Gate D12 is closed if Gate D12A is occupied
D12A	ADG VI	Airbus A380-800	Gate D12A is closed if Gate 12 is occupied

Source: HNTB Corporation

When an ADG IV or ADG V aircraft occupies Gate D3, Gate D2 is operationally closed due to a lack of wingtip clearance. When an ADG VI aircraft occupies Gate D12A, Gate D11 is operationally closed due to a lack of wingtip clearance.

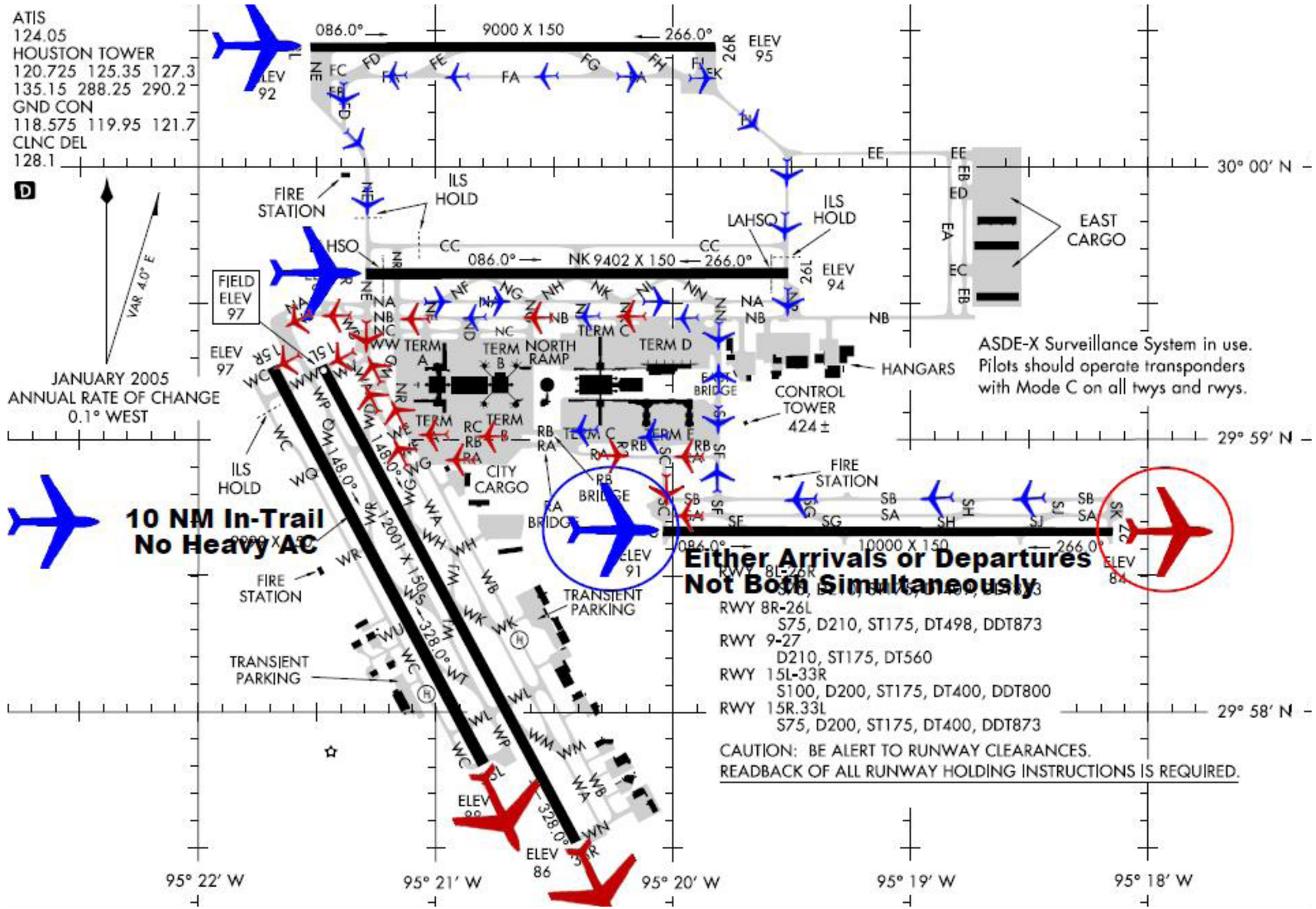
3.2.3 VEHICLE SERVICE ROAD

The Vehicle Service Road (VSR) provides access to the airfield and remote aircraft parking positions for airport service vehicles such as baggage tugs, maintenance vehicles, ground service equipment, operations vehicles, and a large array of aircraft servicing vehicles. The Terminal D Apron Level gates are served by a 25 foot VSR aligned at the tail end of parked aircraft parallel and along the entire length of the passenger terminal building.

3.2.4 AIRCRAFT FLOW

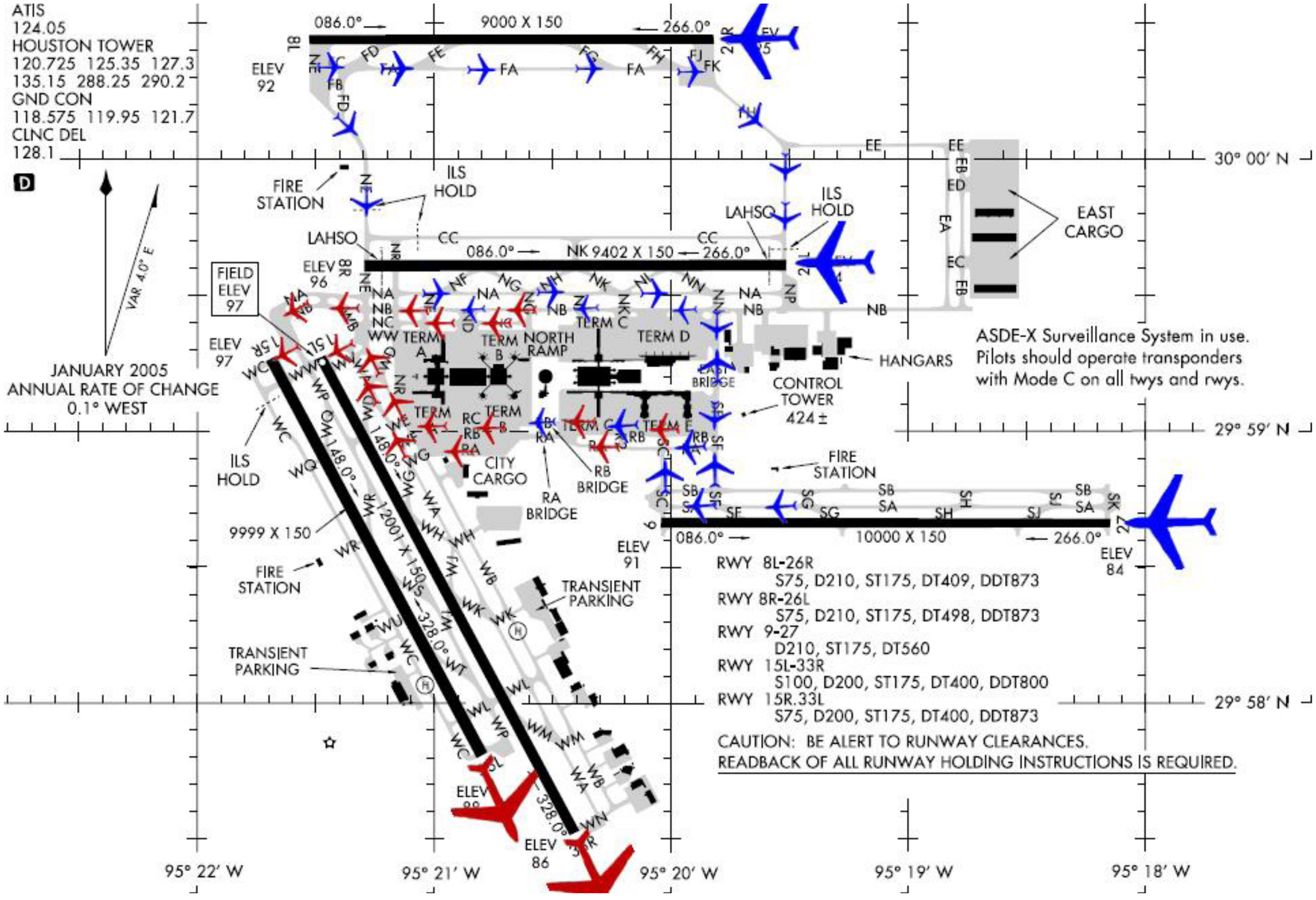
IAH currently operates a majority of aircraft operations in either a "West Flow" or an "East Flow" condition, depending on which direction the Air Traffic Control Tower (ATCT) is directing aircraft to approach the airport. West aircraft flows arrive via Runways 26R, 26L, or 27. East aircraft flows arrive via Runways 8R and 8L, and occasionally Runway 9. Departure flow is almost always via either Runway 15R or 15L. Taxiway flow adjusts to these two primary arrival conditions. The current aircraft taxiing flow under East and West Flow conditions is depicted in **Figure 3.22** and **Figure 3.23**. Aircraft access from/to north and south airfield is based on current FAA ATCT standard operating procedures.

East Flow Taxi Routes



Not to Scale

West Flow Taxi Routes



Not to Scale

3.2.5 APRON UTILITIES

Apron utilities include all of the equipment and infrastructure required to provide power, pre-conditioned air, other utility services for aircraft, and hydrant fueling. Each of the following subsections provides details about the existing apron utilities.

3.2.5.1 Aircraft Ground Power (GPU)

A central 400 Hz power system is located at the Basement Level of the terminal. This central system feeds power to all of the gates. At present, each gate can only provide power to one 90 kVA receptacle. The 747-400/800, 777-200LR/300ER, and A340 have two 90 kVA receptacles. Power for this system comes from the regular building power supply from CenterPoint Energy, as noted in **Section 3.1.2.5**. The 400 Hz power is fed underground to the apron and distributed to the gates in a system of duct banks and manholes. An additional duct bank with nine empty 2.5 inch conduits is routed to a pull box on the apron and is available for future gates. It is reported that this system is near the end of life and should be replaced with individual units at each gate. Airport management has decided to supply additional gate power so that aircraft will not need to operate the auxiliary power units (APU) or use separate ground power units (GPU). Gate D12A, the A380 gate, has already undergone this transition and the remaining gates are scheduled for this transition during future Terminal D modernization projects.

3.2.5.2 Aircraft Pre-Conditioned Air (PCA)

A central glycol system is located in the Basement Level as noted in **Section 3.1.1.1**. This system feeds glycol coolant to all gates, except Gate D12A. Power for this system comes from the normal building power supply. This system is near the end of life and will be replaced with individual PCA units at each gate in upcoming projects.

The system cannot provide sufficient cold temperatures to adequately cool wide-body aircraft. The PCA units have been de-rated to 60 tons because of this, although their capacity is 120 tons. This item is linked to the glycol system deficiencies and it was estimated in 2011 that it would require an $11 million upgrade with no additional capacity to continue to provide aircraft cooling with this system. In 2012, new PCA units were placed on the Passenger Boarding Bridges for Gate D12A to accommodate the A380 aircraft using that gate. HAS is currently working to replace the glycol system completely and place stand-alone PCA units on all passenger boarding bridges.

3.2.5.3 Passenger Boarding Bridges (PBB)

Power for Passenger Boarding Bridges (PBB) is provided from a 225 amp normal power panel located at each gate. This panel feeds bridge power and air conditioning. The power supply is not adequate for the proposed new passenger boarding bridges and will need to be replaced. The Gensler PDM states that six 800 amp spaces on the existing switchboard-A2 could provide GPU, PCA, and PBB power. The peak kVA loading demand of SWBD A2 is 763 kVA (i.e., around 920 amps). This is a 4,000 amp bus providing a current of approximately 3,000 amps. As noted earlier, airport management has decided to proceed with providing gate power and PCA units for each gate. This has already been done for Gate D12A. The remaining PBBs will be upgraded in upcoming Terminal D projects. The current operability and service life condition of the PBBs shall be assessed at the time of design/construction, prior to making a final recommendation for reuse.

3.2.5.4 Passenger Boarding Bridge Potable Water Cabinets

Potable Water Cabinets are intended to be reused with the existing PBB. All equipment on each PBB is to be inspected and repaired on a case-by-case basis. Potable water systems must be compliant with current regulatory requirements for aircraft service (i.e., EPA, USDA).

3.2.5.5 Hydrant Fueling

The existing hydrant fueling system servicing the terminal is located along the north side of Terminal D. It is connected to the fuel farm on the west side of the airport along Aldine-Westfield Road and is operated by a consortium of airlines. Allied Aviation operates and maintains the fuel farm for the consortium. The existing system is shown in **Figure 3.24**. Fuel is supplied to the fuel farm by several pipelines running throughout the area.

Jet-A fuel is pumped throughout the airport by a transmission system that feeds several distribution lines which in turn serve the various hydrants at each parking position. System pressure fluctuates between 180 pound-force per square inch gauge (psig) at the fuel farm and 120 psig at the cargo area. The transmission and distribution system consists of the following elements:

- Three 18 inch fuel lines supply fuel from the fuel farm to the airport main fuel vault located on the west side of Terminal A.
- Five lines (three 14 inch and two 12 inch) run out of the main fuel vault to airside north and serve Terminals A North, B North and C North.
- Five lines (three 14 inch and two 12 inch) run out of the main fuel vault to airside south and serve Terminals A South, B South and C South.
- Four lines (two 14 inch and two 12 inch) serve Terminals D/E
- Two lines (12 inch each) continue to the east to serve the cargo facility

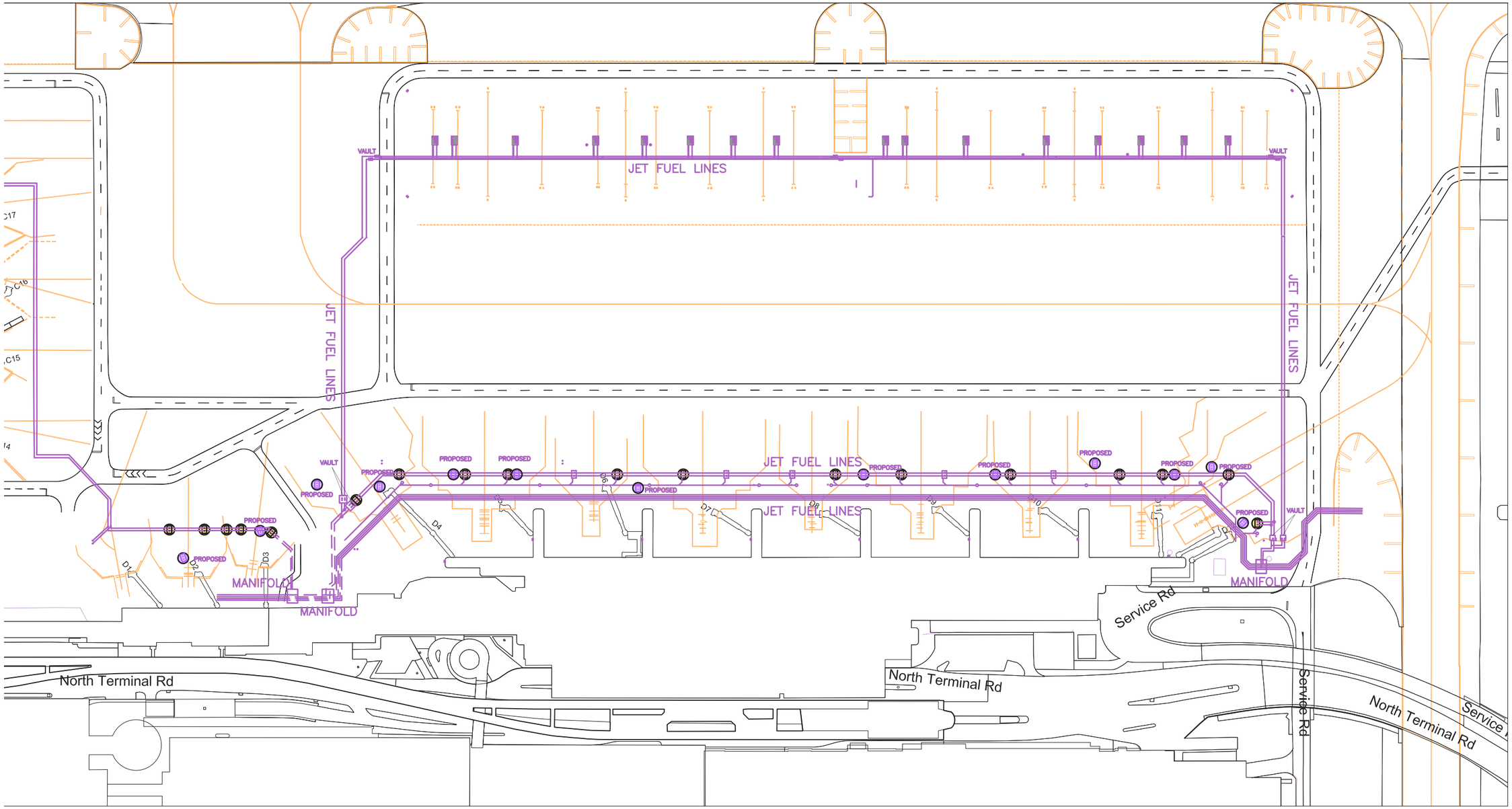
The transmission system lines are connected to fuel valve manifolds located above ground at each end of Terminal D. The valve manifolds allow for isolation of individual transmission lines and divert fuel to the Terminal D fuel distribution system. The fuel distribution system consists of two 12 inch fuel loops that branch off the above ground manifolds and distribute fuel to hydrant pits located at each Terminal D aircraft parking position. These same two 12 inch loops branch off again to form a second set of lines that distribute fuel to the hardstand positions.

The fuel distribution system includes the hydrant fuel pits, high point vents, low point drains, isolation valve vaults, motor-operated isolation valves, cathodic protection, emergency fuel shut-off (EFSO), and a dedicated drainage system. Each aircraft parking position is served by two hydrant fuel pits. Fuel trucks with pumps connect to the fuel pits and transfer fuel to the aircraft. All of the fuel pits are plumbed together. The fuel pits are designed to drain into the storm water system and eventually to a lift station vault located on each side of Terminal D. The common drain line is closed off at the last fuel pit prior to the lift station vault. The isolation valve vaults have sump pumps to collect storm water and fuel spills. These vaults are pumped out periodically. Pipeline integrity leak detection is performed at the fuel farm using pressure charts to determine loss of pressure over the system (loss of fuel). There is no separate leak detection system, such as the Hansa Consult type, that is used. Global Cathodic Protection is the current testing firm for the corrosion control system. That system consists of impressed current and sacrificial anode beds located airside near Gates D12 and D4.

The Emergency Fuel Shutoff (EFSO) system is a safety system to shut off the flow of fuel in case of an emergency. It consists of emergency push buttons at each gate and input/output (I/O) control boards located in three different electrical rooms within Terminal D. The hydrant gate EFSO is connected parallel with the hardstand system. In the event of an EFSO activation, all four Motor Operated Valves (MOV) will close thus stopping the flow of fuel to the hydrants and hardstand system.

Fuel is stored in above ground vertical tanks at the fuel farm. The combined capacity of those tanks is 13 million gallons. The average daily fuel consumption ranges between 1.6 and 1.8 million gallons per day (mgd) according to Allied Aviation. The fuel farm has 16 hydrant pumps rated at 1,000 gpm/each and four lead (high pressure) pumps with a flow of 600 gpm for a total peak flow rate equal to 18,400 gpm. Each pump has a filter

Existing Hydrant Fuel Lines



Scale: 1" = 175' 0' 175'

separator sized to match the pump flow. Peak daily demand is 4,500 gpm. Estimated current Terminal D demand is 2,800 gpm for six wide-body and six narrow-body aircraft. The existing hydrant fuel trucks are rated to flow at a maximum of 800 gpm.

3.3 Site Utilities

This section reviews the existing site utilities serving the Terminal D complex. This includes the domestic water supply, sanitary sewer system, storm sewer system, natural gas, and fuel distribution system that are external to Terminal D.

3.3.1 12.5 kV SITE POWER

CenterPoint Energy provides power to the building at 12.47 kV from a single utility vault located at the east end of the building on the Ticketing Level. Terminal D is fed from dual 15 kV 3#500 kcmil and 1#3 ground, utility feeders sourced from two separate CenterPoint Energy circuits, GR3 and IT6, each with an automatic primary selector switch for redundant service to the facility. Peak utility demand is 2,278 kVA. Each supply line feeds a distribution panel through a breaker of 1,200 A each, for a total capacity of 11,000 kVA. All switchgear are 480/277 volt, three-phase, four wire.

3.3.2 WATER SUPPLY SYSTEM

An 8 inch PVC line provides the existing Terminal D water supply. The 8 inch line branches from the existing 16 inch water line loop located at the roadside just south of Terminal D. The existing 16 inch line is expected to provide any additional demand that might be required. Refer to **Figure 3.25**. A 4 inch water line branching from the 16 inch main around Gate D3 runs north and feeds an apron environmental drainage network with 2 inch and 1.5 inch water lines. The 8 inch line supplies water to a COH required surge tank located in the Basement Level (74) Main Mechanical Room.

3.3.3 FIRE PROTECTION WATER SUPPLY SYSTEM

The Basement Level (74) surge tank serves both the fire pump and the domestic water booster pumps. The fire pump is electrically driven (200 hp) and has a capacity equal to 1,500 gpm (140 psi). A 15 gpm jockey pump provides fire water to a complete standpipe and automatic sprinkler system. The Fire Department Pumper Truck Connections (FDC) are located landside, near the east entrance of Terminal D. Two fire pump test station connections are located adjacent to the FDCs.

3.3.4 SANITARY SEWER

The existing building has a complete sanitary waste and vent system at all of the required locations. The existing sanitary waste system is in serious need of repairs in many places throughout the building. A sanitary sewer report prepared by Amani Engineering in June 2010 chronicled the overall condition of the sanitary waste system including the existing grease piping system and existing grease interceptors currently in place. That report confirmed the poor condition of the sanitary system and the need to repair sections of the system.

The existing terminal building has two grease interceptors located outside the building. The main grease trap for the building is located at the west end (approximately 1,500 gallon capacity) and the other one is located at the east end truck dock (approximately 750 gallon capacity).

The existing Terminal D sanitary sewer system is composed of six subsystems listed below. **Figure 3.26** graphically depicts the existing sanitary sewer system.

- Service Lines
- Collector Line
- Gate D4 Lift Station
- Bypass Line
- Transfer Line
- Terminal D West Lift Station

The service lines are 6 inch lines that carry the building wastewater to a collector line. The collector line is an 8 inch gravity line that runs parallel to the terminal on the apron side. The slope of the 8 inch collector line is not known. However, the collector invert elevation at the lift station has been surveyed during HAS Project 638A and is recorded at 72.03 ft. This invert elevation (72.03 ft) appears to be approximately 2 ft above the terminal basement elevation that is approximately at 70.0 ft. The collector line discharges into the Gate D4 lift station.

The Gate D4 Lift Station is a 10 ft diameter, 28 ft deep submersible lift station equipped with two 3 hp pumps with a firm capacity of 280 gpm. The lift station lifts the Terminal D wastewater load and discharges it into the COH manhole number IC104069 located near Gate D4. HAS Project 638A is upgrading the lift station. The main structure will remain in its present location with top slab elevation at 95.98 ft and with base elevation of the wet well at 67.98 ft. The pumps will be replaced with two new 5 hp pumps with a firm capacity of 365 gpm at 25 ft TDH (Total Dynamic Head). The electrical control panel and other peripheral equipment will all be upgraded accordingly.

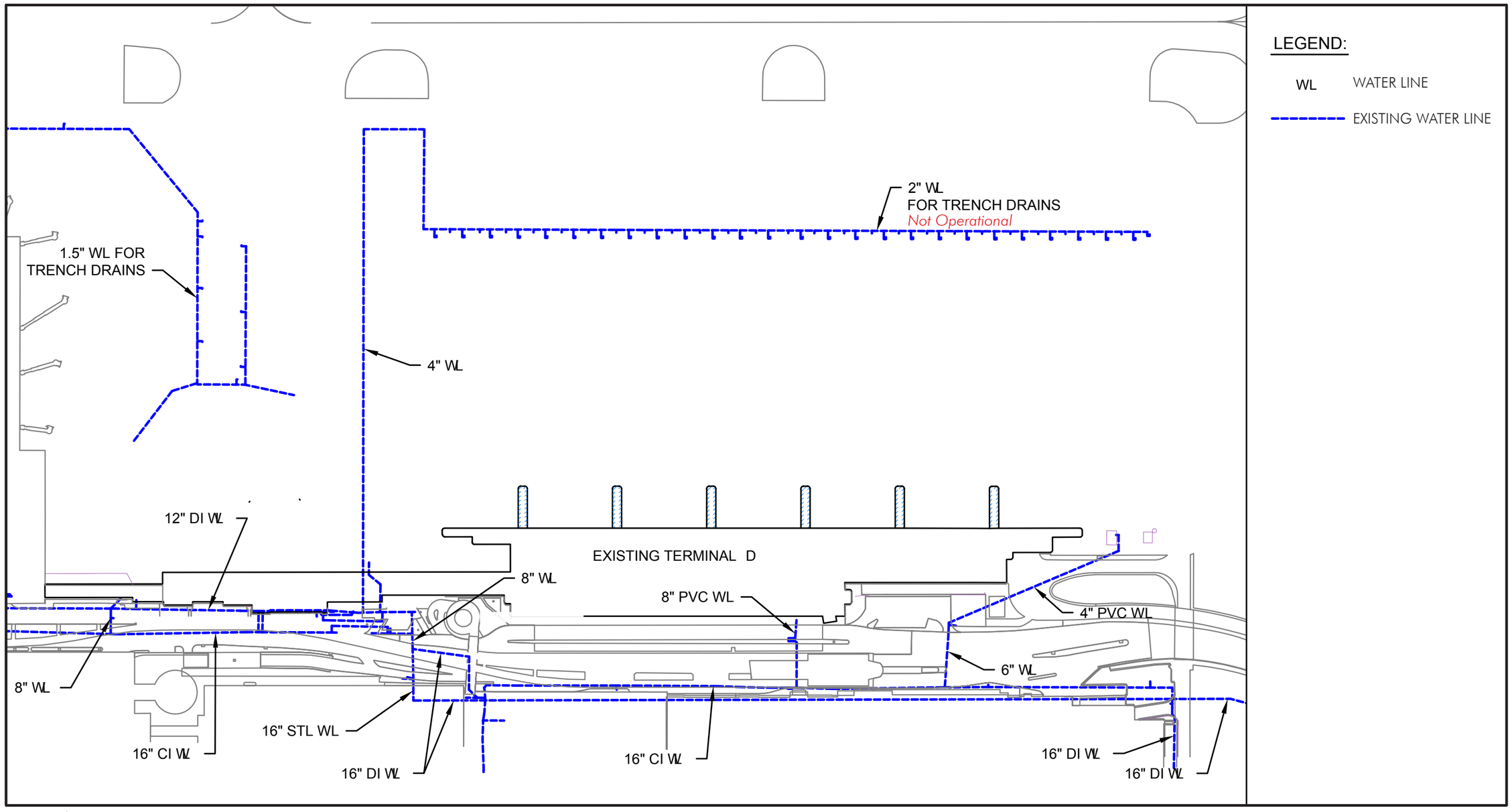
A 12 inch cast iron (CI) bypass gravity line, constructed in 1987, carries the wastewater load of a few facilities located to the east of Terminal D. This line runs parallel to the collector line and discharges into the COH manhole number IC104069. The wastewater load coming from the east through this 12 inch line, per the HAS Project 638A study, is about 48 gpm. The line grade, per COH Geographic Information System (GIMS), is only 0.117%. That is far less than the minimum COH requirement of 0.26%.

Manhole number IC104069 combines wastewater loads from the 8 inch collector line and the 12 inch bypass line, a total of 328 gpm per the Project 638A study, and transfers it from airside to roadside via a 12 inch DI gravity sanitary sewer pipe transfer line that is sloped at 0.117%. The transfer line discharges into the Terminal D West Lift Station.

The Terminal D West Lift Station was constructed in 2004 as a part of the International Services Expansion Program. This lift station is an 8 foot diameter, 12 foot deep submersible lift station equipped with two 3 hp pumps with a firm capacity of 328 gpm. The lift station receives combined wastewater generated from Terminal D plus the bypass line and discharges, via a 6 inch force main, to the COH manhole number IC1040E01, located just outside of FIS building.

HAS Project 638A & B made sewer pump station improvement at Terminal D. The main structure remained at its current location with a top slab elevation of 87.42 feet and with a base elevation of the wet well at 75.58 feet. The pumps were replaced with two new 10 hp pumps with a firm capacity of 425 gpm at 21 feet TDH. The electrical control panel and other peripheral equipment was upgraded accordingly.

Existing Terminal D Water Lines



0′ 200′

Existing Terminal D Sanitary Sewer Lines

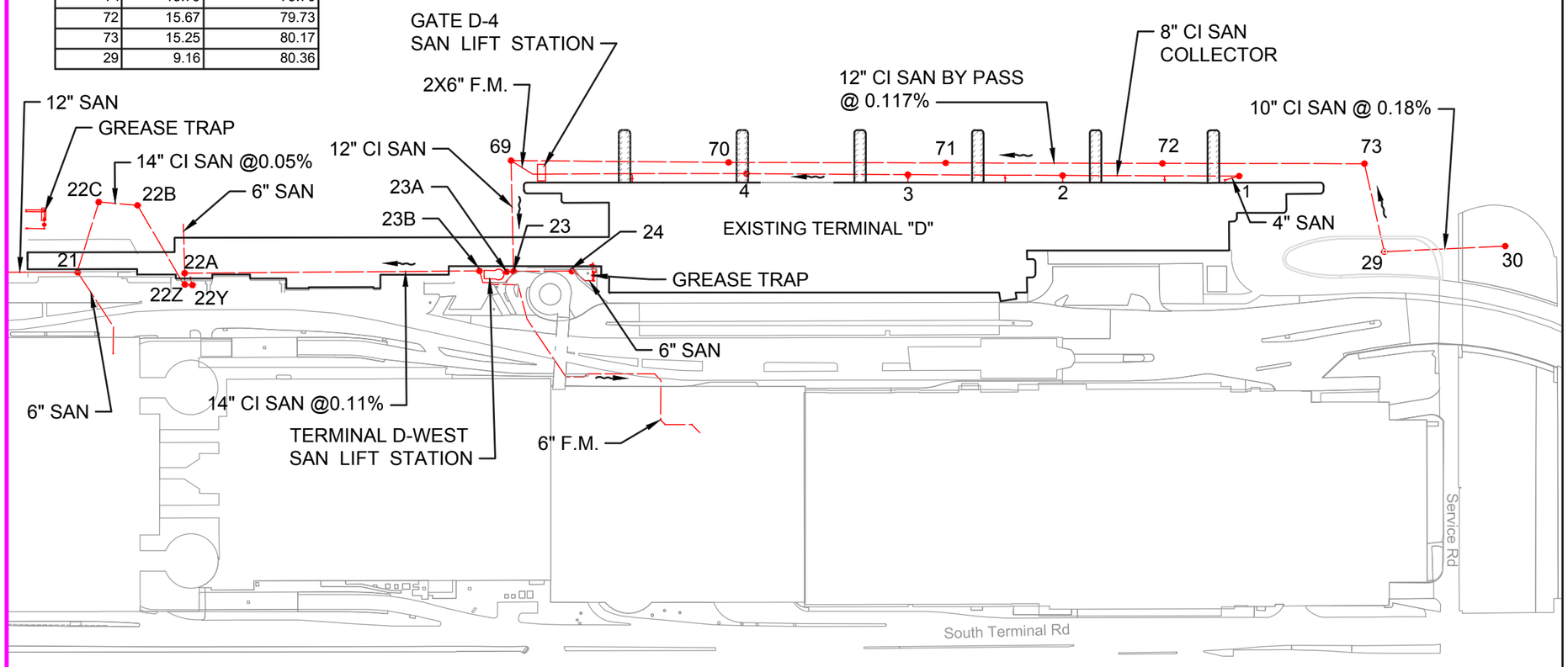
EXISTIG SAN SWR MANHOLES		
MH #	DEPTH	INVERT ELV.
20	11.68	77.49
21	11.65	77.91
22C	17.08	77.99
22B	17.08	78.01
22A	7.31	82.48
23B	7.60	78.14
23	7.50	78.48
24	5.58	78.59
69	16.24	78.63
70	16.20	79.30
71	15.79	79.70
72	15.67	79.73
73	15.25	80.17
29	9.16	80.36

EXISTIG SAN SWR MANHOLES		
MH #	DEPTH	INVERT ELV.
1	7.80	87.90
2	20.00	75.65
3	21.01	74.75
4	22.23	73.80

EXISTING LIFT STATIONS
GATE D-4: 10 FEET DIAMETER, 28 FEET DEEP 2 SUBMERSIBLE PUMPS W/ FIRM CAPACITY OF 280 GPM EACH STORAGE DEPTH OF 4 FEET
TERMINAL D-WEST: 8 FEET DIAMETER, 12 FEET DEEP 2 SUBMERSIBLE PUMPS W/ FRIM CAPCITY OF 328 GPM EACH. STORGAE DEPTH OF 3 FEET CONSTRUCTED IN 2004 HAS BY PASS GRAVITY LINE

LEGEND:

SAN	SANITARY SEWER LINE
F.M.	FORCE MAIN
●	MANHOLE
69	CITY MH NO. *IC1040* 69
←~	FLOW DIRECTION



0′ 200′

3.3.5 STORM SEWER SYSTEM

The Terminal D apron is served by a contaminated storm water collection system located approximately 600 feet north of the terminal building illustrated in **Figure 3.27**. This system consists of a slotted drain collection system, a dual conveyance system, and an environmental pump station. A slotted drain intercepts potentially contaminated storm water runoff from the aircraft parking and diverts it to the environmental pump station where it is segregated for treatment or allowed to bypass and flow into the drainage system. The existing apron grading is illustrated in **Figure 3.28**.

3.3.6 NATURAL GAS

The existing structure has a natural gas system in place as seen in **Figure 3.29**. The natural gas meter/regulator is located at Level 88 on the east end of the terminal. The beginning pipe size is 4 inches and reduces to a three inch pipe around column line eight on the Departure Level (total developed length is approximately 1,100 feet). The entire natural gas line is encased in a 6 inch steel sleeve. The as-built drawings indicate the meter/regulator is sized for 1,750 cf/hour at four ounce (oz) pressure. Refer to **Chapter 7**, Site Electrical and IT, Phases 3 & 4, to see the location of existing gas meter to Terminal D.

3.4 Terminal C Building

Terminal C opened in 1981; it was and remains the largest terminal at IAH accommodating the facilities and operations of United Airlines exclusively. Terminal C consists of three separate buildings: an eight-level central building at landside and two, two-level concourse buildings at airside. The Central Building accommodates all terminal access and passenger processing functions. Pedestrian bridges at the north and south sides of the main building connect to the concourse buildings at the adjacent north and south airside areas for aircraft boarding. Other pedestrian bridges and walkways on the east and west sides connect to adjacent parking garages.

3.4.1 TERMINAL C CENTRAL BUILDING

The Terminal C Central Building, shown in **Figure 3.30**, **Figure 3.31**, and **Figure 3.32** accommodates all terminal access and passenger processing functions. Functionally, the Central Building vertically segregates access, deplaning, enplaning, and parking functions, as follows:

- Level LL1 is below grade and provides space for building mechanical spaces and the right-of-way and boarding platform of the Inter-Terminal Train (ITT) system. The ITT is a non-secure train system that connects Terminals A, B, C, D, E, and the Marriott Hotel.

- Level 1 (**Figure 3.30**) is at grade and provides baggage claim areas, baggage offices, public services, deplaning curbside, parking access, and operational offices for ground transportation.

- Level 2 (**Figure 3.31**) provides airline ticketing/flight check-in counters and offices, two security screening checkpoints, limited public waiting areas, public services, enplaning curbside, parking access, and a small concession space within the non-secure area of the ticketing lobby. In addition to the check-in counters in the lobby there is a smaller check-in located within the east garage at this level that is utilized by patrons using the remote parking shuttles that drop passengers there. Immediately east of the drop off location is a bay of accessible parking.

- Level 3 (**Figure 3.32**) provides elevated access above the ticketing lobby and secure corridor below connecting the adjacent parking structures to the east and west through the center of the terminal. Along the north and south building face mezzanine offices for are provided for airline offices. Due to security requirements, access to these office mezzanines is independent from the garage connector, accessed from the level below except for fire egress. The Level 3 Mezzanine also provides a connection to Terminal E via a corridor connection along the south face of the Terminal C East Garage.

- Levels 4, 5, 6, and 7 provide convenient parking spaces for the traveling public and are linked to the east and west garages by bridge structures which allow connectivity between all three parking structures at certain levels.

The upper parking levels of the Central Building connect with the upper levels of the adjacent east and west parking garages creating large contiguous parking floor plate while providing cover for the curbside drop-off and pick-up activities below.

While the baggage claim facilities are in the Central Building, the baggage sorting, handling and screening areas are in the adjacent east parking structure baggage handling facility. Baggage is transported to and from the north and south airside concourse buildings via tug tunnels, with inbound baggage carried via conveyors to the bag claim carrousels located on Level 1.

3.4.2 TERMINAL C NORTH CONCOURSE

A "T-shaped" concourse building located to the north of the Central Building provides airside aircraft boarding facilities. The North Concourse is shown in **Figure 3.33** and **Figure 3.34**. A pedestrian bridge extending from the north of Level 2 in the Central Building provides access to the Terminal C North Concourse. Because the security screening checkpoints are in the Central Building, security screened passengers may freely circulate between the concourse buildings. Furthermore, passengers may also transfer to all other terminals using the aerial Terminal Link system. They may also walk to Terminal D from the North Concourse building.

The Terminal C North concourse building is a two-level structure with passenger related facilities at the upper level and airline/aircraft related facilities at the lower, apron level. There are a total of 12 active gates at the North Concourse Building, with two additional gate positions unused; one gate having been decommissioned and removed (C27) and the second (C15) blocked from use by the adjacent gates handling of larger widebody aircraft. All gates serve United Airlines aircraft.

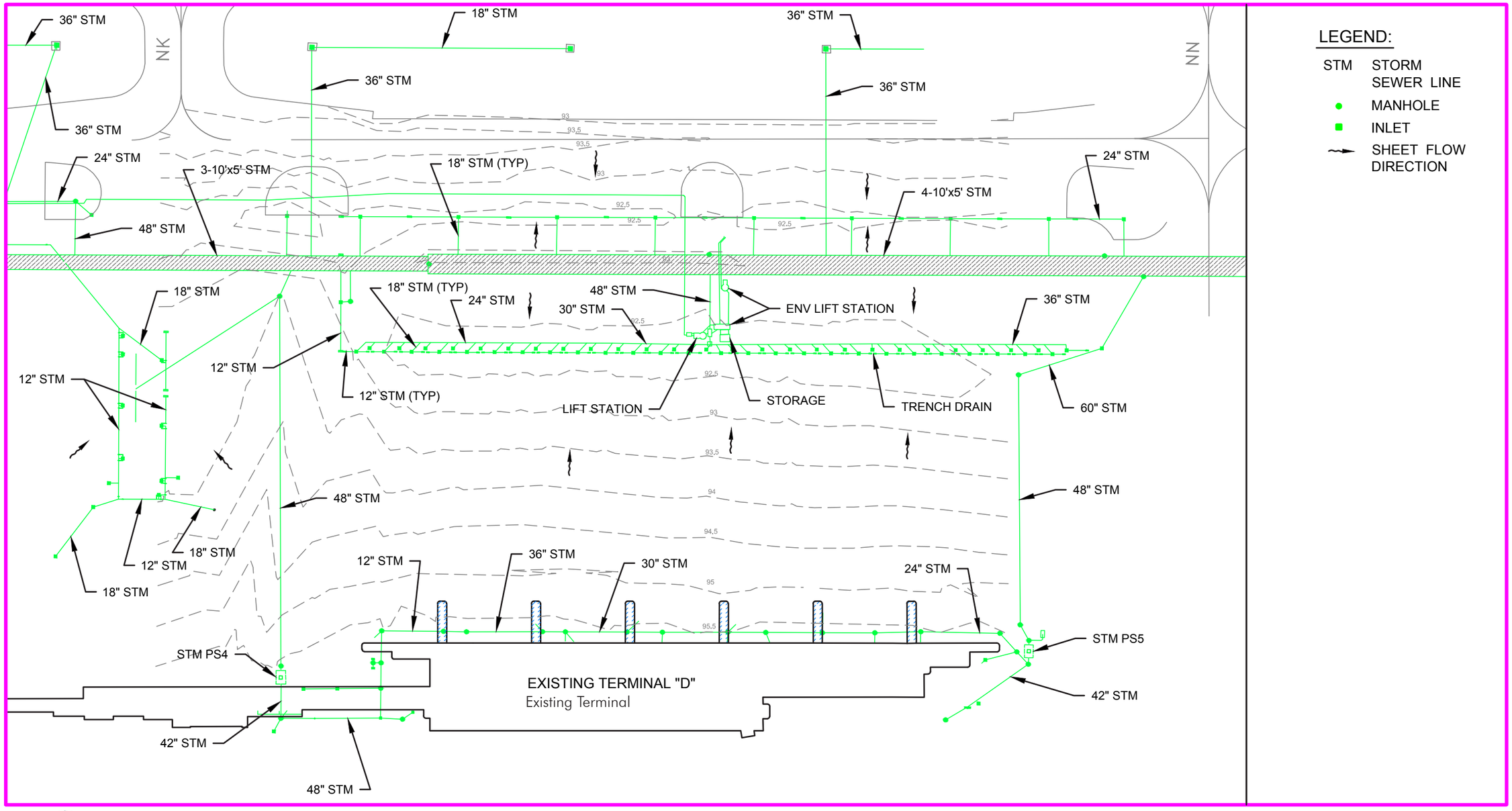
3.4.2.1 Terminal C North Structural Assessment

Structural drawings for the original Terminal C project were issued for construction in August 1977, and were issued as a final record set in June 1983. There are 64 structural sheets which document the design for the main terminal and garage building, helical ramps, stairs, north concourse, east concourse, tug tunnel, and other associated structures.

Structural notes on the drawings indicate the floor and roof live loads that were used, the specified properties for concrete and steel materials, and soil bearing pressure that was used in sizing the spread footings. The Uniform Building Code was commonly used in Texas at that time, which would have dictated a uniform wind load of at least 25 psf.

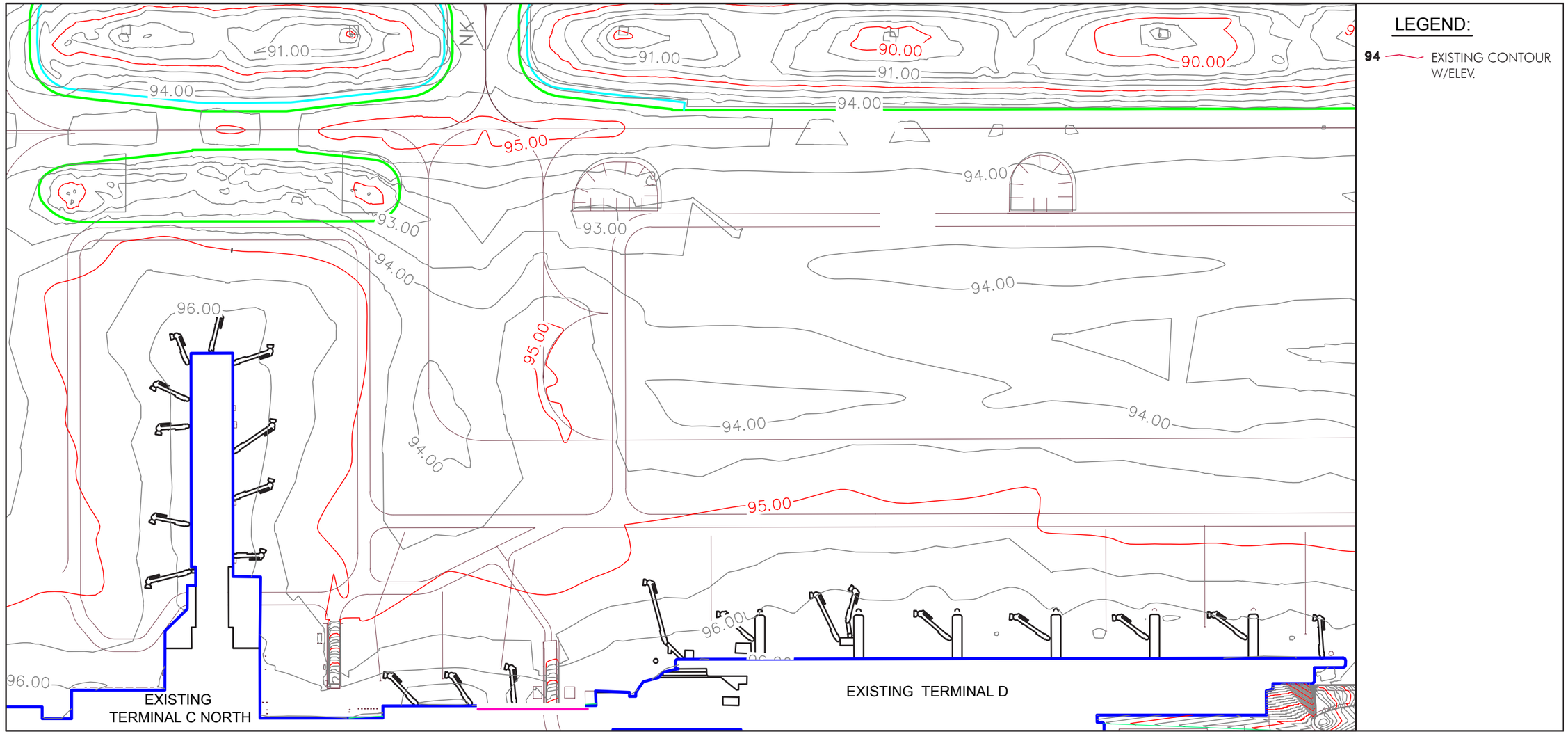
Building codes and design guides have changed since 1977 resulting in higher "design" wind loads and prescriptive requirements to address serviceability issues. However, more sophisticated analysis procedures exist today to allow us to analyze the structure in three dimensions and take better advantage of materials and framing configurations so that the end result is typically not that much different than what was previously used. This is why

Existing Terminal D Storm Sewer/Apron Drainage



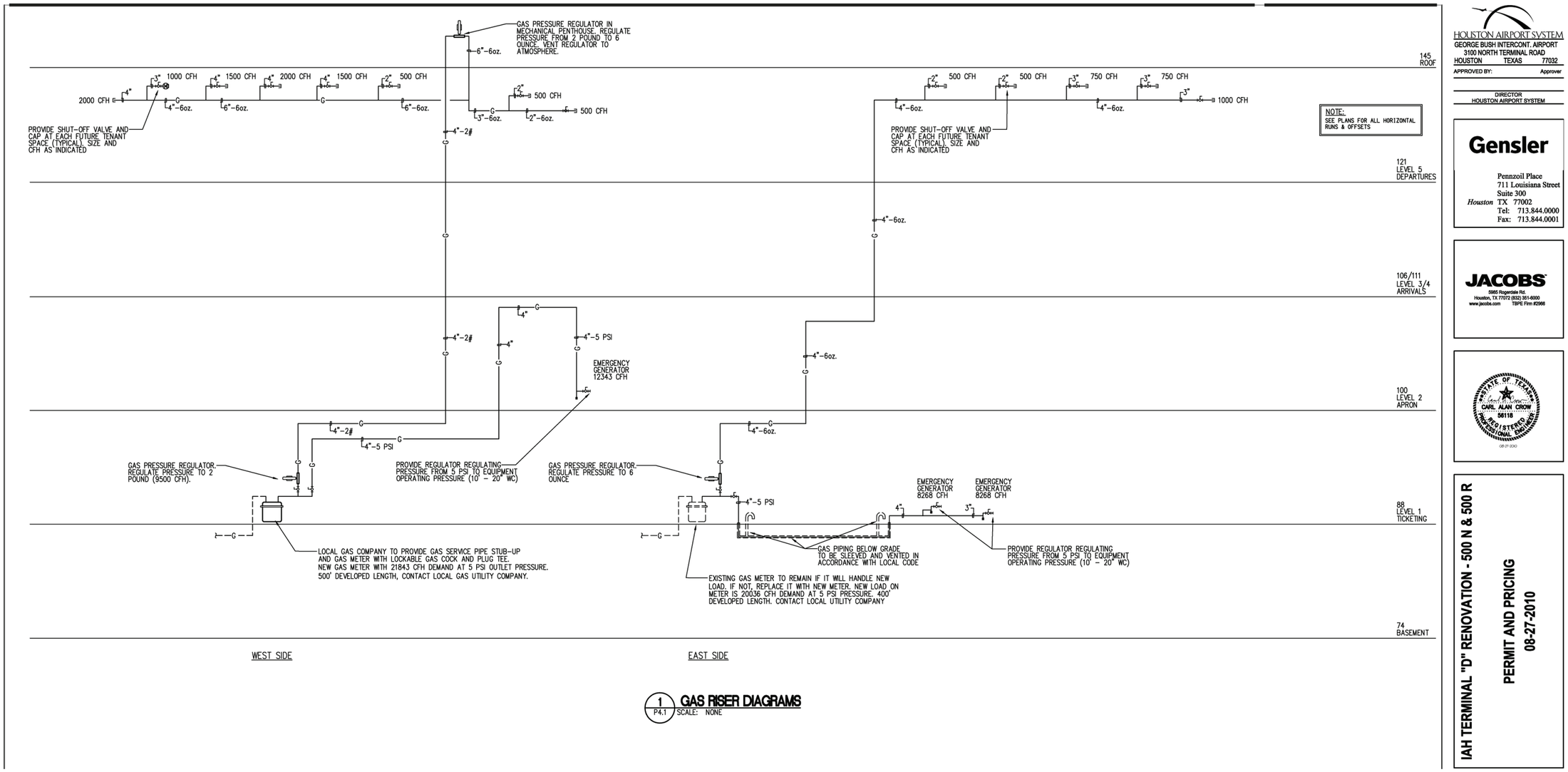
0′ 200′

Existing Apron Grading



0′ 100′ 200′

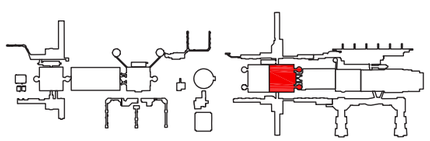
Existing Terminal D Natural Gas System



Drawing Not to Scale

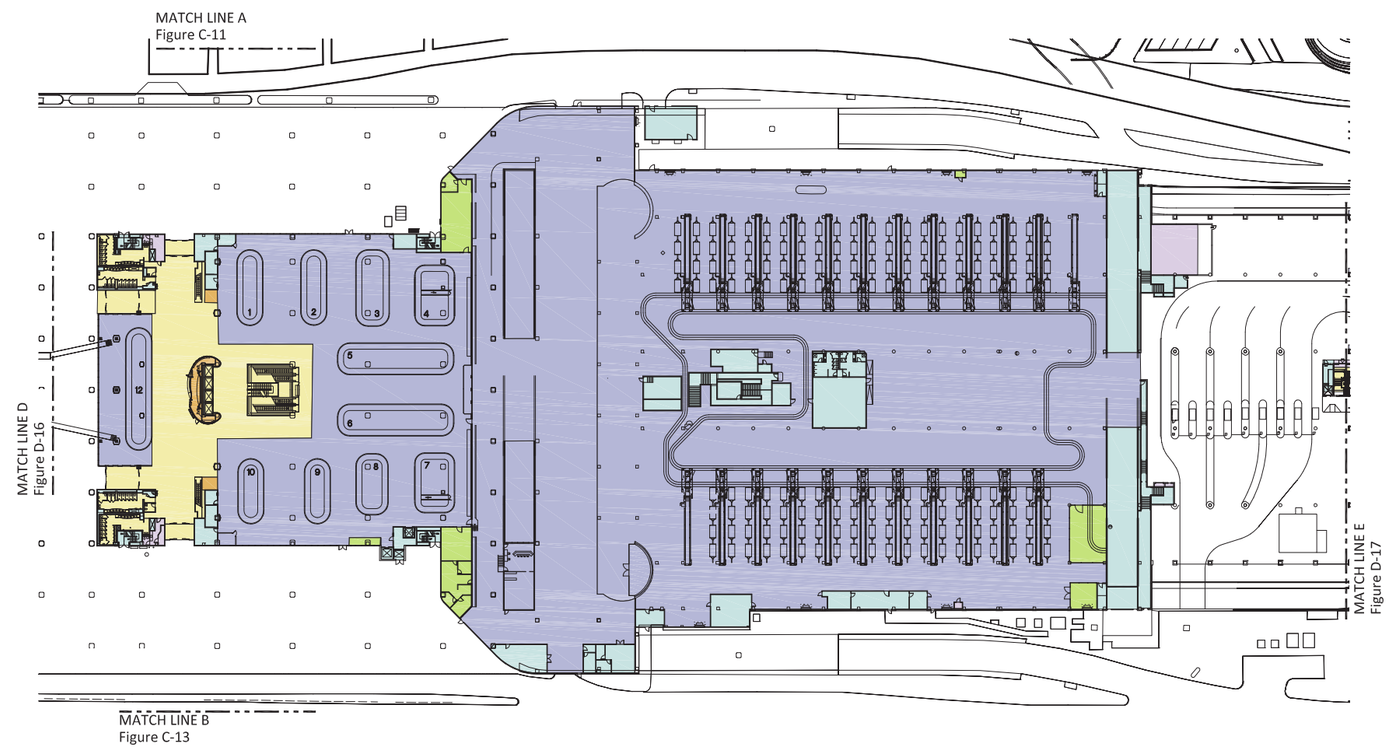
Terminal C - Level 1

KEY MAP



LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

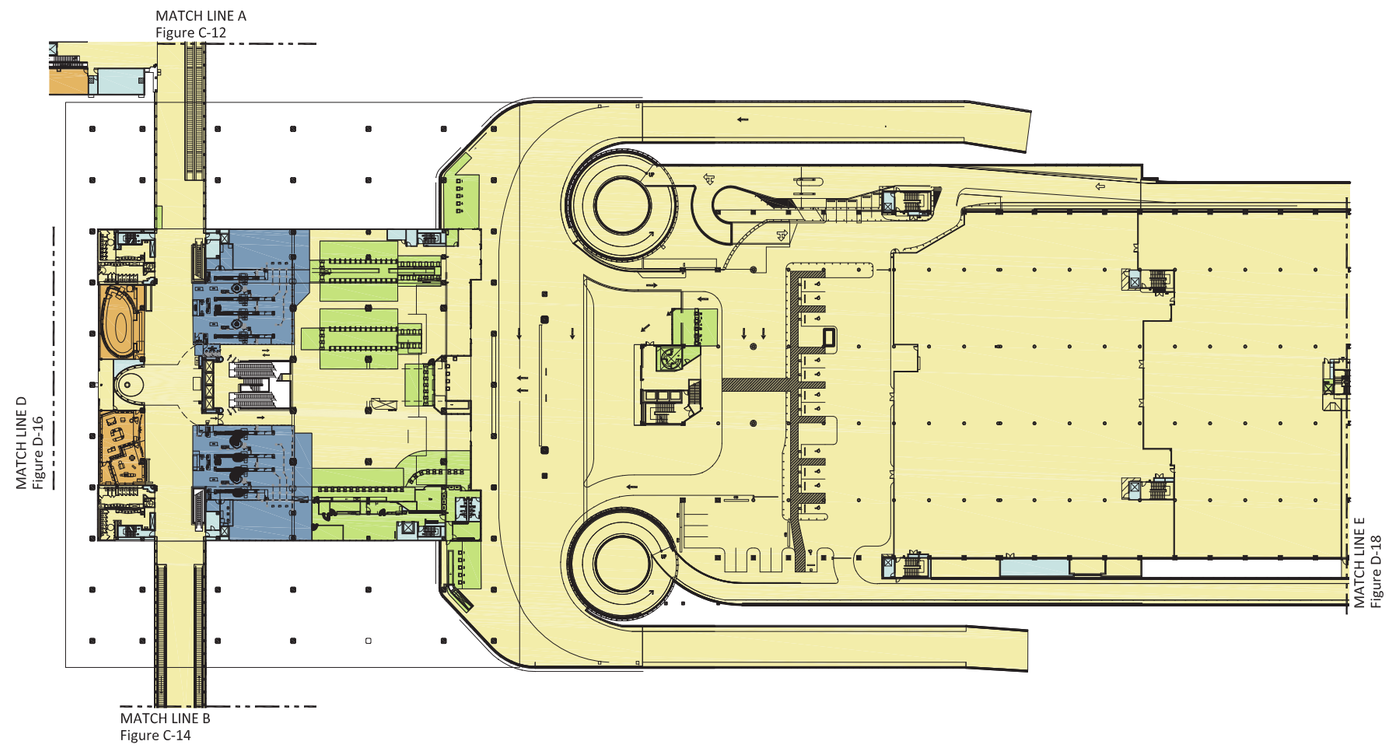


Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdIR Architects, Inc., December 21, 2012
LeighFisher

Drawing Not to Scale

0′ 125′

Terminal C - Level 2



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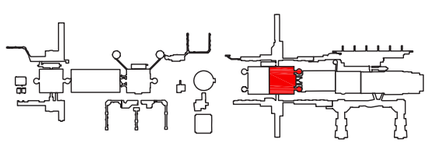


LEGEND

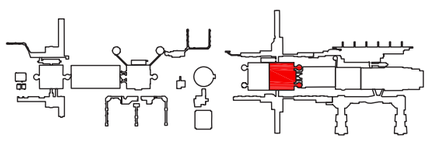
- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdIR Architects, Inc., December 21, 2012
LeighFisher

Drawing Not to Scale

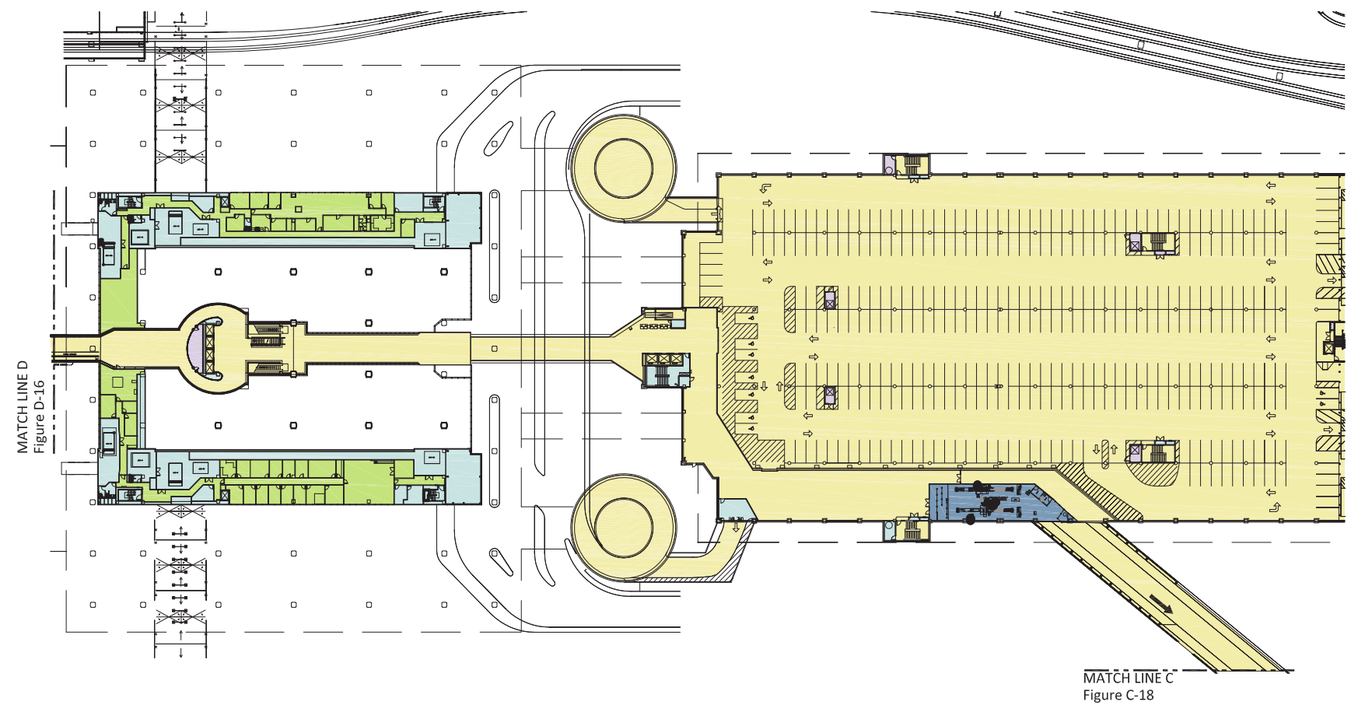
Terminal C - Level 3

KEY MAP



LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

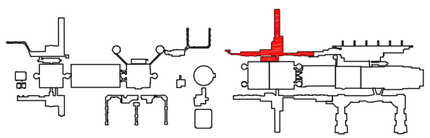


Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdIR Architects, Inc., December 21, 2012
LeighFisher

Drawing Not to Scale

Terminal C - North Concourse Level 1

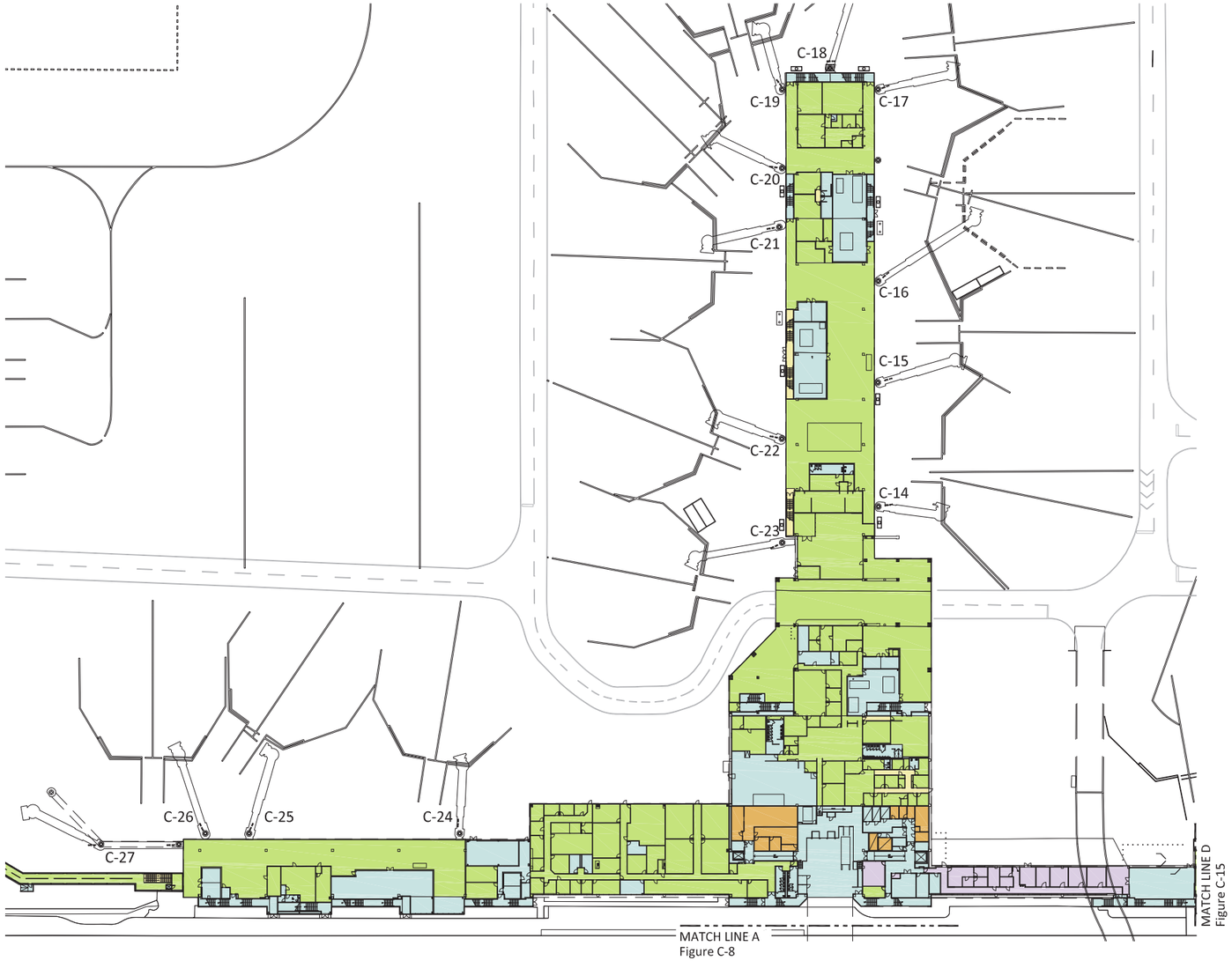
KEY MAP



LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
- Building Services & Support

Source: HAS Records and IAH Airport Layout Plan, August, 2006
Prepared by: RdIR Architects, Inc., December 21, 2012
LeighFisher



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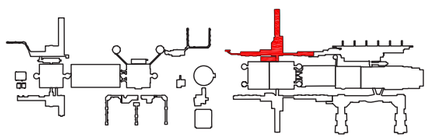
Terminal C - North Concourse Level 2

KEY MAP



LEGEND

- Airline
- Concessions
- Baggage Handling
- Security
- Customs & Border Protection
- HAS
- Public Space
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Source: HAS Records and IAH Airport Layout Plan, August, 2006
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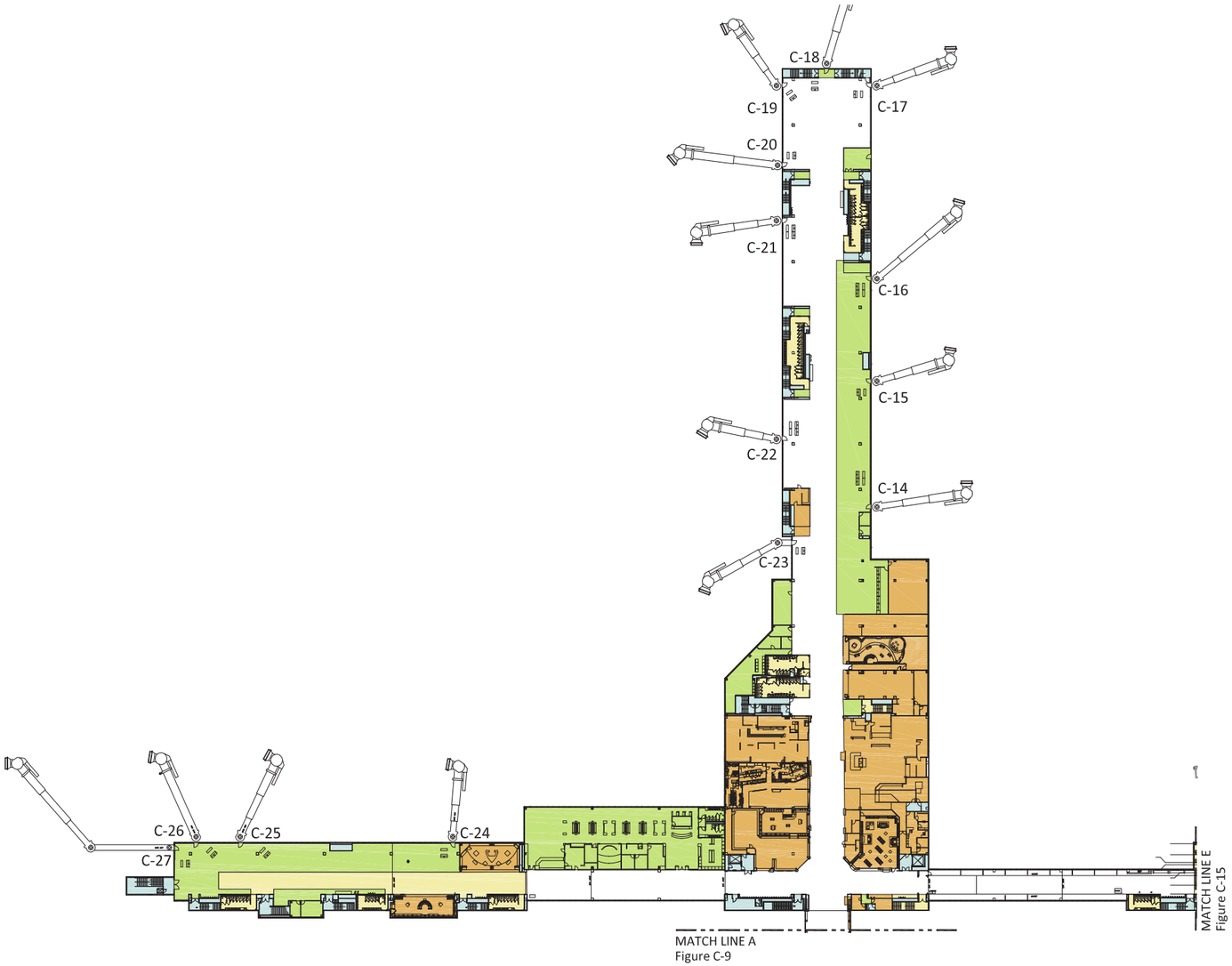
LeighFisher



Drawing Not to Scale

buildings designed before present day codes are still viable and not typically retrofitted. (The exception is buildings in California and other high seismic areas, where new data showed that many buildings were in critical need of upgrades to resist lateral loads from earthquakes.)

Any proposed expansion of Terminal C would include both vertical and horizontal components, which would require new structural elements and may also require strengthening of the existing structure to accommodate the modifications. A new (proposed) Sterile Corridor would encapsulate the existing structure, thus providing a new exterior skin that would be designed to meet current wind load requirements. It is anticipated that all wall and roof components would be specified to meet FM Global wind loading requirements and impact resistant glazing would be incorporated to further protect primary operation areas.

As is the case in any retrofit (renovate) project, the analysis would begin with a complete assessment of the existing structural system to determine existing capacity to resist wind loads. Once a baseline is established, the engineering firm would determine if additional bracing would be needed to upgrade the existing structure to present code requirements and/or to allow for further expansion of the facility. Any new bracing components would be located within the new expansion areas wherever possible, to minimize work inside the building.

3.4.2.2 Terminal C North Ramp Control Tower

An existing Ramp Control Tower (RCT) is located on the far north end of the Terminal C North concourse. The RCT is a multistory ancillary building located above Level 2 shown in **Figure 3.35**. The purpose of the RCT is to authorize aircraft operations in the non-movement (taxilanes/aircraft parking apron/ramp/hardstand) area for Terminal C North and Terminal D. The RCT provides clearance to pilots and ground handlers to push aircraft back from the gate for departure and assure unobstructed access to park at a gate for arrivals. North of Terminal C North and Terminal D, past the Vehicle Service Road (VSR) is the boundary between the non-movement area and the movement area. Aircraft and vehicles contact ground controllers located in the IAH Air Traffic Control Tower when requesting access into the movement area. The movement area consists of the taxiway and runway system.

3.4.3 TERMINAL LINK STATION C

Passengers in Terminal C can connect to stations at Terminals A, B, and D (with its connecting corridor to Terminal E) via the Airport's Terminal Link Station located between the Central Building and the North Concourse Building. The station is accessed via the secure corridor bridge that links the North Concourse to the Central Building. The station itself spans North Terminal Road and is sufficiently elevated to allow the concourse bridges to pass under the elevated guideway structure. An elevator, escalators, and stairs connect the station to the secure corridor.

3.4.4 PASSENGER CIRCULATION

Enplaning passengers entering the terminal from the below grade level (if using the ITT system for access from other terminals or the hotel) proceed up the central elevator/escalator core to the Ticketing Lobby at Level 2. Those arriving from the enplaning road system enter the Level 2 Ticketing Lobby directly.

Passengers driving and parking in the adjacent west garage enter at grade through Level 1 and up the centrally located elevator/escalator to Level 2. Alternately, they may enter via bridge links to the Mezzanine (Level 3), and go down via stairs or elevators to ticketing on Level 2. Completing check-in procedures at the airline ticket counters, passengers proceed through one of two security screening checkpoints to a secure corridor extending to the bridges connecting to the concourse buildings. At the north bridge, elevator and escalators provide access to the Terminal Link system for passengers connecting with flights in other terminals.

Once in the concourse buildings, passengers may patronize food and merchandise facilities available near the concourse entries or proceed directly to their holdroom in one of the three concourse legs of each concourse. In the North Concourse Building, passengers may also connect with Terminal D, at its connection with the eastern concourse leg. Similarly passengers may proceed to the eastern leg of the South Concourse Building to connect with the domestic and international operations of United Airlines in Terminal E.

Deplaning passengers proceed from the concourse buildings to the Central Building using the same bridges and secure corridor systems used by enplaning passengers. Once in Level 2 of the Central Building, passengers may transfer to other terminals via the Terminal Link accessed at the north secure corridor bridge.

Passengers terminating in Houston enter the Central Building and descend on dedicated escalators connecting directly to the Level 1 baggage claim area below. Alternately, they may exit the secure corridor into the ticketing lobby and circulate down to the baggage claim area using the central elevator/escalator core. Passengers may also utilize a bridge connection linking the western end of Terminal E to the Terminal C East Garage at Level 3 and from there connect via the non-secure mezzanine bridge to the Central Building of Terminal C.

Having claimed their baggage, deplaning passengers may exit the Central Building in one of four ways: (1) proceed directly to the deplaning roadways with private car pick-up on the north and taxi and rental car pickup to the south, (2) proceed to the center of the west side of the building for access to the adjacent garage structure at grade level, or (3) ascend the central elevator core of the building accessing the mezzanine level bridge connections to adjacent parking structures or to the rooftop parking levels, (4) descend to Level LL1 for access to the Inter-Terminal people-mover system.

Terminal C also accommodates large United Airlines Club Lounges (in both the North and South Concourses) and ancillary customer facilities for young travelers, a chapel, and a nursery in the South Concourse.

3.4.5 BAGGAGE CIRCULATION

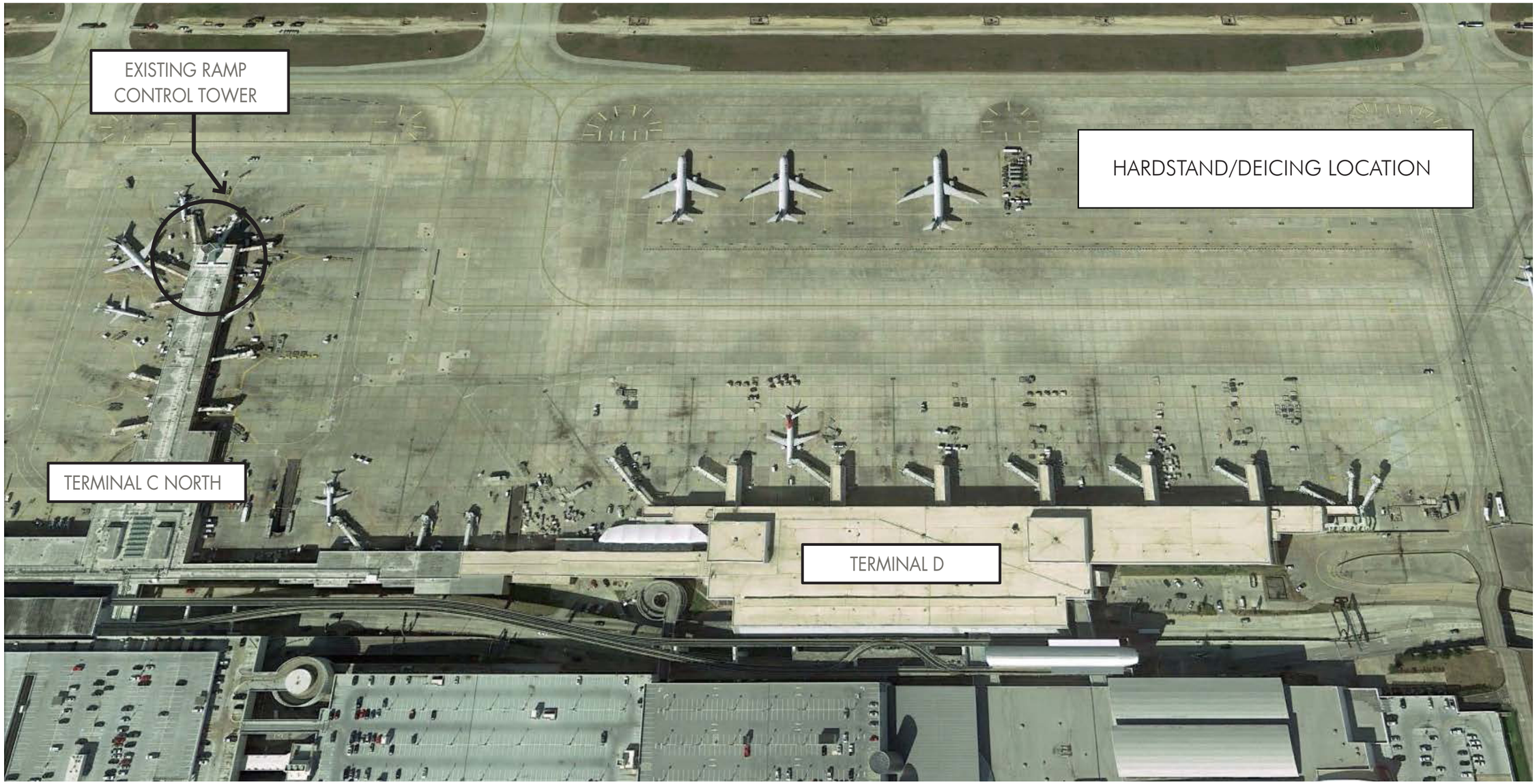
All enplaning and deplaning baggage is carried by conveyor systems to the baggage handling areas in Level 1 of the adjacent and contiguous parking garage east of the Central Building. Enplaning baggage is first checked in at the ticketing/check-in counters on Level 2 of the Central Building where it is tagged and then moved via conveyors under the Level 2 enplaning roadway to rise again into the Transportation Security Administration (TSA) screening located on Level 2 of the adjacent parking structure. Screened baggage is transferred by conveyor to United's bag sorting area on Level 1 of the parking structure. Once sorted, baggage is transferred to aircraft on the north and south concourse airsides by baggage carts towed by tugs through the tunnels at the northeast and southeast ends of the Central Building. Deplaning baggage is brought to the same baggage handling area by baggage tugs through the same tunnels into the bag sorting area. Once sorted, baggage is either transferred to connecting flights or deposited on conveyors that are directly connected to the respective baggage claim devices located on Level 1 of the Central Building.

3.4.6 TERMINAL MECHANICAL/ELECTRICAL/PLUMBING (MEP) SYSTEMS

The existing conditions of the utilities system serving Terminal C have been documented in The Terminal C Condition Assessment by the Burns & McDonnell Team in April 2014. The mentioned assessment showed that the majority of the systems have 10 plus years of remaining life. It is anticipated that most, if not all, of the systems will need to be replaced if the building is renovated.

A Main Mechanical Room is located at the ITT Level of the Central Building of the terminal. This room accommodates air handler units, hydronic pumps for the cooling and heating water, heat exchangers, air compressor, domestic

Existing Ramp Control Tower



water heaters, domestic water booster pumps, a domestic water storage tank tied to the main water line and distributed to the entire Terminal C including Terminal C North. A pair of 14 inch chilled water lines and 10 inch hot water lines from the main mechanical room provide service to Terminal C North.

3.4.6.1 Chilled Water

Terminal C, along with the other IAH terminals, receives its chilled water directly from the airport Central Plant distribution system located to the northwest of the Terminal C ITT Lobby. Water is treated at the plant and sent through the distribution system at a temperature of 40 degrees Fahrenheit. The water travels along the main distribution header, delivers the chilled water into Terminal C via a 24 inch line, exits through a 24 inch line back into the main distribution header, and returns to the Central Plant. Terminal C has three 3,470 gpm horizontal split case pumps located on the Basement Level in the main mechanical room. The pumps were installed in 2002 and appear to be in good condition. The chilled water pumps were originally installed with coyote drives and have since been replaced with variable frequency drives (VFD). These pumps provide chilled water circulation throughout Terminal C. No major discrepancies were noted by building maintenance staff and all observed piping and insulation systems for chilled water appear to be in good condition. Refer to **Figure 3.36** and **Figure 3.37** for existing Terminal C North Chilled Water Flow Diagrams.

3.4.6.2 Hot Water System

Hot water for Terminal C is supplied by three hot water heat exchangers located on the Basement Level in the Main Mechanical Room. Airport high temperature hot water is brought to the shell and tube heat exchangers and heat is transferred to the closed-loop building hot water system. Three building hot water pumps (1,250 gpm each) circulate the water through the building air handlers and terminal units. Refer to **Figure 3.38** and **Figure 3.39** for existing Terminal C North Hot Water Flow Diagrams

As of March 2014 it was noted that all three high temperature hot water control valves in the mechanical room's hot water system needed repair. Two were observed leaking at the valve packing while the other was out of service. Without proper maintenance to these control valves, the mechanical room will be unable to supply high temperature hot water to heat exchangers and subsequently the Terminal C space heating load will not be serviceable.

3.4.6.3 Temperature Control

Building temperature controls for all terminals and the Central Plant at the airport currently use or will soon use Allerton field controllers supervised from a common operator interface maintained by OpenTech Controls Inc. The system is fully BACnet compliant. OpenTech is currently updating the operator interface software for the Central Plant controls to URVIEW supplied by Tridium which will provide enhanced programming and control features. This frontend is intended to be extended in the future to the rest of the airport systems and will be used on new or renovation projects.

The temperature control systems have capability for temperature setback and time of day scheduling of equipment operation but this has not been implemented.

3.4.6.4 Air Handling Units

Terminal C North contains a mix of dedicated outside air units, dual duct variable air volume (VAV) air handling units, and constant and variable volume multi-zone units with a hot and cold deck/duct connection. These units supply air to the majority of the building. Most of the air handling units at Terminal C North are located in two mechanical rooms at the Apron level. Dedicated outside air pretreatment air handling units are also provided in these mechanical rooms. Fan coil units provide service to smaller areas. Exhaust fans are curb mounted on the roof.

In general, the units are in fair to good condition and most of them are within 10 to 15 years of useful life, assuming a maintenance plan is implemented to avoid further deterioration and extend their life. Refer to **Figure 3.40** and **Figure 3.41** for existing Terminal C North air handling unit location plan.

3.4.6.5 Electrical System

Terminal C North receives 480 V electrical service from switchgear in Terminal C Core and from two pad mounted transformers dedicated to Terminal C North.

The electrical system in Terminal C Core is in relatively poor condition as documented in the Assessment of Electrical Infrastructure report issued by Jacobs in November 2013. Electrical feeders were replaced in 2002 but most of the original electrical panels and switchgear installed in 1978 are still in service. Of the approximately 200 electrical equipment items in Terminal C North, almost half have exceeded their expected life. Where original manufacturer breakers are no longer available, substitute breakers have been installed which do not allow for complete closure of the panel dead-front enclosure. Refer to **Figure 3.42** for Terminal C Core electrical one line diagram.

A 750 kVA 480 V transformer and a 3,000 kVA 4.16 kV transformer provide additional power to Terminal C North. These transformers are served from CenterPoint transfer switches that allow service to be manually transferred between two 12.47 kV primary feeders. Automatic transfer on loss of one source of primary power has not been provided.

The Terminal C North electrical system utilizes a radial distribution configuration. This design consists of single feeders from switchgear to switchboards in lieu of redundant feeders and tie breakers needed to provide high reliability. Refer to **Figure 3.43** for Terminal C North electrical one line diagram.

3.4.6.6 Standby Power Distribution

An emergency generator serving Terminal C North provides power for life safety systems in event of an interruption of main power from CenterPoint.

3.4.6.7 Lighting

The majority of the lighting in Terminal C is in the process of being upgraded by the maintenance staff. Rooms still contain older T-12 fluorescent lamps and ballasts that are inefficient. According to the Terminal C condition assessment by Burns & McDonnell, most of the linear fluorescent lighting fixtures have T8 lamps in the public spaces. There are also recessed can down-lights along the concourse. Lighting in mechanical and electrical rooms consists of T12 and T8 Strip fixtures. Maintenance personnel have been replacing the T12 fixtures with fluorescent T8 fixtures. Only a few of the T12 fixtures remain. It was reported that plans were in place to upgrade the remaining T12 fixtures with new fluorescent T8 fixtures. Lighting for individual spaces is controlled by local switches.

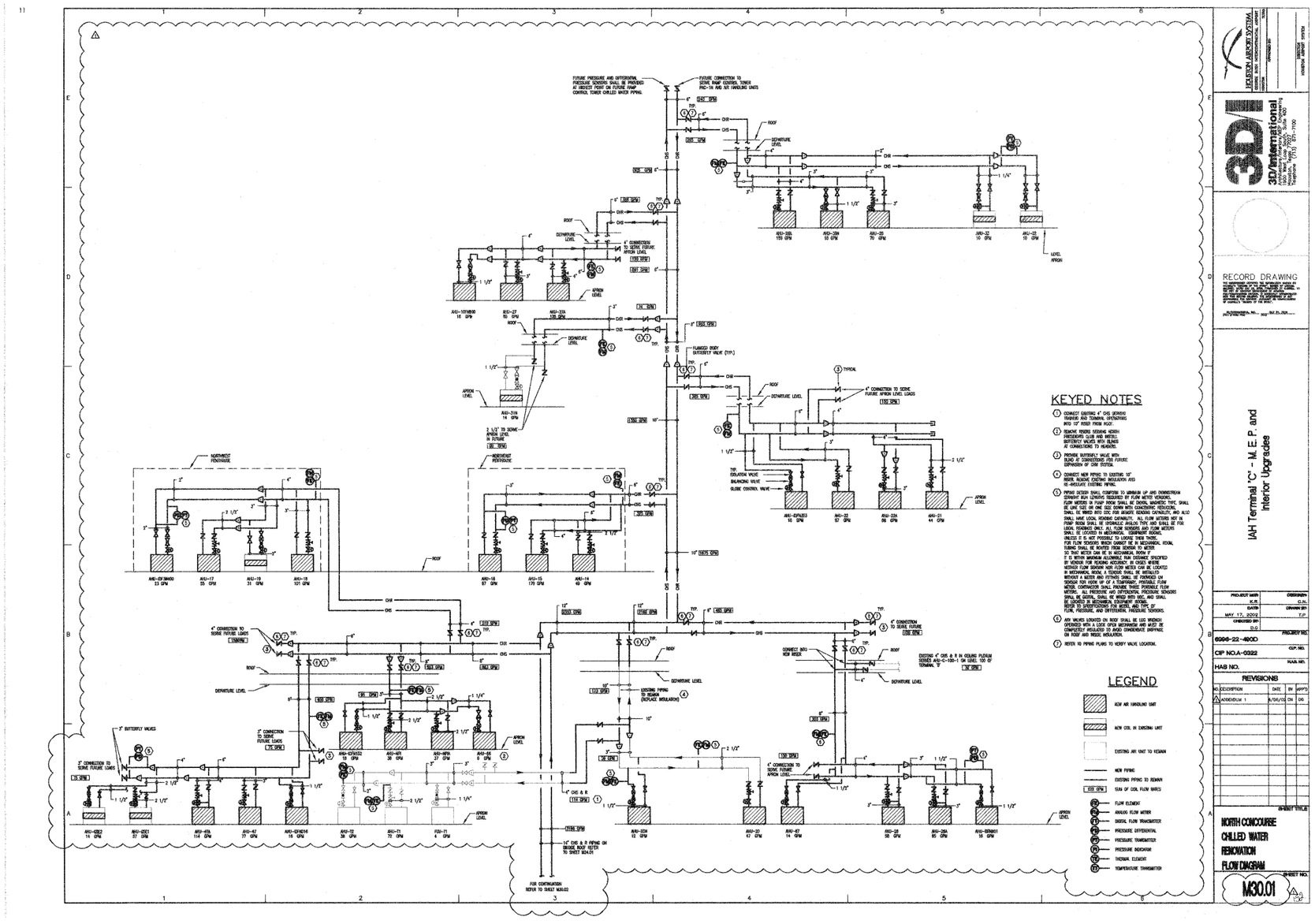
3.4.6.8 Natural Gas

The existing Terminal C North structure is served with a 2 inch natural gas line. The natural gas meter/regulator is located on the landside, adjacent to the Terminal C building face, to the west of the main entrance. CenterPoint Energy owns the service pipe in North Terminal Road up to and including the gas meter. The service pipe is plastic. Line pressure is between 30 psig and 40 psig. Service pressure downstream of the meter is to be confirmed at 2 psig or 5 psig with CenterPoint Energy. Natural gas is primarily used for cooking appliances at food concessions. Of the natural gas piping that was surveyed, that on the roof specifically was found to be severely rusted and corroded per the Condition Assessment report by Burns & McDonnell.

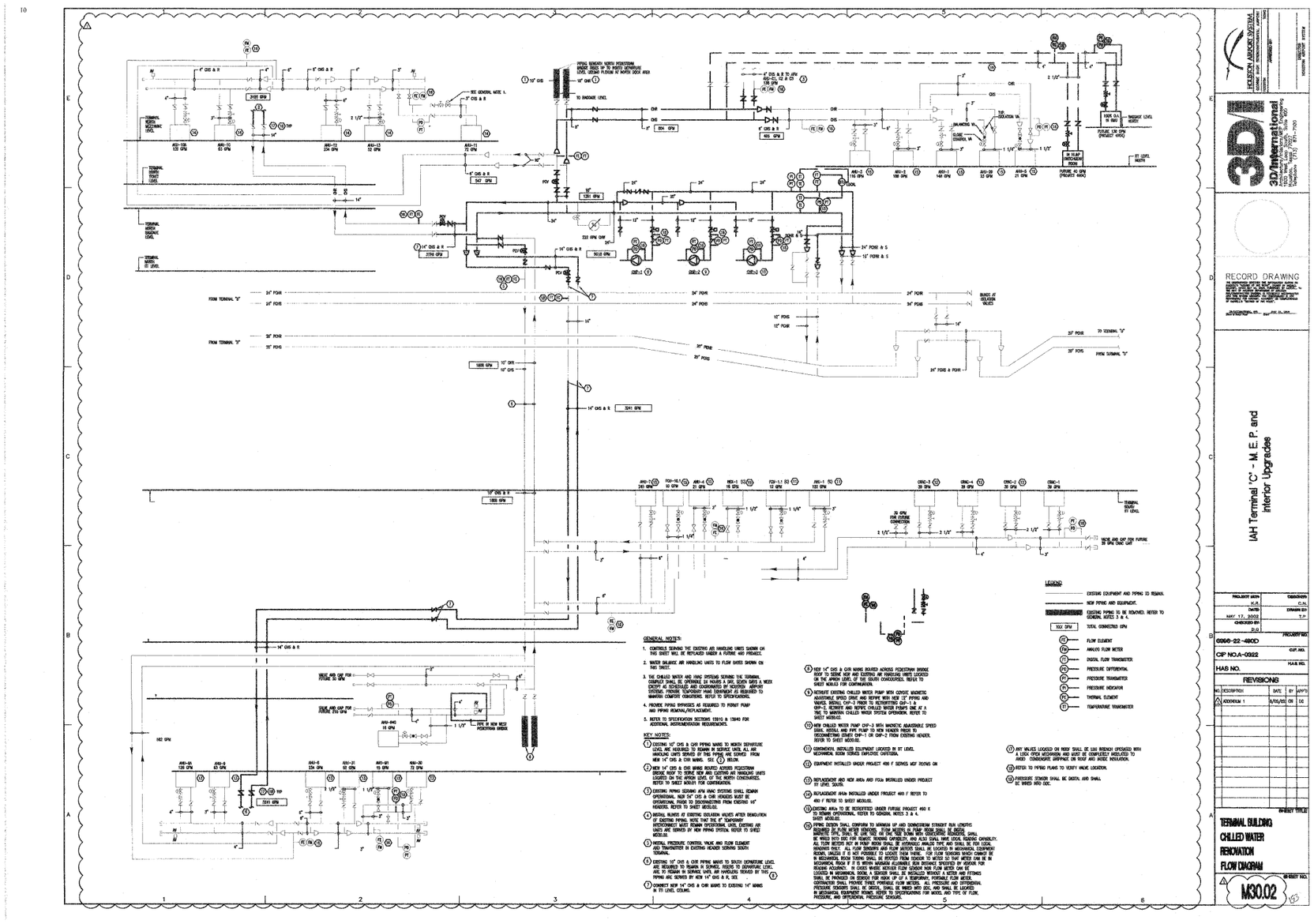
3.4.6.9 Fire Suppression and Life Safety

Unlike Terminal D, no fire sprinkler protection system is installed in Terminal C. Evidence of a stand pipe system was observed on the airside, located just west of the C Pier, which included a single hose cabinet, with a 1 1/2 inch hose, 100 feet in length. The cabinet pressure gage indicated 180 psig static pressure. A 6 inch line provides

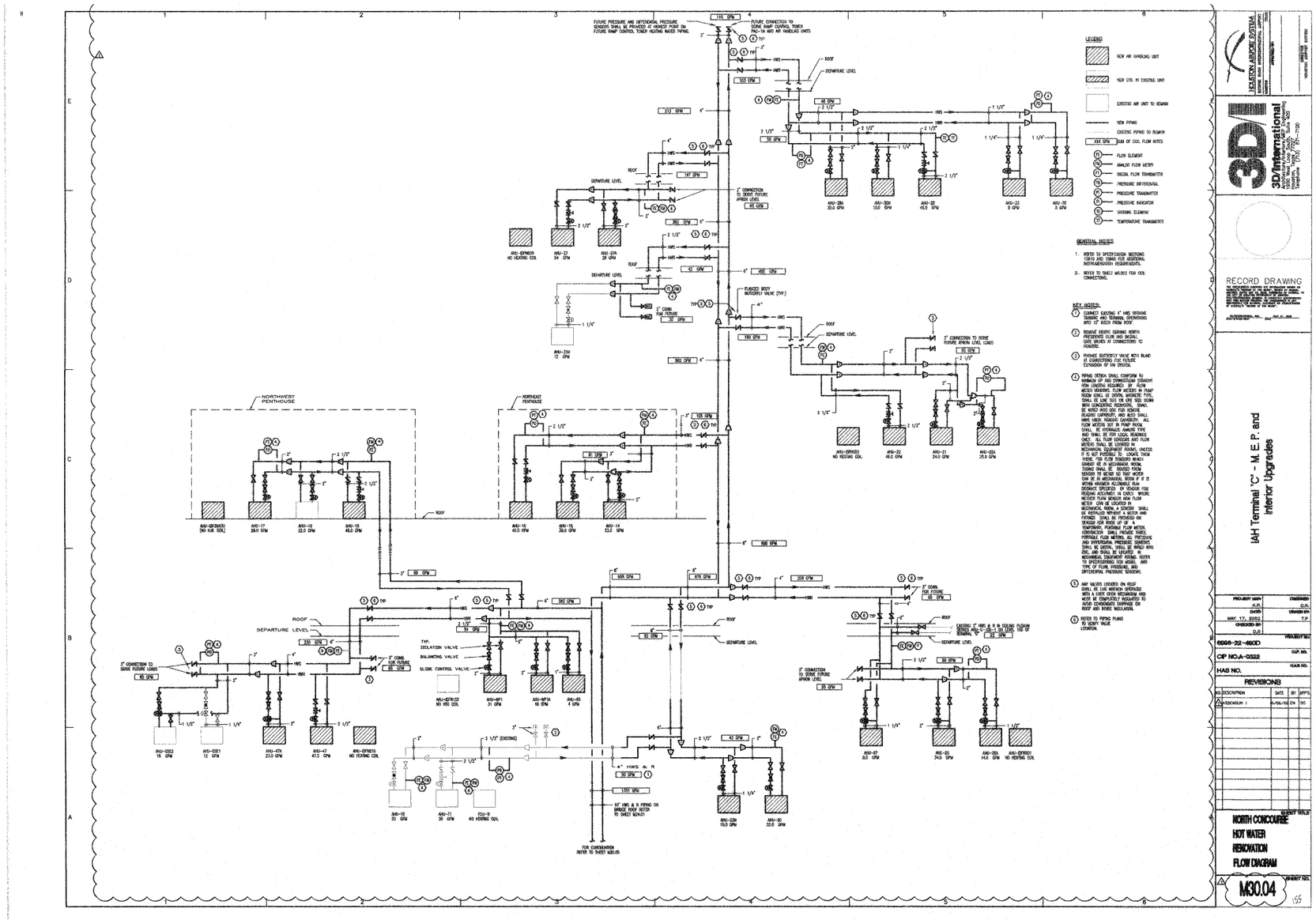
Terminal C - North Chilled Water Flow Diagram



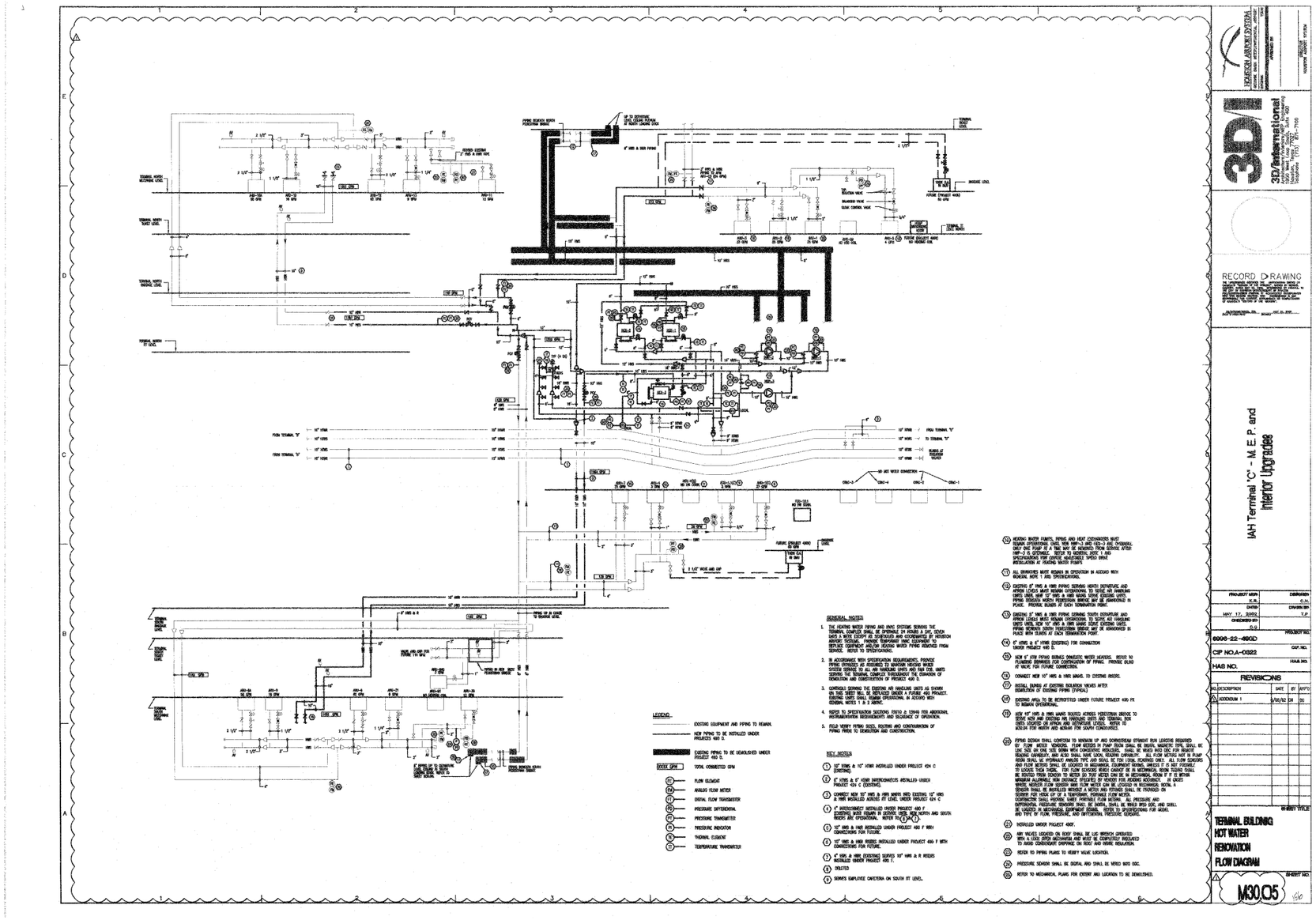
Terminal C - Building Chilled Water Flow Diagram



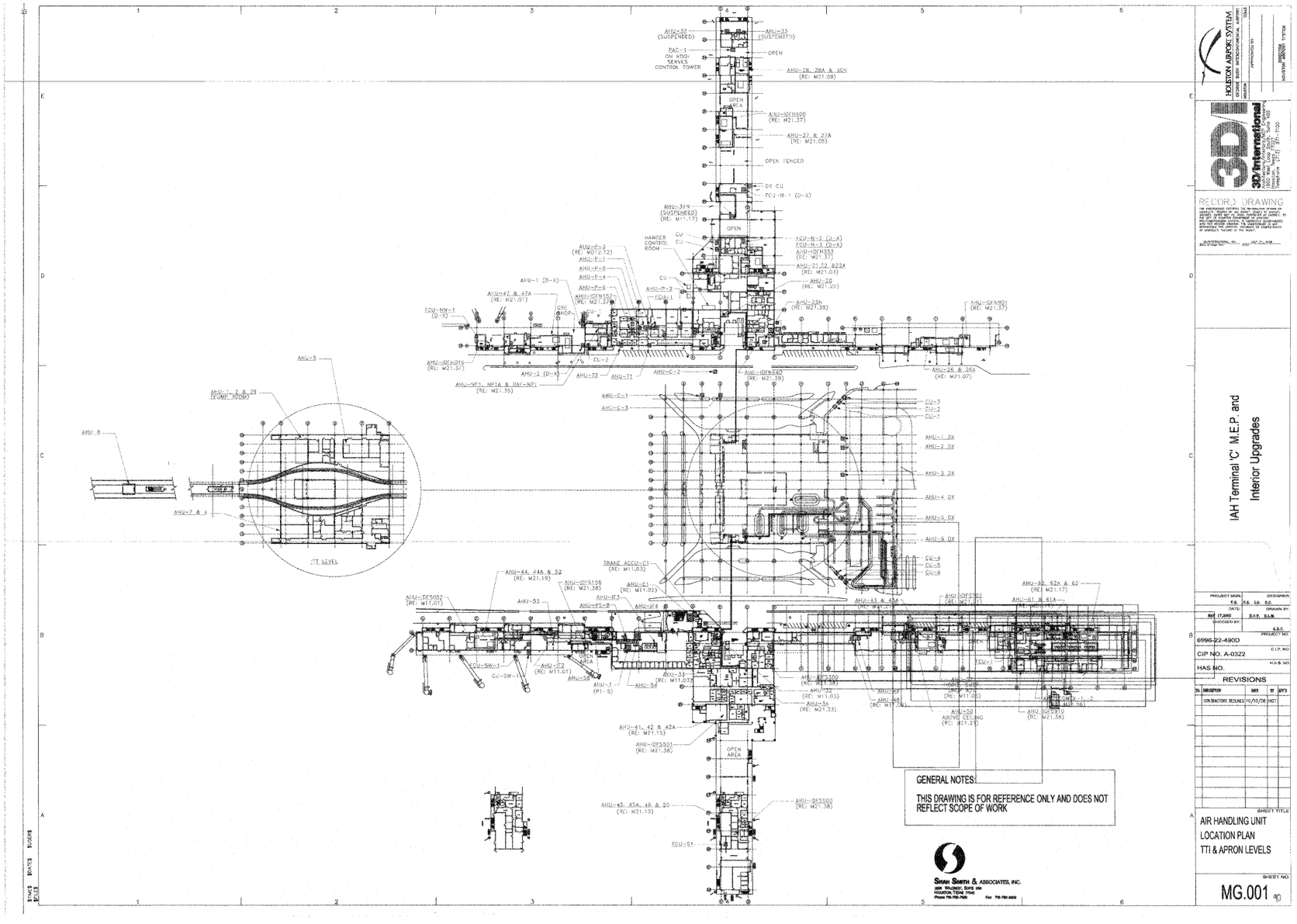
Terminal C - North Hot Water Flow Diagram



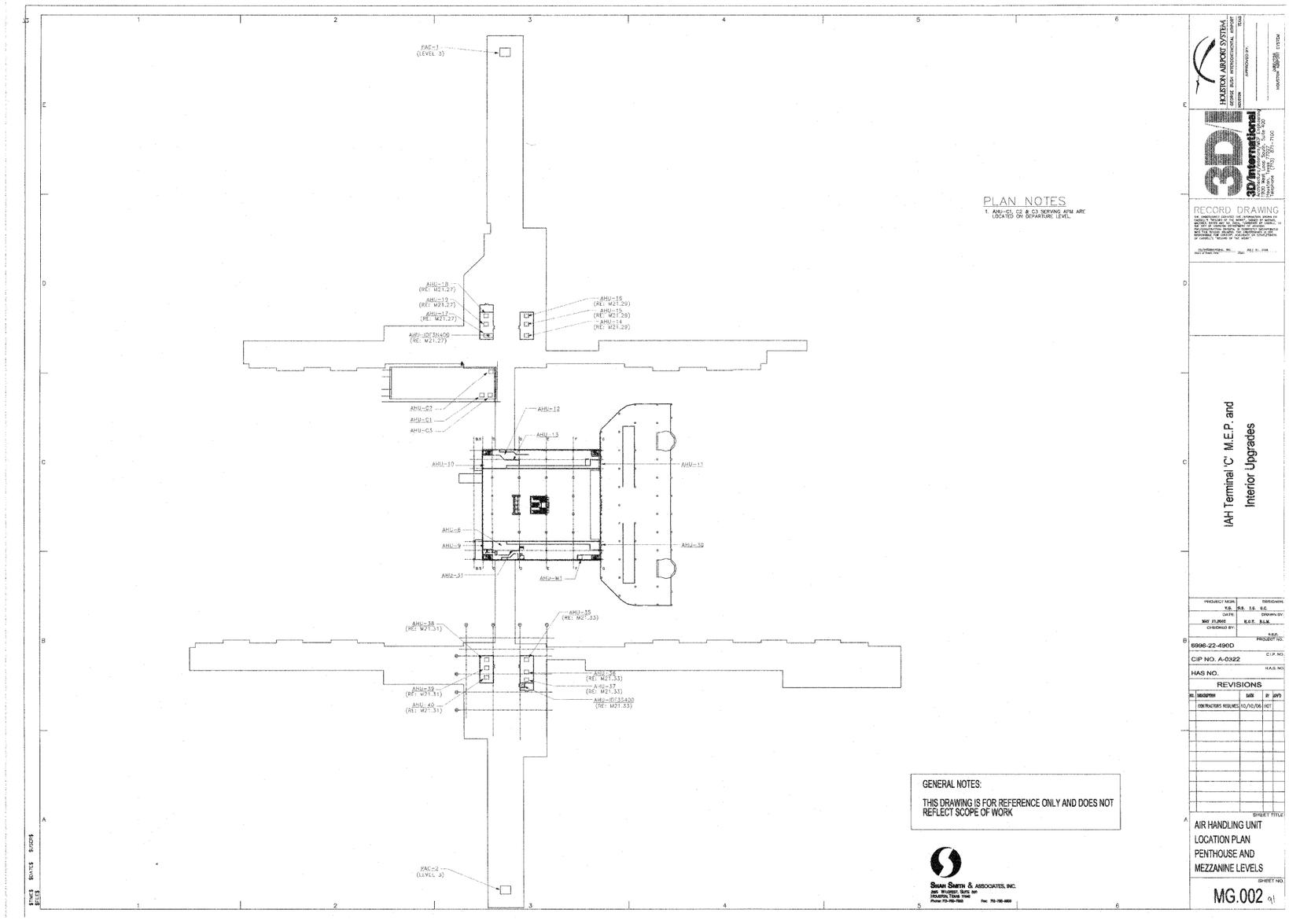
Terminal C - Building Hot Water Flow Diagram



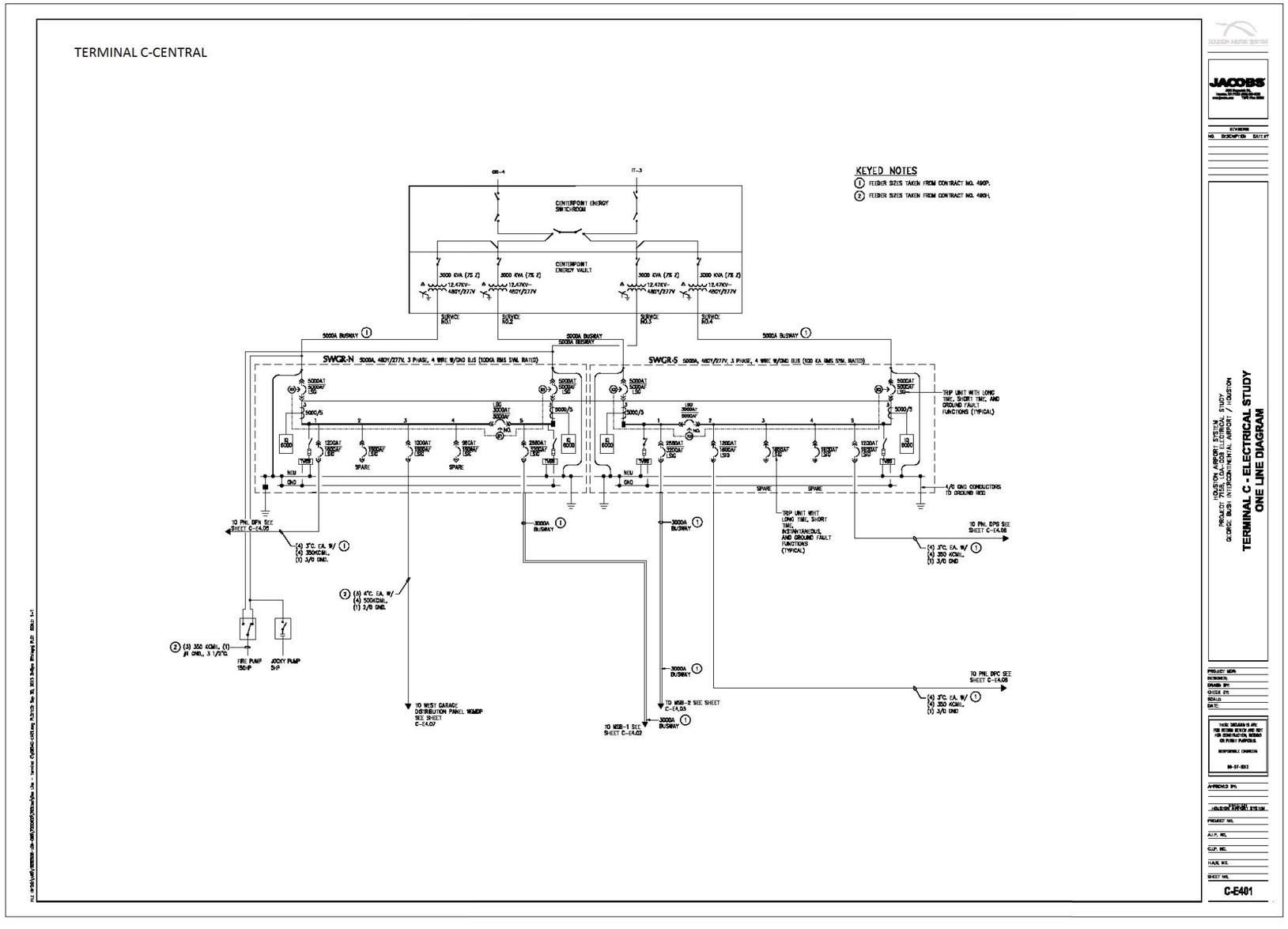
ITT & Apron Levels - AHU Location Plan



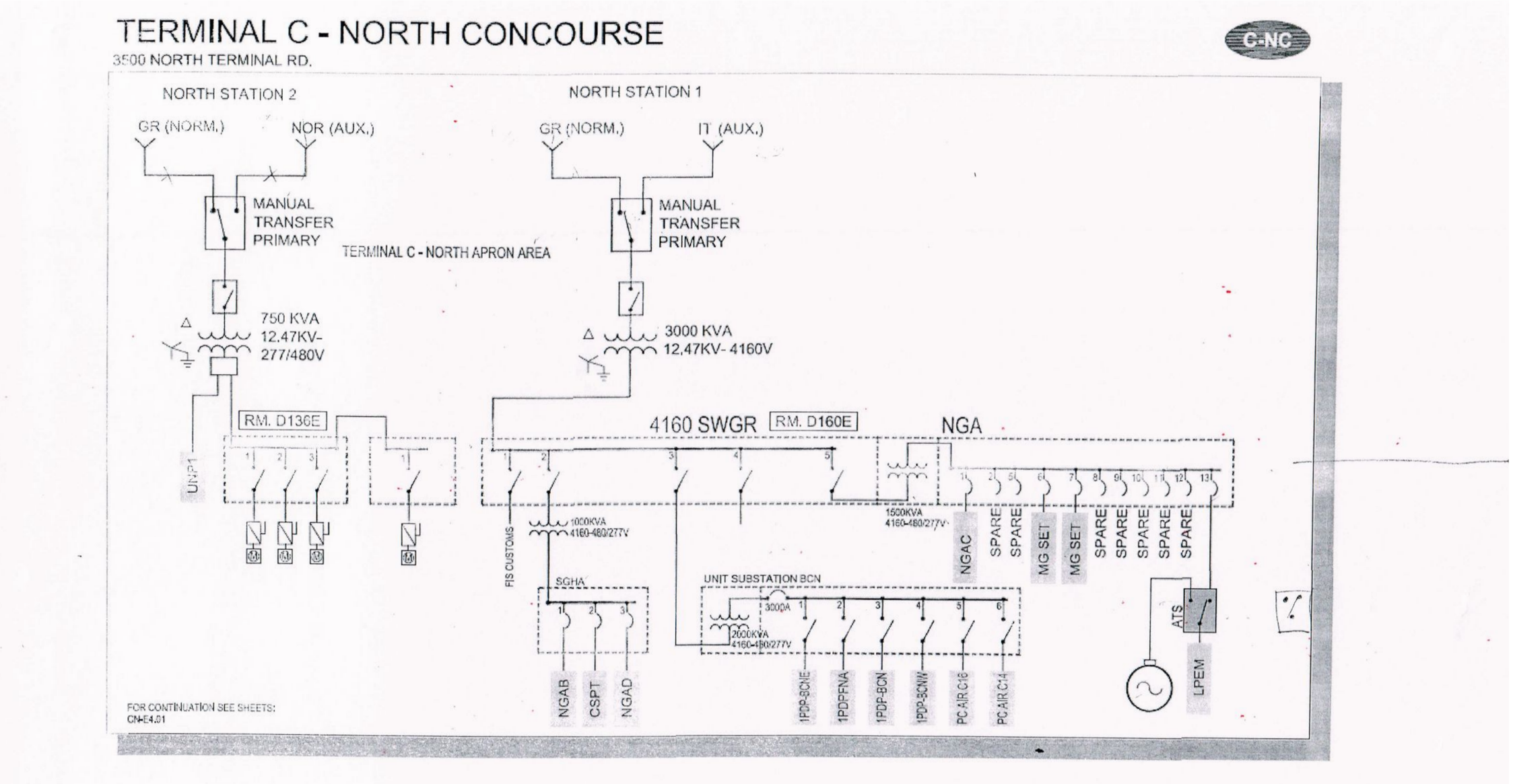
Penthouse and Mezzanine Levels - AHU Location Plan



Terminal C - Central Electrical One Line Diagram



Terminal C - North Electrical One Line Diagram



the existing Terminal C water supply. The 6 inch line branches from the existing 12 inch ductile iron water line loop located at the North Terminal Road, just south of Terminal C. The existing 12 inch line serves the fire hydrants located landside, along the sidewalk in front of Terminal C.

3.4.6.10 Dewatering System

No dewatering system was observed at Terminal C.

3.4.6.11 Life Safety System

The life safety systems are operational and are currently code compliant. There are no known deficiencies within the life safety systems in Terminal C. The current life safety system code requirements are grandfathered in for the Terminal C area. Any future upgrades to the system will require the system to be brought up to full code compliance.

3.4.6.12 Information Technology

The existing Terminal C Information Technology (IT) system is set up similar to Terminal D's, in the sense that the IDF rooms are fed from traditional "Hub and Spoke" arrangement. However the key differentiator is that the central MDF is located in Terminal C Core, and a Building Distribution Frame (BDF) exists in Terminal C North feeding the IDF spokes via fiber optic and copper connections. In addition to the IT infrastructure for the existing Terminal C North, it also houses the IT infrastructure for the existing Terminal C South and the Terminal C Core. The main airport fiber optic (FO) loop also utilizes the Terminal C MDF as a go-between when routed between terminals and other ancillary buildings, which means that almost all airport-wide FO pathways land on Terminal C, MDF, patch panels, or are routed through Terminal C, MDF raceways.

The majority of the existing IDF rooms are served off of central air systems with some rooms having temperature control and some rooms not having control. Most of the IDF rooms do not have dedicated air handling systems meeting current HAS requirements. See **Figure 3.44** and **Figure 3.45** for locations of existing Terminal C IDF, IT rooms.

The existing access control system uses a distributed architecture consisting of redundant head-end servers with automated fall over, intelligent field panels (IFP), and contactless smart card readers and access media. The existing access control software application is ProWatch by Honeywell. The head end system is currently in place and operates on redundant servers located in the Terminal A MDF.

Communication between head-end and IFPs is via network switches on a secure VLAN across the common HAS LAN.

Standard card readers and access media are iCLASS contactless by HID. HAS utilizes a secure iCLASS Elite key managed by HID to ensure a unique security format. Current iCLASS products in use include model R10 for mullions, R40, RK40 (with keypad) card readers and, 16 k smart card credentials.

Existing distributed video surveillance system architecture utilizes redundant head-end database servers at the Terminal A MDF and Administration Building, with camera servers and storage arrays located in the respective facility (Terminal C) MDF. HAS holds a DVM site license.

3.4.6.13 Building Automation System

The majority of the HVAC units are controlled through the BAS. However, similar units are not all controlled in this way. According to the Burns & McDonnell assessment, the system appears to have multiple sequences and set points for similar types of units. The evaluation also showed that several of the pressure readings displayed within the BAS are not accurate.

In general, the building automation system sensors may need to be calibrated to obtain more truthful information on the reliability of the equipment.

3.5 Airside

The following subsections describe the current gating capabilities at Terminal C North as well as information on aircraft gates, aircraft circulation, ground service vehicle roads, and aircraft specialty services.

3.5.1 GATE LAYOUT

Terminal C North is currently served by 13 aircraft contact parking positions, Gates C14 through C26. These positions allow parking for 13 narrow-body (Group III or smaller) aircraft. In addition, there are three positions capable of accommodating wide-body (Group V) aircraft if operations at adjacent gates are restricted. The aircraft parking at Terminal C North is shown on **Figure 3.46**. A Visual Docking Guidance System (VDGS) provides aircraft with precision parking guidance to the appropriate nose-wheel stop bar at the majority of the gates at Terminal C North.

The Terminal C North apron also shares the off-gate aircraft parking with Terminal D, which is approximately 700 feet north of the Terminal D facility. This area is primarily used for hardstand operations and remain-overnight (RON) aircraft parking. The parking area dimensions are approximately 300 feet (depth) by 1,600 feet (length).

The hardstand can accommodate regional aircraft and wide-body aircraft in various combinations. The existing terminal apron pier is served by a north-south ADG V taxilane to the west along with dual ADG IV and ADG V taxilanes east of the pier also oriented north-south and positioned between Terminal C North and the hardstand parking area.

3.5.2 GATING CAPABILITIES

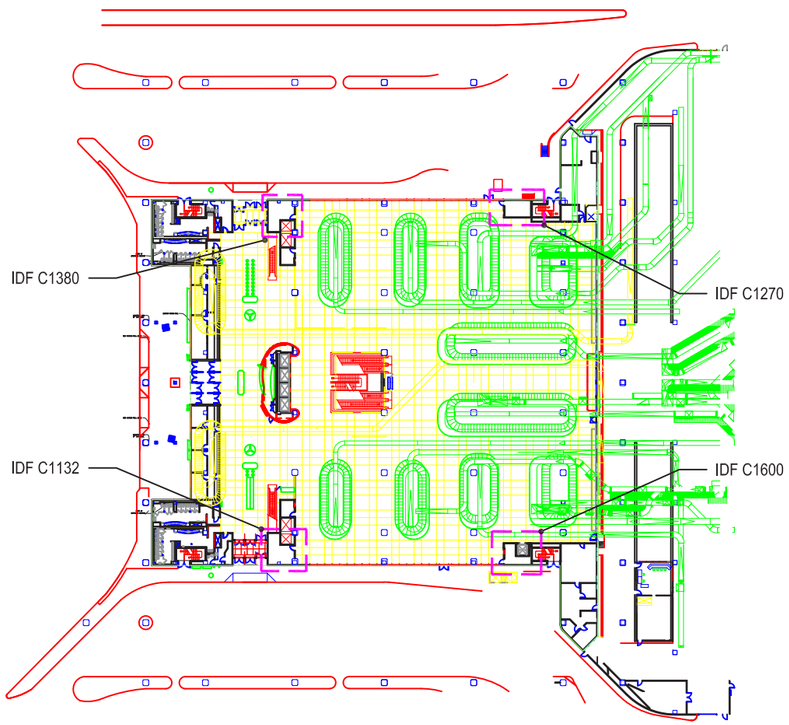
In its current configuration, Terminal C North has a total of 13 United Airlines exclusive use gates (C14-C26). All 13 gates are capable of accommodating narrow-body aircraft, while three gates are capable of accommodating wide-body (ADG V) aircraft if restrictions are in place on adjacent gate usage. Gates C14 and C16 can simultaneously operate wide-body aircraft if Gate C15 is closed, while Gate C19 (using the alternate lead-in line at C19W) can accommodate a wide-body Group V) aircraft if Gate C20 is closed.

The Terminal C North hardstand was developed in 1998 to provide additional aircraft storage and commercial use opportunities. The pavement area can accommodate six ADG V aircraft or various combinations of smaller aircraft. Current hardstand uses include United Airlines international RJs on the west portion of the ramp and large aircraft on the east portion. The hardstand is designed to accommodate as many as seven RJ aircraft and three to four larger aircraft on the east. United Airlines routinely uses the hardstand for ADG III and ADG IV aircraft. The hardstand is also used as a deicing location when needed and a parking location for irregular operations.

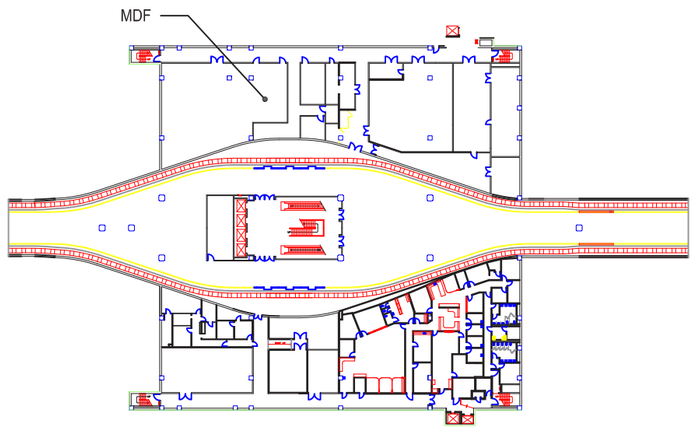
The Terminal C North hardstand has also been used for deplaning large inbound aircraft when necessary. The hardstand is not currently used for enplaning large aircraft since there is sufficient space available at Terminal C North.

Since the Terminal C North gates are common-use gates, each gate is designed to accommodate all certain classes of aircraft so that there is flexibility in assigning gates. Gate classes are defined for Terminal C North to reflect FAA aircraft classifications as described in FAA Advisory Circulars 150/5300-13A, Airport Design. **Table 3.4** summarizes the existing gate capabilities of each of Terminal C North's existing gates. The six aircraft groupings and their associated wingspan ranges are provided for reference below.

Existing Terminal C Core IT



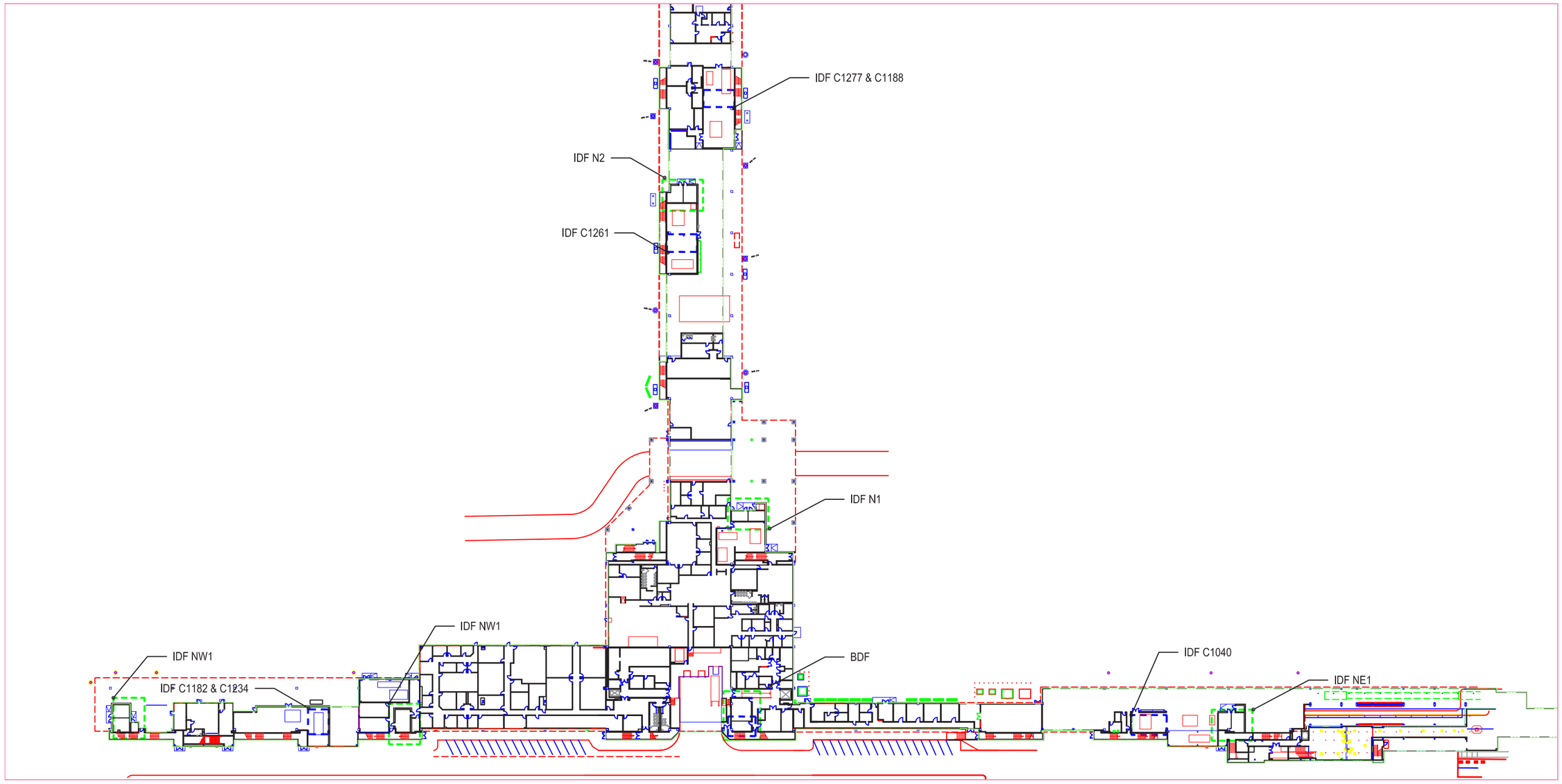
BAGGAGE LEVEL



ITT LEVEL

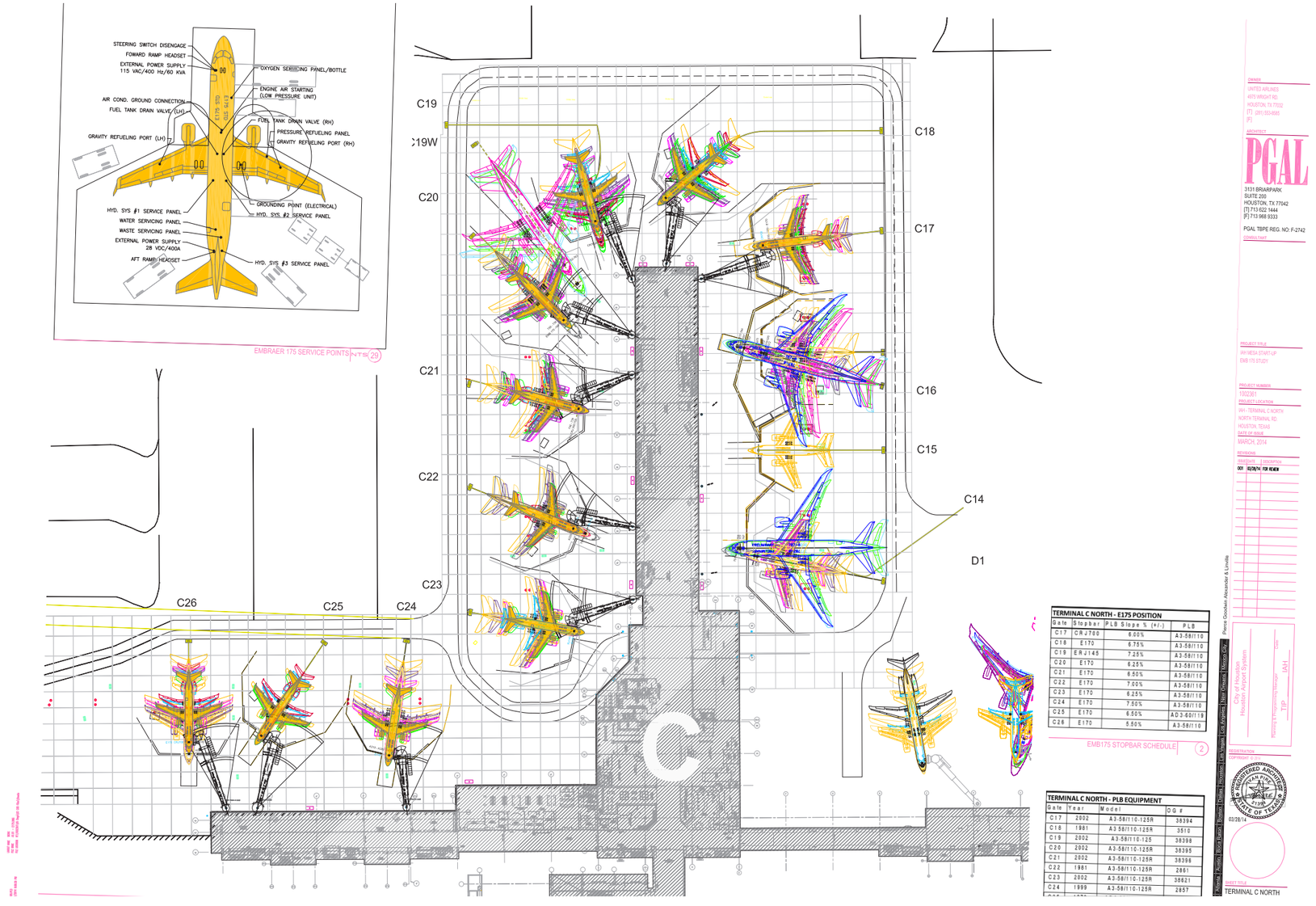
0' 50 100'

Existing Terminal C - North Baggage Level - IT



0′ 50 100′

Terminal C - North Overall Airfield Plan



Drawing Not to Scale

- ADG VI = wingspan of 214 ft up to but not including 262 feet (Airbus A380)
- ADG V = wingspan of 171 ft up to but not including 214 feet (Boeing 777)
- ADG IV = wingspan of 118 ft up to but not including 171 feet (Boeing 757)
- ADG III = wingspan of 79 ft up to but not including 118 feet (Boeing 737)
- ADG II = wingspan of 49 ft up to but not including 79 feet (ERJ-145)
- ADG I = wingspan less than 49 ft (small general aviation aircraft)

Table 3.4 – Existing Terminal C Gate Inventory

GATE	MAXIMUM ADG	REPRESENTATIVE AIRCRAFT	DEPENDENCIES
C14	ADG V	Boeing 777-200	Gate C15 is closed if ADG V is at C14. Maximum independent aircraft is ADG III.
C15	ADG III	Boeing 737-300	Gate C15 is closed if an ADG V aircraft is at either Gate C14 or C16.
C16	ADG V	Boeing 777-200	Gate C15 is closed if Gates C16. Maximum independent aircraft is ADG III.
C17	ADG III	Boeing 737-900	Gate D3 is closed if ADG IV or V is at D2W
C18	ADG III	Boeing 737-900	N/A
C19 (C19W)	ADG V	Boeing 777-200	Gate C20 is closed if an ADG V aircraft is at C19. ADG V parks on alternate lead-in line at Gate C19W. Maximum independent aircraft is ADG III.
C20	ADG III	Boeing 737-900	N/A
C21	ADG III	Boeing 737-900	N/A
C22	ADG IV	Boeing 757-200	N/A
C23	ADG III	Boeing 737-900	N/A
C24	ADG III	Boeing 737-900	N/A
C25	ADG III	Boeing 737-900	N/A
C26	ADG III	Boeing 737-900	N/A

Source: HNTB Corporation

3.5.3 VEHICLE SERVICE ROAD

The Vehicle Service Road (VSR) provides access to the airfield and remote aircraft parking positions for airport service vehicles such as baggage tugs, maintenance vehicles, ground service equipment, operations vehicles, and a large array of aircraft servicing vehicles. The Terminal C North gates are served by a 25 foot VSR aligned at the tail end of parked aircraft parallel and along the entire concourse building pier. The VSR network at Terminal C North links to the adjacent Terminal B to the west and Terminal D to the east. A portion of the VSR is routed under the Terminal C North just south of gates C23 and C14.

3.5.4 APRON UTILITIES

Apron utilities include all of the equipment and infrastructure required to provide power, pre-conditioned air, other utility services for aircraft, and hydrant fueling. Each of the following sub-sections provides details about the existing apron utilities.

3.5.4.1 Aircraft Ground Power Units (GPU)

400 Hz power is located at the ramp level of both the north and south Terminal C Concourse. The centralized systems provide power for the facilities Passenger Boarding Bridges.

3.5.4.2 Aircraft Pre-Conditioned Air (PCA)

Pre-conditioned air (PCA) units for the Passenger Boarding Bridges for Terminal C are point of use packaged units. These are self-contained units that include the compressors, condenser coils and fans, evaporator coils, and blower fan.

3.5.4.3 Passenger Boarding Bridges (PBB)

Passenger Boarding Bridges are also called jetways or loading bridges and are an enclosed connector that extends from the building at an airport terminal gate to an aircraft, allowing passengers to board and disembark without going outside. PBBs are either fixed or movable, swinging radially or extending in length.

Passenger Boarding Bridges include some or all of the following components:

- Building Rotunda with fixed column support.
- Tunnel section including exterior finishes and weather seals, interior finishes, lighting, and ventilation systems.
- Cab (Bubble) Rotunda with service stairs and moveable support column (bogie) with vertical drive system to raise and lower the Rotunda threshold elevation and horizontal drive system to move the PBB to accommodate different aircraft types.
- Bellows adaptor to aircraft.
- Hurricane tie-down anchors.

Power for Passenger Boarding Bridges (PBB) is provided from a 225 amp normal power panel located at each gate. This panel feeds bridge power and air conditioning. The power supply is not adequate for the proposed new passenger boarding bridges and will need to be replaced.

3.5.4.4 Passenger Boarding Bridge Potable Water Cabinets

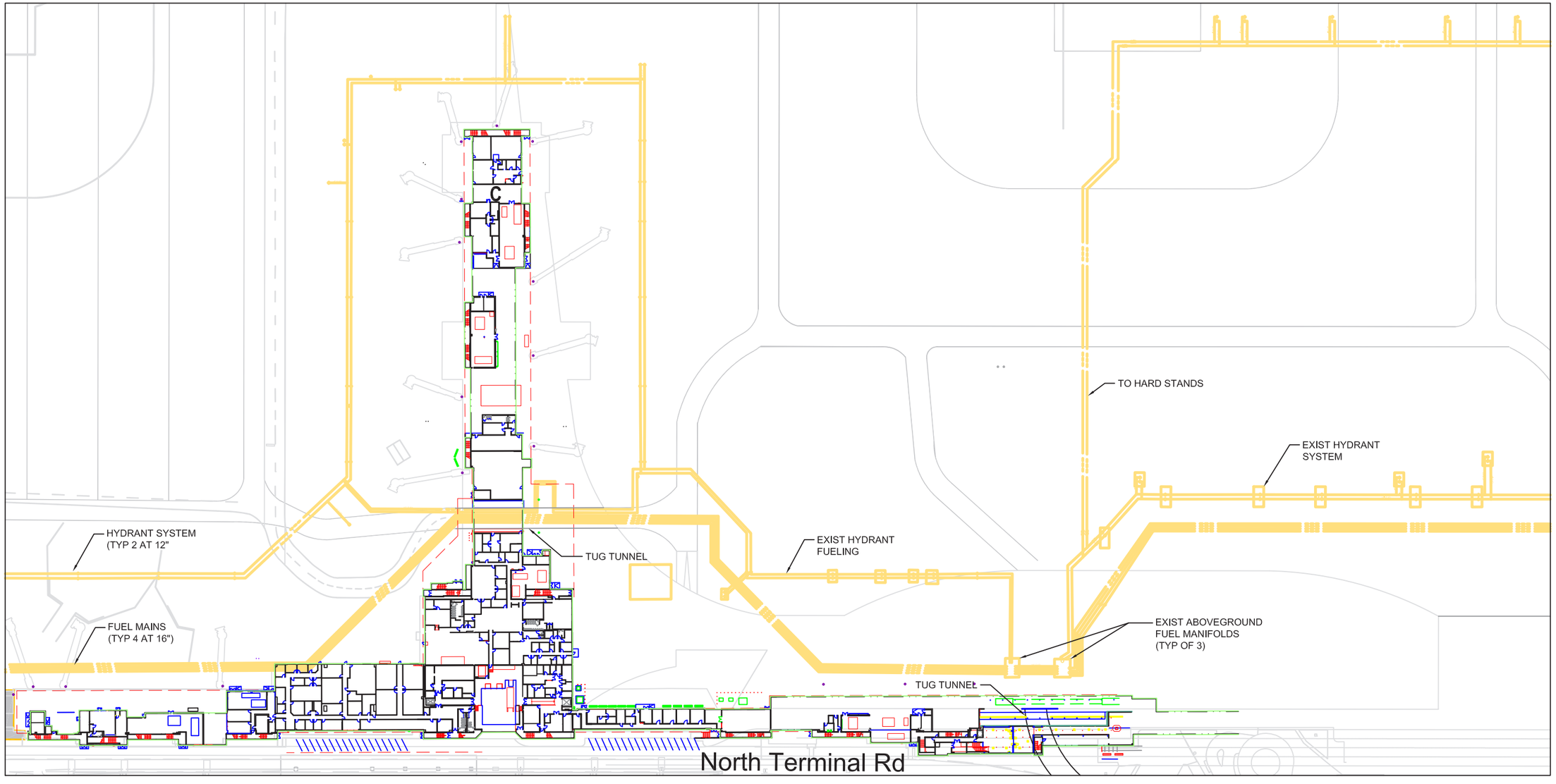
Potable water cabinets exist on each PBB. Potable water systems must be compliant with current regulatory requirements for aircraft service (i.e., EPA, USDA).

3.5.4.5 Hydrant Fueling

The existing hydrant fueling system runs along the north side of Terminal C. It is connected to the fuel farm, located on the west side of the airport, along Aldine-Westfield Road and is operated by a consortium of airlines. Allied Aviation operates and maintains the fuel farm for the consortium. The existing system is shown in **Figure 3.47**. Fuel is supplied to the fuel farm by several pipelines running throughout the area.

Jet-A fuel is pumped throughout the airport by a transmission system that feeds several distribution lines which in turn serve the various hydrants at each parking position. System pressure fluctuates between 180 pound-force per square inch gauge (psig) at the fuel farm and 120 psig at the cargo area. The transmission and distribution system consists of the following elements:

Existing Hydrant Fueling



0′ 125′

- Ten 16 inch fuel lines supply fuel from the fuel farm to the airport. Five run to the north main fuel vault and five lines run to the south main fuel vault. The main fuel vaults are located on the west side of North and South Terminal A.
- The north five 16 inch lines run east, out of the main fuel vault, to airside north and serve Terminals A North, B North and C North.
- The south five 16 inch lines run east, out of the main fuel vault, to airside south and serve Terminals A South, B South and C South.
- The five 16 inch lines reduce to four at the aboveground manifold located east of Terminal B and west of Terminal C.
- Two 16 inch lines continue to the east to serve the cargo facility

The transmission system lines are connected to fuel valve manifolds located above ground at each end of Terminals A & B. Terminal D has three aboveground manifolds; two are located on either side of the tug tunnel and one is located at the east end. Each manifold includes high point vents and low point drains for the fuel mains to allow drain down to the west. The valve manifolds allow for isolation of the fuel mains and the individual hydrant lines. The manifold hydrant lines include motor operated valves, which will shut when an Emergency Fuel Shutoff Valve is pushed. Each hydrant system consists of two 12 inch fuel loops that distribute fuel to hydrant pits located at each aircraft parking position.

The hydrant fuel distribution system includes the fuel pits, high point vents, low point drains, isolation valve vaults, double block and bleed isolation valves, cathodic protection, emergency fuel shut-off (EFSO) and a dedicated drainage system. Each aircraft parking position is served by two hydrant fuel pits. Hydrant fuel carts, with meters and filters, connect to the fuel pits and transfer fuel to the aircraft. All of the fuel pits are plumbed together. The fuel pits are designed to drain into the storm water system and eventually to a lift station vault located on each side of Terminal C. The common drain line is closed off at the last fuel pit prior to the lift station vault. The isolation valve vaults have sump pumps to collect storm water and fuel spills. These vaults are pumped out periodically. Pipeline integrity leak detection is performed at the fuel farm using pressure charts to determine loss of pressure over the system (loss of fuel). There is no separate leak detection system, such as the Hansa Consult type, that is used. Global Cathodic Protection is the current testing firm for the corrosion control system. That system consists of impressed current and sacrificial anode beds located airside near Gate D4 and the west side of Terminal C.

The Emergency Fuel Shutoff (EFSO) system is a safety system to shut off the flow of fuel in case of an emergency. It consists of emergency push buttons at each gate and input/output (I/O) control boards located in two different electrical rooms within Terminal C. In the event of an EFSO activation, all four Motor Operated Valves (MOV), located at each above ground manifold, will close thus stopping the flow of fuel to the hydrants and hardstand system.

Fuel is stored in above ground vertical tanks at the fuel farm. The combined capacity of those tanks is 13 million gallons. The average daily fuel consumption ranges between 1.6 and 1.8 million gallons per day (mgd), according to Allied Aviation The fuel farm has 16 hydrant pumps rated at 1,000 gpm/each and four lead (high pressure) pumps with a flow of 600 gpm/each for a total peak flow rate equal to 18,400 gpm. Each pump has a filter separator sized to match the pump flow. Peak daily demand is 4,500 gpm. Estimated current Terminal C demand is 2,800 gpm for six wide-body and six narrow-body aircraft. The existing hydrant fuel trucks are rated to flow at a maximum of 800 gpm.

3.6 Site Utilities

This section reviews the existing site utilities serving the Terminal C complex. It includes the domestic water supply, sanitary sewer system, storm sewer system, natural gas, and fuel distribution systems that are external to Terminal C.

3.6.1 12.5 kV SITE POWER

The electrical services to the Terminal C Core Building originate at CenterPoint's Vault with two 2,500 kVA 277V/480V transformers and two 277V/480V transformers. One 2,500 kVA transformer supplies SWGR-N Service 3 Main to the 3,000 A busway to MSB-1 and one 3,000 kVA transformer supplies SWGR-N Service 1 Main. The two mains are connected in a Main-Tie-Main configuration. Another 2,500 kVA transformer supplies SWGR-S Service 2 Main to the 3,000 A busway to MSB-2 and one 3,000 kVA transformer supplies SWGR-S Service 4 Main. These two mains are also connected in a Main-Tie-Main configuration. The Main-Tie-Main switchgear includes a kirk key system manual tie and the vault includes an automatic transfer primary control system. The normal configuration is for one primary circuit from one substation to supply power to two transformers, each of which supply one main of SWGR-N and one main of SWGR-S. The other primary circuit from the other substation normally supplies power to two transformers, each of which supply the other main of SWGR-N and the other main of SWGR-S.

The 14 month peak load history from one electrical utility transformer indicates a peak load of 965 kVA or 32% of the transformer rating and 23% of the switchgear rating. The 14 month peak load history from the second electrical utility transformer indicates a peak load of 171 kVA or 7% of the transformer rating and 4% of the switchgear rating. The sum of the two peak loads is 1,136 kVA or 45% of one transformer rating and 27% of the switchgear rating when the switchgear tie breaker is closed and the switchgear is supplied from one of the two redundant transformers. The 14 month peak load history from the third electrical utility transformer indicates a peak load of 419 kVA or 17% of the transformer rating and 10% of the switchgear rating. The 14 month peak load history from the fourth electrical utility transformer indicates a peak load of 1,284 kVA or 43% of the transformer rating and 31% of the switchgear rating. The sum of the two peak loads is 1,703 kVA or 68% of one transformer rating and 41% of the switchgear rating when the switchgear tie breaker is closed and the switchgear is supplied from one of the two redundant transformers.

The Terminal C North Concourse is supplied from both electrical service from the Terminal C Core Building and from supplemental electrical service dedicated to the North Concourse. The supplemental electrical service to the Terminal C North Concourse is a pad-mounted 750 kVA three phase four wire wye 277V/480V electrical service transformer. The 277V/480V pad-mounted transformer is supplied from a CenterPoint manual transfer switch (MTO) allowing the service to transfer between two different 12.47 kV primary circuits. The CenterPoint MTOs operate manually; however, CenterPoint can provide ATOs for automatic operation. The transformer is a radial distribution and supplies two switchboards. The main switchboard is a single main lug only configuration with output fused switches and does not include a dual main or tie breakers.

The 14 month peak load history from the electrical utility transformer indicated a peak load in August 2013 of 207 kVA. The peak load corresponds to 28% of the transformer rating and 21% of the switchboard rating.

The Terminal C North Concourse is also supplied from a second supplemental electrical service with a pad-mounted 3,000 kVA three phase four wire wye 2.4kV/4.16kV electrical service transformer. The 2.4 kV/4.16 kV pad-mounted transformer is supplied from a CenterPoint manual transfer switch (MTO) allowing the service

to transfer between two different 12.47 kV primary circuits. The CenterPoint MTOs operate manually; however, CenterPoint can provide ATOs for automatic operation. The 4,160 V switchgear is a radial supplied main lug only configuration and does not include a dual main or tie breakers. The 4,160 V switchgear also supplies three unit substations rated for 2,000 kVA, 1,500 kVA and 1,000 kVA.

The 14 month peak load history from the electrical utility transformer indicated a peak load in August 2013 of 1,425 kVA. The peak load corresponds to 48% of the transformer rating and 16% of the switchboard rating.

3.6.2 WATER SUPPLY SYSTEM

A 6 inch line provides the existing Terminal C water supply. The 6 inch line branches from the existing 12 inch ductile iron water line loop located at the roadside just south of Terminal C. The existing 12 inch line is expected to provide any additional demand that might be required. Refer to **Figure 3.48**. A network of 2 inch, 1.5 inch, and 3/4 inch water lines serves the environmental inlets on both sides of the existing Terminal C North.

3.6.3 FIRE PROTECTION WATER SUPPLY SYSTEM

A six inch line provides the existing Terminal C water supply. The six inch line branches from the existing 12 inch ductile iron water line loop located at North Terminal Road, just south of Terminal C. The existing 12 inch line serves the fire hydrants located landside, along the sidewalk running south of Terminal C. Refer to **Figure 3.48**.

3.6.4 SANITARY SEWER

The existing building has a complete sanitary waste and vent system at all of the required locations. The existing sanitary waste system is in serious need of repairs in many places throughout the building. A sanitary sewer report prepared by Amani Engineering in June 2010 chronicled the overall condition of the sanitary waste system including the existing grease piping system and existing grease interceptors currently in place. That report confirmed the poor condition of the sanitary system and the need to repair sections of the system.

The existing terminal building has two grease interceptors located outside the building. The main grease trap for the building is located at the east side and the other one is located at the west side of the building.

The existing Terminal C sanitary sewer system is directly connected to the existing 14 inch CI gravity sewer line located to the south of the building and running west. **Figure 3.49** graphically depicts the existing sanitary sewer system.

3.6.5 STORM SEWER SYSTEM

The Terminal C roof drains are collected by a network of RCP storm lines ranging from 12 inches to 30 inches. The system discharges into the three 10 x 5 storm box culverts located just south of taxiway NA.

The Terminal C Apron is served by a contaminated storm water collection system on the west, north, and east sides of the Terminal. This system consists of a slotted drain collection system and a dual conveyance system. A slotted drain intercepts potentially contaminated storm water runoff from the aircraft parking area and diverts it to the environmental station located to the north of Terminal B North where it is segregated for treatment or allowed to bypass and flow into the drainage system. The existing apron drainage and grading is illustrated in **Figure 3.50**.

3.6.6 NATURAL GAS

Terminal C is divided into three main sections: the Central Building (which includes check-in, baggage, and TSA), a north and south building (which houses tenant spaces such as shops, restaurants, etc.), and terminal gates. Each of these buildings has natural gas meters and regulators serving either a tenant space/restaurant or the terminal overall. CenterPoint Energy owns the distribution piping to the meters that serve the terminals. The natural gas distribution line runs north on JFK Boulevard and runs east on South Terminal Road at 4 inches, continues north up to North Terminal Road where it reduces down to a 2 ft line, on the east end of Terminal D. The line continues west to serve Terminal C North and C Core.

3.7 Landside

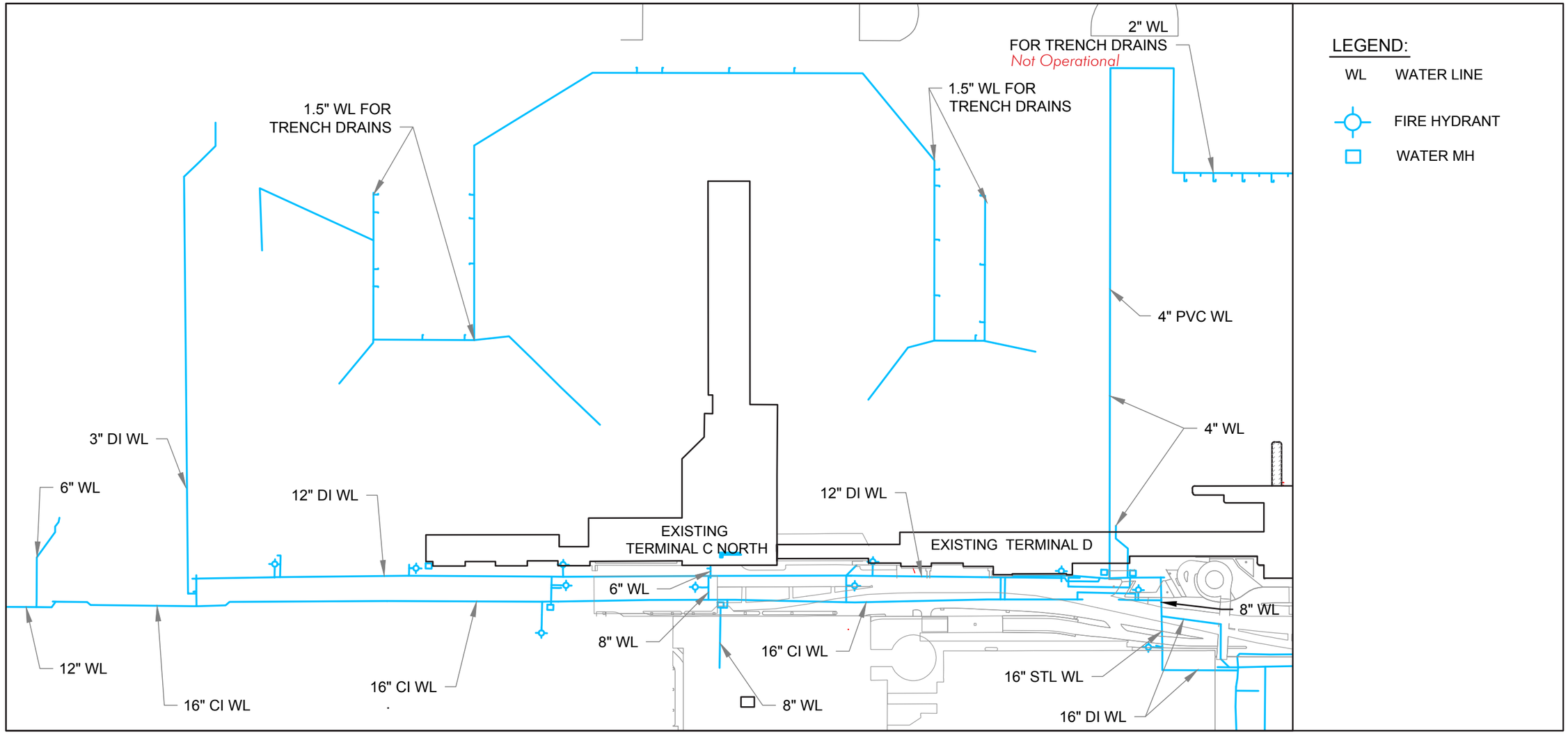
The Terminals C and D landside system consists of the roadways, curbsides, parking, and site utilities that serve Terminals C and D. **Figure 3.51** illustrates the existing Terminals C North and D landside and lane allocations by terminal, through the Terminals C/D/E complex. An overview of landside infrastructure and operations is provided in this section. However, a more detailed comprehensive review and analysis of terminal area landside operations is being prepared as part of the Bush Intercontinental Airport Master Plan Update, currently in development by the LeighFisher consultant team.

3.7.1 ROADWAYS

North Terminal Road provides landside access to Terminal D and is a one-directional roadway running east to west. All landside vehicle traffic can access North Terminal Road via John F. Kennedy Boulevard from the south and via Will Clayton Parkway from the east. Traffic enters the terminal area from the east and Terminal D is accessed from the right lane. However, when entering the terminal area, the Taxiway SF bridge obstructs driver's views of the terminals and curbsides and limits driver's decision distance. Immediately after Taxiway SF the roadway diverges to provide access to Terminal D to the right and Terminals E and C to the left. Past the gore point the one lane serving Terminal D widens to four lanes providing two lanes each to the inner and outer curbs. The inner roadway then widens to three lanes in front of Terminal D providing space for private vehicle passenger drop-off activity. The outer roadway serves commercial vehicle passenger drop-off. The inner curbside roadway also provides access to a helix which connects to the parking garage.

On the left side of the entrance roadway past Taxiway SF three lanes provide access to Terminals E and C with the center lane signed for Terminal C traffic. The right lane is signed for the Terminal E Upper Level Roadway and the left lane for the Terminal E Lower Level Roadway. Once past the Terminal E Upper Level Roadway diverge point, an extra lane on the north side of the roadway is designated for Terminal C traffic providing two Terminal C access lanes bypassing Terminal E. Immediately past the entrance to the Terminal E Lower Level Curbside the left lane provides access to the Terminal C Upper Level Roadway which serves the Ticketing Level of Terminal C. Both lanes also continue to the Terminal C North Lower Level Curbside which accommodates private vehicle passenger pick-up activity serving Terminal C Baggage Claim. Adjacent to the Terminal C North curbside a single lane exiting Terminal D merges back to the main North Terminal Roadway. As the lanes continue past Terminal C two right lanes continue to the Terminal A and B complex while the two left lanes loop around Terminal C providing access to the Terminal C Garage and also allowing vehicles to exit the terminal area or recirculate back to Terminals D, E, or C. This loop also provides access to the Terminal C South curbside.

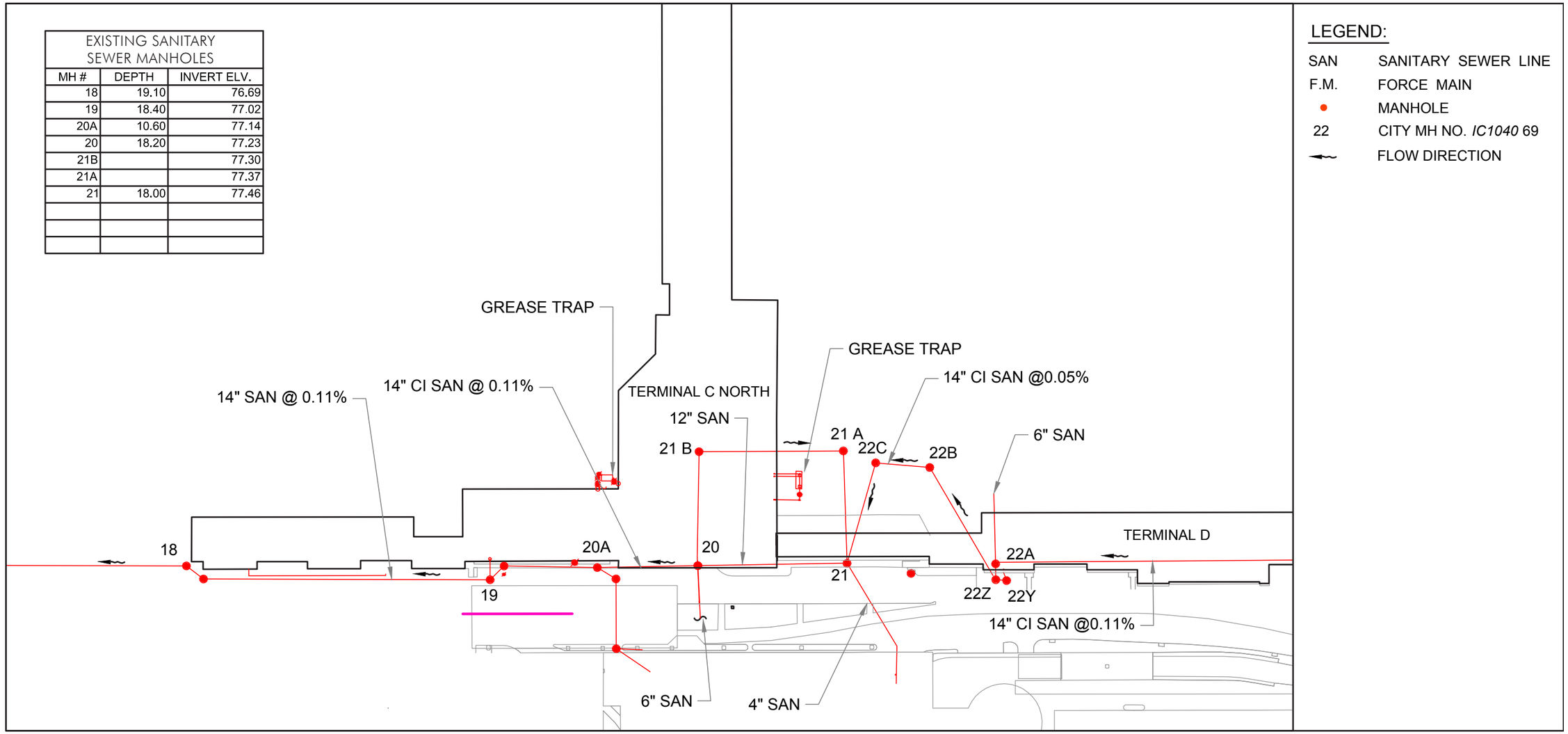
Existing Terminal C - North Water Lines



0′ 100′ 200′

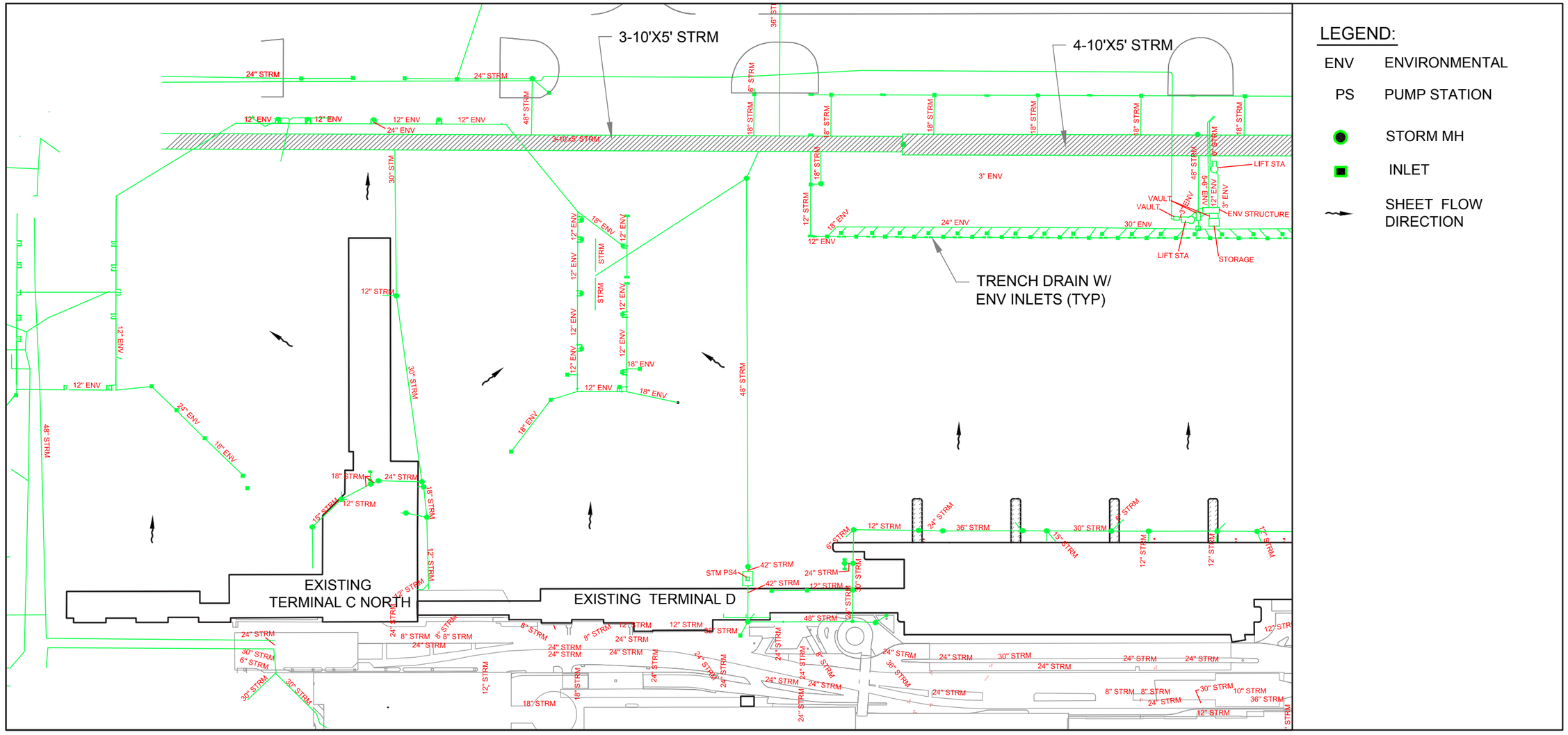
Existing Terminal C - North Sanitary Sewer Lines

EXISTING SANITARY SEWER MANHOLES		
MH #	DEPTH	INVERT ELV.
18	19.10	76.69
19	18.40	77.02
20A	10.60	77.14
20	18.20	77.23
21B		77.30
21A		77.37
21	18.00	77.46



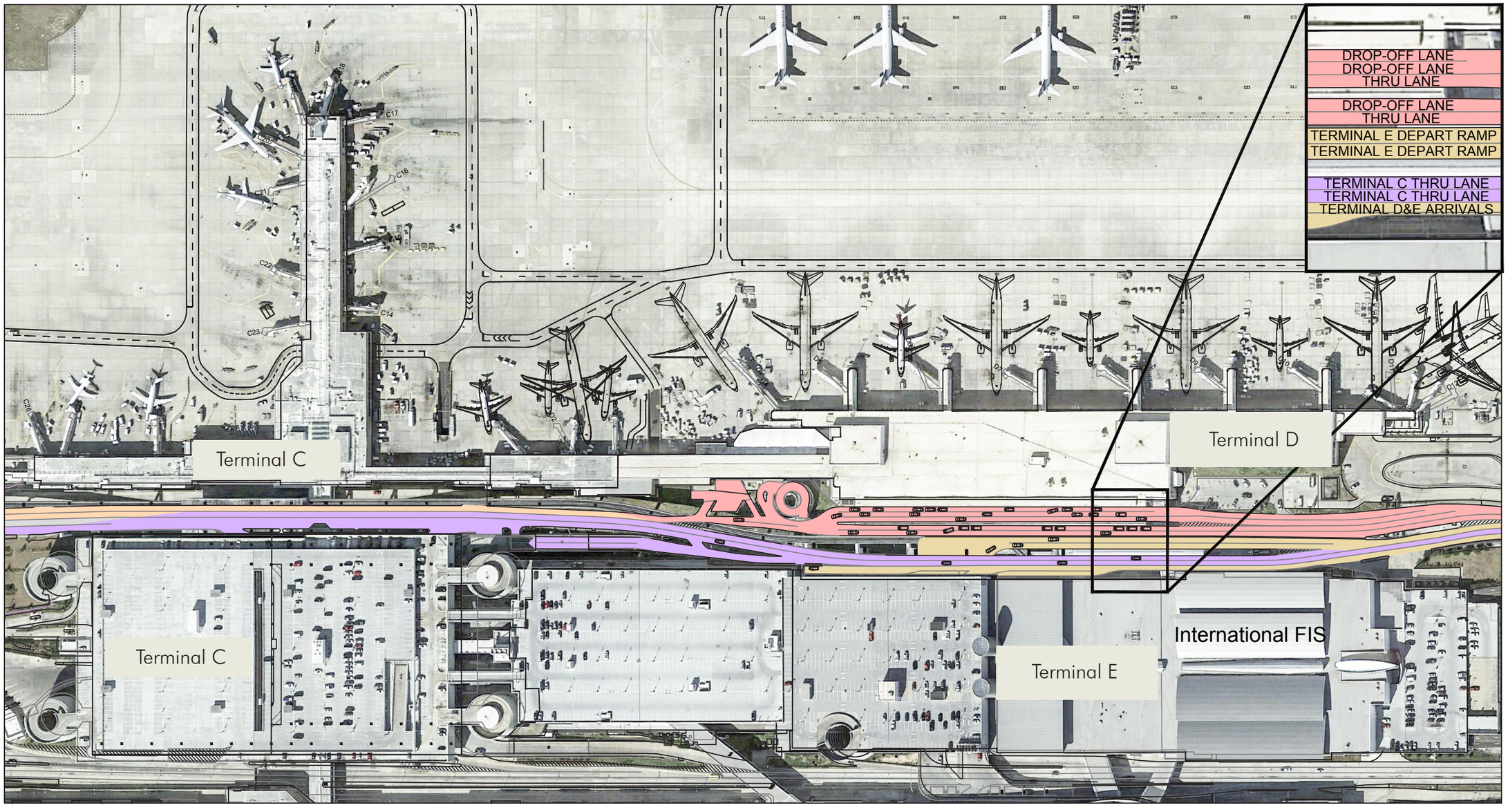
0′ 60′ 120′

Existing Terminal C - North Storm Sewer Lines



0′ 100′ 200′

Existing Roadway Terminal Allocation



0′ 100′ 200′

To recirculate, vehicles exit the terminal area toward Will Clayton Parkway proceeding east to Colonel Fisher Boulevard where vehicles can turn left to access westbound Will Clayton Parkway and the terminal area.

3.7.2 CURBSIDE

Information in this subsection was taken from data generated as part of the IAH Peak Week Study conducted in 2010, information obtained from the Gensler Team Study, and visual observation by the TDMP Team. As noted earlier, the Bush Intercontinental Airport Master Plan Team is currently studying curbside conditions in the terminal area, including Terminals C and D.

Terminal D Curbside

The Terminal D curbside is unique in that it only serves departing international passengers. Arriving international passengers are processed through the CBP and exit via the Terminal E CBP arrivals curb. Any domestic passengers departing from Terminal D are processed through Terminal C.

The existing curbside at Terminal D is single level and at-grade with a three lane 677 foot curbside roadway adjacent to Terminal D serving private vehicle passenger drop-offs and a second 677 foot two lane curbside roadway served by an island curb serving most commercial vehicles. Each lane is 10 feet wide. Private vehicles, limousines, and taxis drop-off passengers on the inner curbside and drop-off in the lane adjacent to the terminal with an effective curb length of approximately 520 feet, adjusting for four pedestrian cross-walks and traffic control where vehicles are not allowed to park. Rental car, parking, and other shuttles use the outer curbside, dropping off in the lane adjacent to the median island with an effective curb length of approximately 577 feet for a total of approximately 1,100 feet of effective curb length at Terminal D.

Peak curbside activity at Terminal D occurs mid-afternoon between 2:00 pm and 4:00 pm with the peak hour, according to the 2010 Peak Week Survey, accommodating approximately 410 vehicles. The average vehicle dwell time (time it takes for vehicles to dwell on the curb and unload passengers) on the Terminal D curbside is 2 min. 30 sec.

During peak periods, the inner Terminal D curbside roadway accommodates a maximum of 69% of its capacity and the outer roadway accommodates a maximum of 52% of its capacity, resulting in Level of Service (LOS) A operations for both curbside roadways.

Terminal C North Curbside

The Terminal C North curbside is designated for private vehicles picking-up arriving passengers at Terminal C and is a single level, at-grade curbside adjacent to the Terminal C Lower Level Baggage Claim area. The curbside has three islands served by seven 10 foot wide lanes, four of which are designed for passenger pick-up and the remaining three for vehicle maneuvering and through traffic. The 10 foot wide 240 foot long island closest to the terminal is served by a pick-up lane on either side with a drive lane adjacent to the terminal. There are also five 10 foot wide columns located along the island. A second drive lane separates the pick-up lanes at the first and second islands and the second 10 foot wide 320 foot long island has one pick-up lane on the south side and six 10 foot wide columns located along the island. The third 7 foot wide 360 foot long island furthest from the terminal has one pick-up lane on the south side and one drive lane between it and the second island. There are also seven 6 foot wide columns located along the island. A single 30 foot crosswalk allows passengers to access each of the islands. The islands, less the crosswalk and columns, provide 838 feet of effective curb space.

Peak curbside activity at the Terminal C North curbside occurs in the afternoon with the peak hour, according to the 2010 Peak Week Survey, accommodating approximately 250 vehicles. The average vehicle dwell time (time it takes for vehicles to dwell on the curb and unload passengers) on the Terminal C North curbside is between 4 and 5 minutes. It was observed during the survey period that during peak periods, the Terminal C North curbside has a high number of private vehicles stacked in front waiting to pick up arriving passengers.

3.7.3 GARAGE TRAFFIC

Two parking garages serve the Terminals C, D, and E complex; Terminal C West Garage with 4,620 spaces and the Terminal C/D/E Garage with 4,307 spaces. According to the Gunda Corporation field survey conducted in October 2012, the Terminal C West Garage was approximately 80% occupied during the am and pm peak periods (8:00 am and 2:00 pm respectively) while the Terminal C/D/E Garage ranged from 75% in the am to 85% in the pm peak periods. These occupancies represent operations on Wednesday, October 24, 2010 and Thursday, October 25, 2010, and were selected to represent typical busy days during a busy month. According to transaction reports the peak months of usage for the garages occur in June and July.

The peak hour vehicles arriving at Terminal D and utilizing the Terminal C or Terminal E garages is approximately 45 vehicles per hour. It includes vehicles parking directly in the garages and vehicles that use the curbside first and then proceed to the garages. Similar to vehicle demands on the inner roadway, the parking peak for the garages occurs in mid-afternoon between 2:00 pm and 4:00 pm, with secondary peaks occurring between 10:00 am and 6:00 pm.

The Terminal C West Garage inbound peak hour occurred between 7:00 am and 8:00 am with 35 vehicles entering, and the outbound peak hour occurred between 5:00 pm and 6:00 pm with 195 vehicles exiting. The D/E Garage inbound peak hour occurred between 1:00 pm and 2:00 pm with 265 vehicles entering, and an outbound peak hour occurred between 2:00 pm and 3:00 pm with 215 vehicles exiting.

Chapter 4 | Program Requirements

4.0 Program Requirements

4.1 Overview

Program requirements were developed to meet the peak hour demand from international and domestic passengers who arrive or depart from the Mickey Leland International Terminal (MLIT) at the George Bush Intercontinental Airport (IAH). The following summary outlines functional facility requirements for check-in and airline ticket offices, holdroom, pre-clearance baggage claim and baggage offices, outbound baggage make-up, and Department of Homeland Security (DHS) facilities including Transportation Security Administration (TSA) passenger security checkpoint and checked baggage screening facilities. Non-passenger processor facility requirements were developed for airport offices, restrooms, and amenities including chapel, diplomatic suite, air marshal conference rooms, and religious foot wash areas.

Facility and space requirements described in this section denote passenger processing facilities for the forecast planning activity level (PAL) representative of demand for 33 million annual enplaning passengers (MAP). This milestone is known as PAL 33.

The following sections describe in further detail the air service characteristics, passenger attributes, and operating parameters used to derive the functional facility requirements.

4.2 Program Requirements Summary

Simulation modeling, used to determine the quantities and areas required for passenger queues and processors, was developed by applying generally accepted industry standards for level of service (LOS) and performance criteria to a level of demand, typically representing peak periods of activity at each individual functional facility processor or subsystem. **Table 4.1** summarizes and compares the existing inventory and PAL 33 program requirements.

Table 4.1: Program Requirements Summary (1 of 3)

	TERMINAL FACILITIES	INVENTORY	PAL 33 REQUIREMENTS	NOTES
1.0	*Airline Areas*			
1.1	Total Check-in Positions (ea)	68	120	Assumes common-use check-in system: check-in counters + kiosks
1.2	Total Kiosk Positions (ea)	6	72	Assumes kiosks are associated with adjacent bag position in a two-step bag drop process
1.3	Total Linear Frontage Positions (ea)	62	48	Assumes 5.5 ft per linear position; assumes common-use
1.4	Check-in Lobby Area (sf)	15,561	17,160	Assumes 65 ft depth per linear position
1.5	Ticket Lobby Sales Counters (sf)	313	358	Based on international airline survey responses
1.6	Airline Office and Support (sf)	22,226	20,672	Based on airline survey responses
1.7	Gates (ea)	12	15	
1.8	Baggage Service Office (sf)	0	300	10′ x 30′ common use baggage storage space near pre-clearance claim device
1.9	Ramp Operations/Storage Areas (sf)	9,374	7,210	Based on existing and airline surveys
1.10	Outbound Cart Positions (ea)	63	76	
1.11	Baggage Make-up Devices (ea)	5	7	
1.12	Outbound Baggage Make-up & Baggage Room Circulation (sf)	36,880	40,500	Excludes airline operation offices, restrooms, empty cart storage, etc.
1.13	BHS Ground Handler Locker Rooms (sf)	Incl. in 1.12	150	
1.14	BHS Ground Handler Shower (sf)	Incl. in 1.12	100	
1.15	Pre-clearance Baggage Claim Inbound Load Piers (ea)	1	6	Assuming three inbound claims for pre-cleared flights with 2 loading piers each. Initial build provides one claim device and shell space for two additional devices
1.16	Pre-clearance Baggage Claim Inbound Piers (sf)	1,125	9,000	Assumes area for six inbound load piers serving three pre-clearance baggage claim devices (initially provide only 1 pair of piers)
1.17	Pre-clearance Baggage Claim Area (sf)	4,177	27,000	Space for three 280 plf baggage claim devices (158′ x 57′ area); initially provide one carousel with capability to add two more in future
1.18	Oversized and Non-conveyance Delivery (sf)	Incl. in 1.12	60	5′ x 12′ stainless steel slide. Requires cargo elevator
1.19	Baggage Control Room (sf)	Incl. in 1.12	150	Assumes two desks with workstations, office storage, printers etc.
1.20	BHS Common Room (sf)	Incl. in 1.12	240	
1.21	BHS Server Room (sf)	Incl. in 1.12	150	
1.22	O&M Electric Cart Parking and Charging Area (sf)	0	240	
1.23	Tug Cart Charging/Refueling (sf)	0	300	
1.24	BHS Maintenance Facility (sf)	Incl. in 1.12	900	Spare parts, tools, storage
1.25	Common-Use Airline Service Counters	0	180	12 ft wide by 15 ft deep (4′ for agents, 3′ counter and 8′ queue/standing area)
1.26	Airline Clubs (sf)	22,107	70,000	Based on airline survey responses and request for 10,000 SF American Express Centurion Lounge
1.27	Holdrooms (ea)	12	15	
1.28	Holdrooms (sf)	46,195	87,275	Assumes 80% LF, with 20% Standing and 80% Seated, 10% credit at contiguous holdrooms
	Subtotal Airlines Spaces (sf)	**157,960**	**271,950**	

Notes: 1/ Total requirements rounded to the nearest 10 sf. *Prepared by: Ricondo & Associates, Inc., May 2014*
Source: Ricondo & Associates, Inc., May 2014

Table 4.1: Program Requirements Summary (2 of 3)

2.0	Department of Homeland Security (DHS)/Transportation Security Administration (TSA)			
2.1	Passenger Security Screening Checkpoint Lanes (ea)	4	5	Assumes 50/50 split between PreCheck and Standard Passengers (2 PreCheck Lanes + 3 Standard Lanes)
2.2	Passenger Security Screening Checkpoint (sf)	11,452	7,110	Based on TSA Guidelines for checkpoint lanes and recompose area
2.3	Passenger Security Screening Checkpoint Queue Area (sf)	Incl. in 2.2	2,700	Assumes 540 sf per checkpoint lane
2.4	TSA Passenger Security Screening Checkpoint Support Spaces (sf)	2,094	1,500	Assumes 300 sf of support space per screening lane (100 sf per officer, and 6 officers per lane pair).
2.5	Baggage Screening EDS Devices (ea)	6	6	Assumes 680 bags/hour per machine
2.6	Checked Baggage Inspection System (sf)	22,161	40,000	Includes CBRA
2.7	TSA OSR Room (sf)	Incl. in 2.6	500	Assumes two desks with workstations and office storage, printers etc.
2.8	TSA Bag Screening Support Offices (sf)	Incl. in 2.6	1,000	
	Subtotal DHS/TSA Spaces (sf)	**35,710**	**52,810**	

Notes:
1/ Total requirements rounded to the nearest 10 sf.
Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

Table 4.1: Program Requirements Summary (2 of 3 continued)

3.0	*Support Areas (Non-Airline)*			
3.1	Commercial Program (sf)	15,719	81,800	Prepared by AirProjects
3.1.1	*Food Service (sf)*	*4,737*	*28,700*	
3.1.2	*Convenience Retail (sf)*	*2,642*	*6,000*	
3.1.3	*Specialty Retail (sf)*	*1,577*	*16,200*	
3.1.4	*Duty Free Retail (sf)*	*2,680*	*15,900*	
3.1.5	*Services (sf)*	*1,851*	*3,500*	
3.1.6	*Storage (sf)*	*2,232*	*11,500*	
3.2	Chapel (sf)	661	1,000	Chapel contains men's and women's prayer rooms, chaplain's office, storage area and consultation room
3.3	Religious Foot Wash Area - Male and Female (sf)	0	300	Religious Foot Wash Area provides a 150 sf area each for males and females with foot washing fixtures and appropriate drying areas and benches for shoe removal. Foot Wash Area shoud be located adjacent to Chapel.
3.4	HAS Areas (sf)	13,439	0	No HAS offices
3.5	Diplomacy/Diplomatic Suite (sf)	0	5,000	Secure-side facility; contains kitchenette with separate door to corridor and family restroom
3.6	HAS Maintenance (sf)	0	400	(2) 10' x 20' storage rooms for high-lift, floor buffers, etc. with one located at check-in lobby and one located at departure level.
3.7	Air Marshal Conference Rooms (sf)	0	300	One located at sterile level and one located on departures level (150 sf each)
3.8	CBP Interview Room at each International Gate Pod (sf)	0	1,200	80 sf each
3.9	Children's Play Area (sf)	0	600	Departures Level
3.10	Loading Dock (sf)	4,844	5,000	
3.11	Wheelchair Storage Areas (sf)	225	450	150 sf each (one at each end of the ticket lobby and one located within the sterile corridor)
3.12	Electric Cart Storage/Charging Area (sf)	0	100	50 sf each. One located at sterile level and one located on departures level
3.13	Employee Break Rooms (sf)	1,231	1,400	Two employee break rooms; one in each ATO area
3.14	Shared Airline Storage Closets (sf)	0	432	48 sf each, one per common use gate (Option 1A: 7 paired gates + 2 single gates)
3.15	United Services Organization (USO) (sf)	1,150	1,150	Based on existing space
3.16	Former Terminal D FIS Area (sf)	46,800	0	
3.17	Unassigned Areas (sf)	6,795	0	
3.18	Restrooms (sf)	4,715	14,800	2,100 sf module contains 10 - 12 toilet/urinal fixtures per sex, family assistance restroom and janitor closets. One restroom module will be located per every two wide-body gates on a single-loaded concourse or four wide-bodies on a double loaded concourse. Maximum walking distance to nearest concourse restroom will be 400' (approximately 2 wide-body gates). Includes two smaller ticket lobby restroom modules at 1,100 sf each. (Option 1A)
	Subtotal Support Areas (Non-Airline) (sf)	**95,580**	**113,930**	

Notes:
1/ Total requirements rounded to the nearest 10 sf.
Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

Table 4.1: Program Requirements Summary (3 of 3)

3.19	Areas Dependent on Building Configuration			
3.20	MEP and IT Services (sf)	53,130	83,351	Factor: 10.4%
3.21	Mechanical, Electrical, and Plumbing (sf)	44,532	67,558	Factor: 8.4%
3.22	IT (sf)	8,598	15,793	Factor: 2.0%
3.23	Circulation (sf)	180,023	280,762	Factor: 35.0%
3.24				
3.25	Subtotal Areas Dependent on Building Configuration (sf)	233,150	364,110	
3.26	Total Program Area (sf)	289,250	438,690	
	Grand Total Facility Program Area (sf)	**522,400**	**802,800**	

Notes:
1/ Total program requirements rounded to the nearest 10 sf
Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

4.3 Demand Activity – Flight Schedule

Terminal facilities are planned, sized, and designed for initial construction to accommodate peak passenger demands based on a forecast period. Requirements of terminal facilities principally use hourly activity statistics consistent with the average day of the peak month baseline.

The demand basis for planning certain terminal subsystems does not rely on peak numbers of passengers, as much as considerations for the predominant aircraft fleet operating at the airport. For example, sizing pre-boarding lounges (holdrooms) and gate positions to accommodate the largest aircraft listed in the Design Day Flight Schedules (DDFS).

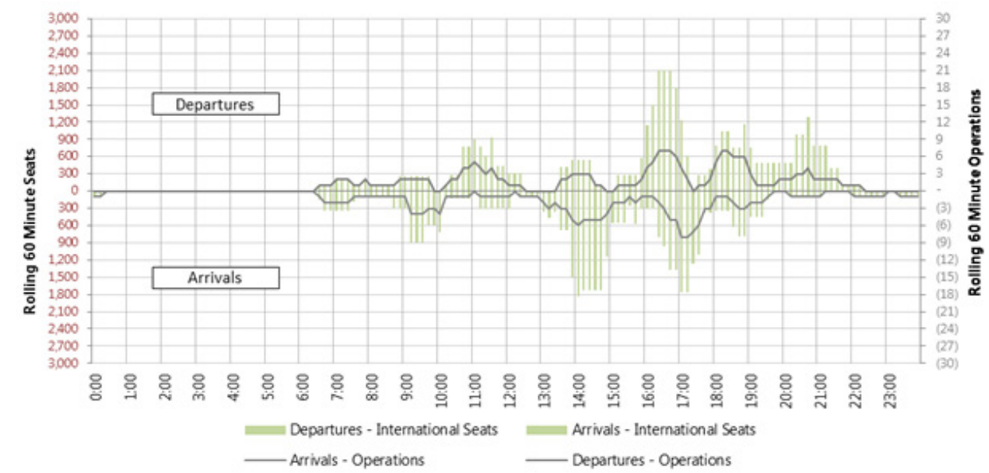
Peak hour activity profiles were derived using the DDFS provided by LeighFisher Associates, Inc. DDFS predict the airport's daily pattern for airline service; therefore they provide information on a flight-by-flight basis pertaining to time of aircraft arrival or departure, airline, aircraft type, domestic/international designation, origin and destination (airport codes), seat capacity, load factor, and originating/terminating passenger percentages (O&D). The detailed schedule for PAL 33 is provided in **Chapter 2**.

Diurnal activity patterns were charted for the DDFS to indicate peak period demand on specific functional areas. **Figure 4.1** illustrates diurnal activity of rolling 60 minute seat lift and operations for PAL 33.

Load factors were applied to the volume of departing and arriving seats on a flight-by-flight basis to derive peak hour enplaned and deplaned passenger volumes. These volumes include all passengers processing through the airport and represent the principal demand on concourse and gate facilities. An additional factor was used to derive the number of passengers beginning or ending their airline travel at the airport, referred to as an originating and destination (O&D) passenger. O&D passengers represent the principal demand for terminal processing facilities. **Table 4.2** indicates the flight schedule summary for the DDFS.

Aircraft gate assignments were provided within the DDFS. The number of gates required, listed by aircraft design group (ADG), are found in **Table 4.3**.

Figure 4.1: PAL 33 Diurnal Activity



Source:
1\ LeighFisher Inc., April, 2014
2\ Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

Table 4.2: Flight Schedule Summary

FACILITY	PAL 33 – TERMINAL D (FOREIGN FLAG ACTIVITY ONLY)	PAL 33 – CBP FACILITY (UA AND FOREIGN FLAGS)
Mickey Leland International Terminal Activity		
Daily Activity		
Departures		
Operations (flights)	35	
Seats (seats)	7,626	
Enplanements (pax)	6,258	
Originations (pax)	5,408	
Arrivals		
Operations (flights)	34	264
Seats (seats)	7,689	39,062
Deplanements (pax)	6,302	32,269
Terminations (pax)	5,416	14,120
Peak Hour Activity		
Departures		
Operations (flights)	7	
Seats (seats)	2,110	
Enplanements (pax)	1,773	
Originations (pax)	1,489	
Arrivals		
Operations (flights)	8	31
Seats (seats)	1,829	5,486
Deplanements (pax)	1,499	4,548
Terminations (pax)	1,237	2,444

Source:
1\ LeighFisher Inc., April, 2014
2\ Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

Table 4.3: Gate Requirement Summary

AIRCRAFT TYPE	PAL 33 REQUIREMENTS
ADG V	11
ADG VI	4
Total	**15**

Source:
1\ LeighFisher Inc., April, 2014
2\ Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

4.4 Level-of-Service Standards and Performance Criteria

4.4.1 LEVEL OF SERVICE STANDARDS

The International Air Transport Association (IATA), Airport Development Reference Manual, 9th Edition, and Airport Cooperative Research Program (ACRP) Report 25, Airport Passenger Terminal Planning and Design, Volume 1: Guidebook were used to define LOS C standards, unless superseded by Houston Airports System guidelines or airline stakeholders preferences. LOS is an industry accepted value system that measures a facility's capability to meet demand in both quantitative and qualitative senses. It provides a framework to compare passenger comfort and experience between subsystems by using transaction times and spatial requirements to define LOS. LOS C is recommended by IATA as the minimum design objective, as it denotes good service at a reasonable cost; whereas LOS A essentially has no bounds. For purposes of this analysis, facility requirements have been calculated to achieve the LOS C goal during peak periods of passenger demand on facilities used to process passengers and baggage, including: check-in, security screening checkpoint, baggage handling and screening systems, CBP federal inspection services and domestic baggage claim.

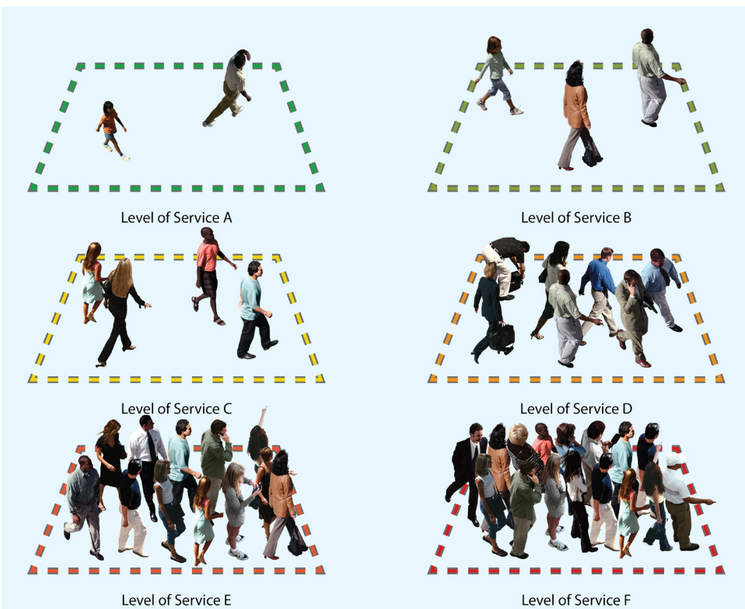
Figure 4.2 and **Figure 4.3** provide representative images of passenger queuing and circulation conditions relative to the IATA framework that can generally be described as follows:

- **LOS A**: Excellent level of service, condition of free flow, excellent level of comfort.
- **LOS B**: High level of service, condition of stable flow, very few delays, high level of comfort.
- **LOS C**: Good level of service, condition of stable flow, acceptable delays, good level of comfort.
- **LOS D**: Adequate level of service, condition of unstable flow, acceptable delays for short periods of time, adequate level of comfort.
- **LOS E**: Inadequate level of service, condition of unstable flow, unacceptable delays, inadequate level of comfort.
- **LOS F**: Unacceptable level of service, condition of cross-flows, system breakdown and unacceptable delays, unacceptable level of comfort.

Figure 4.2: IATA Level of Service Framework – Passenger Queue

SOURCE: John J. Fruin, Pedestrian Planning and Design, 1971
PREPARED BY: HNTB Corporation, 2013

Figure 4.3: IATA Level of Service Framework – Passenger Circulations



SOURCE: John J. Fruin, Pedestrian Planning and Design, 1971
PREPARED BY: HNTB Corporation, 2013

4.4.2 PERFORMANCE CRITERIA

Performance criteria used to establish process duration goals and space allocations were derived from IATA LOS standards, TSA standards and HAS input referenced from previous studies. These criteria were applied to generate unit requirements for check-in, checkpoint, and pre-clearance baggage claim. Performance criteria goals used to analyze facility requirements are indicated on **Table 4.4**.

Table 4.4: Performance Criteria

FACILITY	DURATION	AREA/PAX	NOTES
Check-in			
Remote Kiosk	4-15 minutes	8 sf	Wait time goal varies for international air carriers; see **Appendix B – Check-in Attributes.**
Baggage Drop	4-10 minutes		
Full Agent Assist	5-20 minutes		
Checkpoint	10 minutes	11 sf	Maximum wait time goal during peak period demand at checkpoint.
Baggage Claim	20 minutes	18 sf	First bag shows up at claim unit within 20 minutes after scheduled time of arrival; 18 sf per passenger within active retrieval area around device.

SOURCES:
1/ IATA Airport Development Reference Manual, 9th Edition.
2/ Air France survey
3/ KLM Royal Dutch Airlines survey
4/ Lufthansa Airlines survey
5/ Emirates Airline survey
6/ Air China survey
7/ Aeromexico survey
8/ Atlas Air survey
PREPARED BY: HNTB Corporation, 2013

4.5 Simulation Assumptions - Passenger Attributes

Passenger profiles and characteristics correlate demand and level of service to establish facility requirements for terminal facilities, such as check-in facilities and security screening checkpoints, which are not dependent on equipment types. The passenger profiles and characteristics incorporate unique airport and airline specific sets of assumptions typically obtained from airport observations, surveys, and historical data, which are applied to the design day flight schedule. These assumptions are organized into two components: passenger attributes and show-up profiles.

Passenger attributes determine the distribution of passenger types into group size, travel class (first class, business, or economy), check-in type, and landside modal split. Check-in type identifies the percentage of passengers checking bags, number of checked bags per passenger, and which type of check-in equipment each passenger is expected to use (kiosks, baggage drop, or agent-assisted positions). Landside modal split indicates the mode of transportation passengers use to get to the airport (private vehicle, rental car, shuttle bus, bus, taxicab, or train).

Air carriers who are expected to be located in the new MLIT responded to surveys indicating known and anticipated passenger characteristics, check-in operating parameters, and LOS goals. The information received provided the basis of passenger attributes and level of service goals for the respective airlines. For purposes of this study, the passenger characteristics and LOS goals were grouped by airline destination markets (i.e.: Europe, Latin America, Asia, and Middle East).

4.5.1 SHOW-UP PROFILES

The passenger show-up profile is defined as the earliness distribution of passengers arriving at the terminal prior to the scheduled time of flight departure. Departing passenger show-up profiles are influenced by multiple elements, including domestic or international destination, mode of transportation (landside modal split), distance from the airport, and specific passenger attributes (i.e., passengers checking bags and check-in type), check-in counter close-out times for baggage check, and time of day for scheduled flight departure. Multiple show-up profiles may be used in analyses to capture passenger behavior and operational protocols, such as a profile for passengers checking bags for flights scheduled to depart before 9:00 am versus passengers checking a bag for flights departing after 9:00 pm.

Show-up profiles for international passengers are included in **Appendix A**.

4.5.2 CHECKED BAGGAGE

Checked baggage data was obtained by airline surveys and the IAH 2010 Peak Week passenger survey indicating the percentages for originating passengers checking bags by destination and the numbers of bags checked. Approximately 87% of international passengers check bags with an average of 1.9 bags per originating passenger. **Table 4.5** summarizes the percentage of originating passengers checking bags and numbers of bags per passenger based on destination market.

Table 4.5: Percentages of Originating Passengers Checking Bags

BAGS	EUROPE	LATIN AMERICA	ASIA	MIDDLE EAST
0	13%	13%	13%	5%
1	40%	14%	14%	10%
2	31%	46%	46%	70%
3	12%	19%	19%	10%
4	5%	8%	8%	5%
5	0.3%	0%	0%	0%
+6	0.2%	0%	0%	0%
AVERAGE (BAGS/PAX)	1.6	2.0	2.0	2.0

SOURCES:
1/ TranSolutions. Methods, Assumptions, and Performance Specifications (MAPS) Document. July 2013.
2/ Air France
3/ KLM Royal Dutch Airlines
4/ Lufthansa Airlines
5/ Emirates Airline
PREPARED BY: Ricondo & Associates, Inc., May 2014

4.5.3 PAST STUDIES, INDUSTRY STANDARDS AND APPLICABLE DOCUMENTS

Past studies and guidelines reviewed for applicable data include the following:

- 2010 Peak Week Survey Results – Prepared by Houston Airport Systems and HNTB, published February 2011.
- TransSolutions, Methods, Assumptions, and Performance Specifications (MAPS) Document, July 2013.
- Airport Cooperative Research Program, ACRP Report 25, Airport Terminal Planning and Design, Volume 1: Guidebook, 2010.
- International Air Transport Association, Airport Development Reference Manual, 9th Edition, 2004.
- Checkpoint Design Guide (CDG), Revision 5.1. Transportation Security Administration. May 07, 2014.
- U.S. Customs and Border Protection, Airport Technical Design Standard. August 2011.
- Houston Airport System, International Facilities Access and Assignment Policy, January 2014.

4.5.4 PROGRAM REQUIREMENTS

Simulation and static modeling were used to develop facility requirements, as described in the following subsections. Design day flight schedules (DDFS) were used to provide the demand basis to derive facility requirements for airline check-in, checkpoint, and Department of Homeland Security (DHS) facilities (TSA security screening checkpoint and baggage screening). Area requirements for other airline and non-airline related facilities including airline offices and support, ramp operations, airport offices, chapel, religious foot washing area, air marshal conference room, diplomacy/diplomatic suite, and other amenities were reflective of HAS, airline, and other stakeholder input.

4.6 Check-in

Check-in is defined as the process by which passengers obtain and print their boarding pass and/or baggage tags prior to being screened at the security checkpoint. As technology advances, more choices become available for the departing passenger to complete the above mentioned check-in process. For this reason, some airlines have indicated use of kiosk and two-step check-in (kiosks and baggage drops) processes for future requirements while their current international operations or Terminal D facilities do not incorporate such methods.

The methods and technologies for which passengers obtain boarding passes and baggage tags are defined as passenger check-in attributes and, when associated with passenger show-up profiles and LOS performance criteria, form the basis for check-in facility requirements. These attributes and goals are illustrated in **Appendix B** for international passengers, outlining passenger distribution to specific check-in facilities, transaction rates, and wait time goals.

Performance of the check-in subsystem is analyzed by wait time goals for time in queue and average processing times by passenger type. The amount of time a passenger waits for service and the amount of time required to process each passenger type at an individual check-in position varies depending on the degree of assistance required. For this reason, passenger attributes are segmented into four (4) categories for analysis. The categories include bypass, kiosk, mobile, and agent. Each category utilizes various check-in equipment positions to check-in such as agent counters, kiosks, baggage drop, and mobile (online). They are defined as follows:

- **Bypass (Internet/Mobile Device) Check-in**: Passengers, who do not check bags may check–in remotely, prior to showing up at the terminal, and consequently, do not use terminal facilities.
- **Mobile**: Passengers who have printed their boarding pass off-site (home, hotel, office, etc.), or on their cell phone.
- **Kiosks**: Stand-alone kiosks located in front of inline positions or located remotely from the check-in counter, where passengers acquire boarding passes and/or print baggage tags.
- **Baggage Drop Positions**: Locations where airline staff tag and accept bags from passengers who checked in online (mobile) or at a kiosk for two-step check-in process.
- **Full Service (Agent) Counter Check-in Positions**: Locations where airline staff may assist passengers in acquiring boarding passes and where check-in bags are accepted.

Computer simulation was used to analyze the number of check-in positions needed to achieve the level of service goals for check-in. The calibrated model delineated airline check-in operations for international activity and carrier attributes for PAL 33.

Check-in requirements for each airline were calculated based on individual peak period operations. International airlines were assumed to lease check-in facilities on a common-use basis. The current Houston Airport System International Facilities Access and Assignment Policy, January 2014, provided the basis for calculating total number of check-in facilities required to accommodate international activity under the prescribed performance criteria. A summary of check-in position requirements is shown on **Table 4.6**.

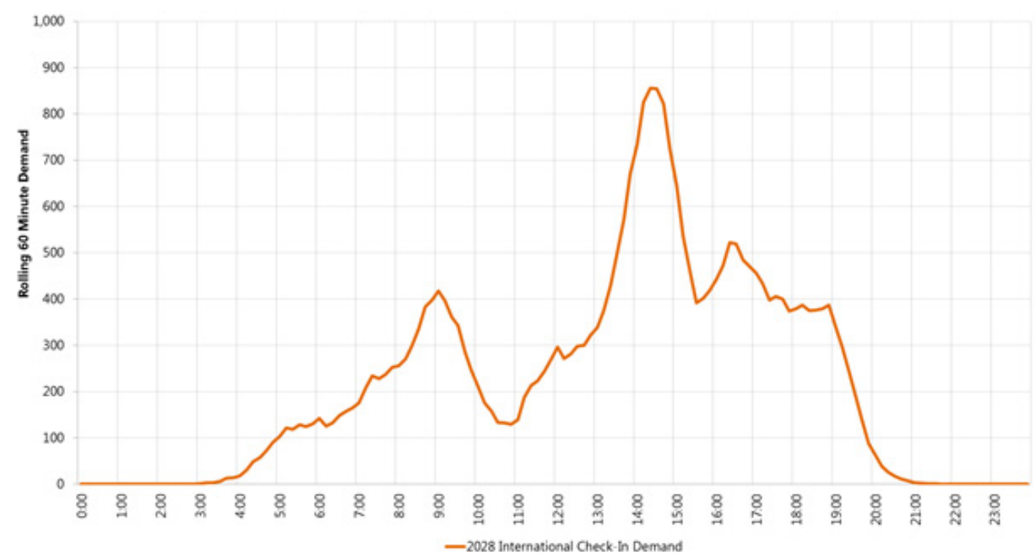
Table 4.6: Check-in Program Requirements

FACILITIES	EXISTING	PAL 33 REQUIREMENTS
Kiosk Positions/1	6	72
Agent Positions/2	62	48
Total Positions	62	120
Total Linear Frontage (5.5 ft/position)	318	264
Depth of Check-in Lobby (ft)	Between 66 and 98 ft	65
Total Check-in Program Area (sf)	**15,561**	**17,160**

Notes:
1/ Aggregate number of positions for all airlines.
2/ In-line positions based on common-use International Facilities Access and Assignment Policy.
Source:
1/ Ricondo & Associates, Inc., May 2014
2/ Mickey Leland International Terminal-PDM. Houston Airport Systems and HNTB, June 2013
Prepared by: Ricondo & Associates, Inc., May 2014

Figure 4.4 illustrates diurnal demand for the future DDFS at check-in facilities after show-up profiles have been applied.

Figure 4.4: International Check-in Demand Activity



Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

Check-in facilities in airport terminals range in configurations depending on airline operational preferences. The various configurations may include traditional linear agent counters with or without built-in self-service devices, island counters, or a mix of remote self-service devices and baggage tag check-in positions. Space requirement variations between these check-in configurations may differ slightly depending on the size of equipment.

Figure 4.5 illustrates a space template for a recommended check-in lobby. Standard international agent positions are assumed to be in an in-line configuration. An in-line configuration allows agents to have a direct induction conveyance belt to introduce passenger bags into the baggage handling system. Kiosks can be remote but considerations for dedicated baggage drop areas have been included at the counter for a two-step check-in process. Current international check-in facilities do not provide kiosk check-in.

Areas that constitute the check-in area are described below:

- **Check-in Position**: The location where passengers are checked in by airline staff or kiosk in the check-in lobby. A single check-in counter position is assumed to be 5.5 ft wide (counter work area and baggage scale) and 13 ft deep from check-in counter face (on the passenger side) to the back wall. Counter depth for both domestic and international positions allows for work area and take-away conveyor belts up to 48 inches wide that accommodate large bags.

- **Transaction Area**: Standing area for passengers and their baggage while conducting transactions at the check-in counter and primary cross aisle circulation for passengers moving to and from the check-in counters. The transaction area is typically 8-10 ft deep from face of check-in counter to ticketing queue boundary and represents the standing area for passengers transacting at check-in counters and primary cross aisle for passengers circulating in front of the check-in counters.

- **Check-in Queue**: Holding area for passengers waiting to transact at check-in counters ranges in depth depending on LOS criteria for square footage per passenger in queue. **Figure 4.5** shows a 25 ft deep ticketing queue. Ticketing queues are typically defined by queue stanchions with serpentine lanes spaced 5 feet between each queue stanchion lane.

- **Circulation Corridor**: A main circulation corridor for passengers and non-passengers moving between ticketing queues and other terminal functions. This area is recommended to be a minimum of 20 ft deep and free of any fixed obstruction to accommodate the cross circulation for passengers and non-passengers.

4.7 Holdrooms

Holdrooms, also called departure lounges, are located at each aircraft gate and refer to passenger pre-boarding areas that contain: seating and standing areas for passengers, airline agent check-in podiums and, boarding/deplaning queuing spaces and aisleways. Holdroom areas are typically based on the seating capacity of the largest aircraft using the gate. Gate assumptions and the number of active gate positions needed to support the design day flight schedule are discussed under the Aircraft Gate Requirements section. Active gate positions are defined as any aircraft parking position used to board passengers, regardless of the number of operations. An active gate position by definition requires a passenger pre-boarding area.

An area factor, representing holdroom area to aircraft seats, has been used to extrapolate overall holdroom space requirements for each size of aircraft operating in the concourse. Holdroom requirements are based on ACRP Report 25 recommendations for LOS C. The following parameters were used to derive the holdroom area factors:

- **Load Factor**: 80% factor applied to the total number of aircraft seats to determine the number of enplaning passengers within the pre-boarding area. Average load factor of all operations are derived from the forecast PAL 33 flight schedule.

- **Seated vs. Standing Passengers**: 80% seated at 17 sf per passenger; 20% standing at 12 sf per passenger.

- **Airline Agent Gate Counter**: the average area of an agent counter is 115 sf, including counter, back millwork, and queue area. A minimum assumption was made for three agent counter positions for an ADG Group V gate equal to 345 sf. ADG Group VI gates assume four agent positions and an area of 460 sf.

- **Boarding/Deplaning Aisleway**: an average assumption of two aisles per holdroom equal to 360 sf (6 ft wide aisle x 30 ft holdroom depth per aisle).

- **Holdroom Depth**: 30 ft

- **Adjacency Credit**: a 10% credit is applied if there is a contiguously located holdroom.

Holdrooms are recommended to be situated such that they are paired or grouped with other holdrooms. Locating holdrooms in close proximity to each other allows the total amount of seating and standing space to be shared, thereby reducing the total space.

Table 4.7 summarizes the overall space requirements for holdrooms based on the number of active gates and fleet mix derived through analyses of the design day flight schedule.

Check-in Counter

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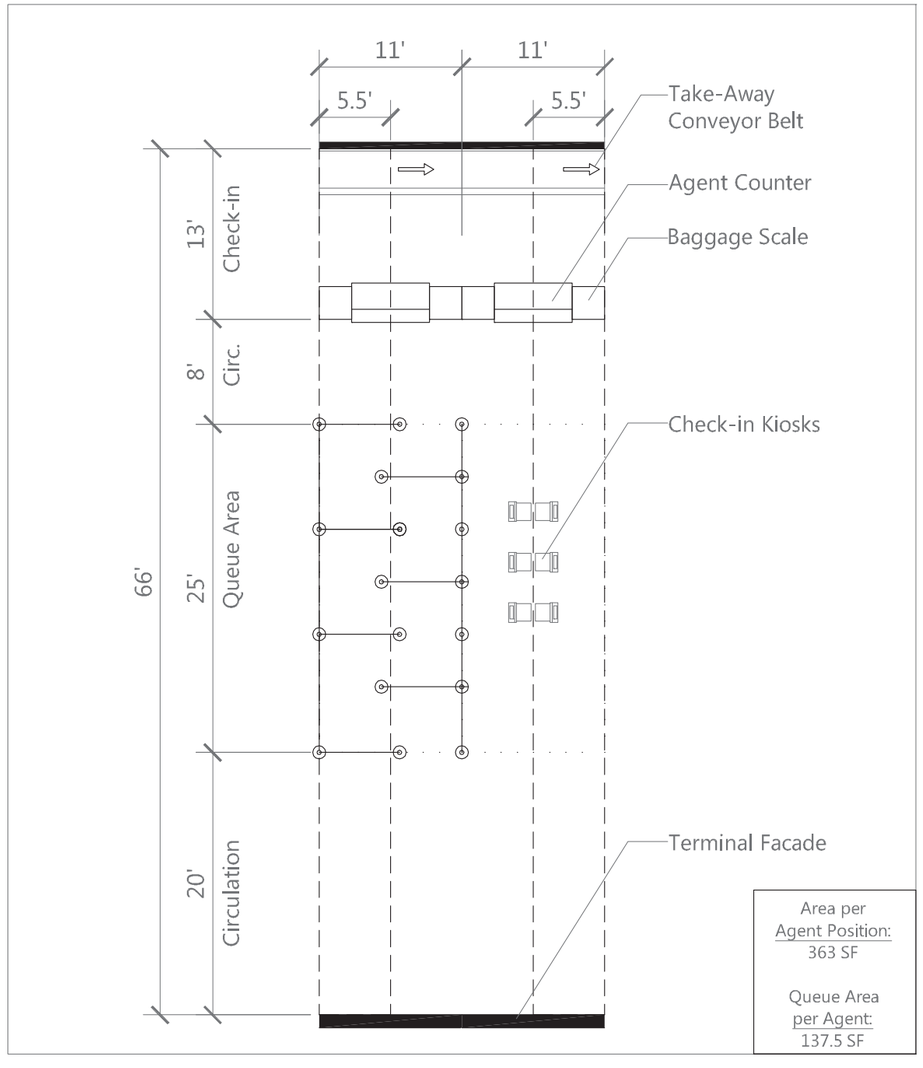


0' 10'

Table 4.7: Holdroom Requirement

	SINGLE ADG V	PAIRED ADG V	SINGLE ADG VI	PAIRED ADG VI
# of Seats on Design Aircraft (seats)	400	400	530	530
Load Factor (%)	80%	80%	80%	80%
# Design Passengers (pax)	320	320	424	424
Percent Seated (%)	80%	80%	80%	80%
Percent Standing (%)	20%	20%	20%	20%
Seated Passenger Area (sf)	17	17	17	17
Standing Passenger Area (sf)	12	12	12	12
Holdroom Sharing Factor (%)		10%		10%
Adjusted Seated and Standing Area (sf)	5,120	4,608	6,784	6,106
# of Podiums @ 115 sf per agent position	3	3	4	4
Area per Podium (sf)	345	345	460	460
# of Boarding/Egress Aisles @ 180 sf per aisle	2	2	2	2
Boarding/Egress Aisle Area (sf)	360	360	360	360
Holdroom Area (sf)	**5,825**	**5,313**	**7,604**	**6,926**
Rounded Holdroom Area (sf)	**5,825**	**5,325**	**7,600**	**6,925**
Gate Requirements (gates)	**2**	**9**	**-**	**4**
Holdroom Area (sf)	**11,650**	**47,925**	**-**	**27,700**
Total Holdroom Area (sf)	**15**			**87,275**

Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

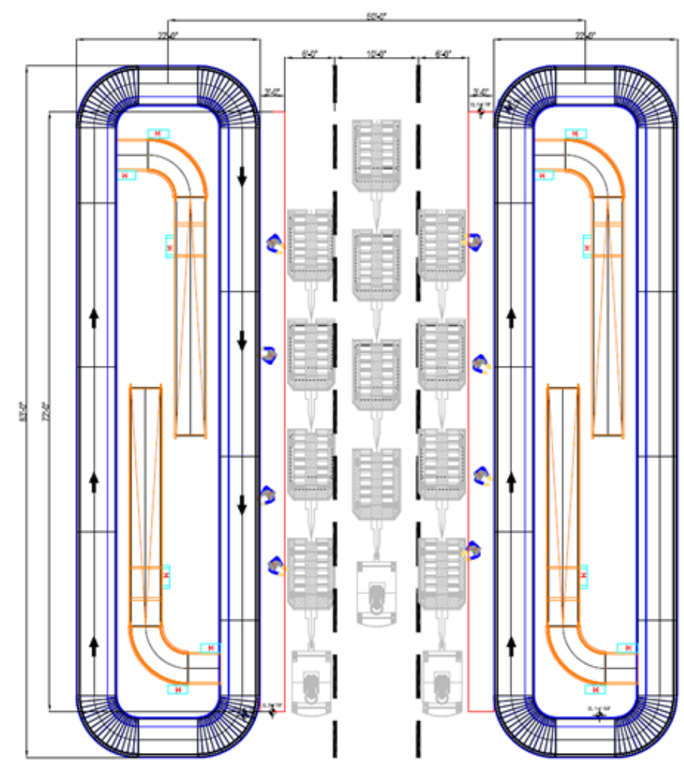
Figure 4.6 illustrates a typical holdroom for a Group V aircraft.

4.8 Outbound Baggage Make-up

A consolidated and centralized baggage sortation system and make-up facility is proposed to be located at the base of the East Pier Concourse. Each device is 45 ft (flat plate) or 50 ft (incline make-up, as shown in **Figure 4.7**) on center with the structural grid and approximately 80 ft long. Each side of the device has a tug and dolly staging lane for container loading and a central drive-thru or passing lane allowing individual containers or dollies to be removed and/or inserted as container loading progresses during the flight buildup period.

The above dimension of 45 ft is based on use of flat plate make up carousels, however this would increase to approximately 50 ft if incline plate devices are preferred by airlines and handling agents, allowing short term storage of bags waiting to be loaded. Incline plate carousels will increase overall bag room area and will involve a wider column span, thus increasing overall facility cost, if this alternative should be adopted.

Figure 4.7: Make-Up Carousel Size and Spacing



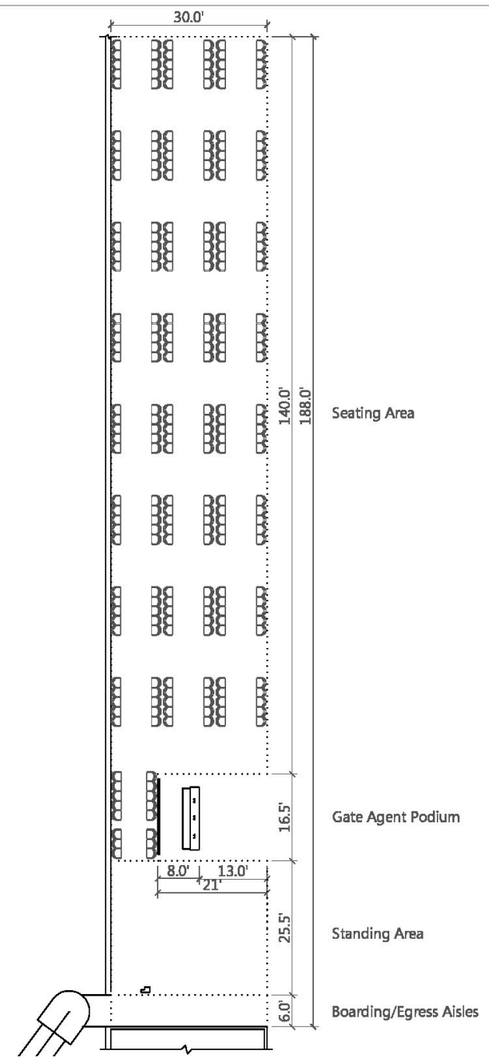
Source: Logplan, LLC, May 2014
Prepared by: Logplan, LLC, May 2014

Two delivery lines should be provided from the checked baggage inspection system (CBIS) up to the sortation system delivering bags to the make-up loops at Apron Level. This assists in maintaining reasonable baggage flow rates on the delivery lines for better sortation performance as well as providing fallback redundancy, allowing sortation and make up to continue even in the event of mechanical failure or a bag jam condition on one of the two delivery/sort lines.

Depending on height availability below the concourse structure it may be feasible to provide an overhead sortation system using a high speed sortation system or similar. In this case the delivery belts from the CBIS area incline from the basement into the ceiling space above the make-up loops to deliver bags to dual sort lines feeding bags sorted to the loops from above. If insufficient height is available for an upper level sortation system, an alternative would be to provide a basement mounted sortation system delivery for bags via incline belts through Apron Level floor penetrations located inside the loop perimeter. This is likely to be significantly more expensive in terms of basement cost and floor penetrations than an overhead delivery system. Sufficient height should be provided

Holdroom Space Template

GEORGE BUSH INTERCONTINENTAL AIRPORT MAY 2014



Seating Configuration Yield

Criteria	Layout Yield
Wait Area (sf)	5,825
Boarding/Egress Aisle (sf)	180
Gate Agent Podium (sf)	345 (3-agent position)
Seating Area (sf)	4,350
Standing Area (sf)	768
Seated/Standing (%)	80/20
Number of Seats (ea)	256

NOTES:
1/ Holdroom reflects sizing to accommodate passengers on a single 400 seat widebody aircraft.

0' 30'

not only for overhead delivery, but also for installation of catwalks to provide access for maintenance of belts, diverters, etc.

It is estimated that the preferred clear height allowing for tug and dolly clearance (approximately 8 ft, 7.5 ft minimum) plus allowance for catwalks/conveyors and maintenance head room (approximately 7.5 ft) indicates a need for 15.5 ft clear height from the Apron Level to the underside of structure and services below the Departure Level. Further discussion will be needed on this issue to determine if this height can be achieved or if compromises with regard to maintenance access will be considered acceptable by HAS. In the event that sufficient height below the Departure Level is not achievable it will be necessary to provide for a delivery and sortation system located in a basement below the make-up area. In this case the main cost for delivery from the Basement Level will be construction of a basement extension below the make-up area for sort lines with diverters to each of the eight loops.

As an option, the sortation system can be equipped with a manual encode subsystem to identify bags which could not be read by an Automatic Tag Reader (ATR) and sent to their correct loop. Without a manual encode system, one loop would be assigned the run-out destination for these no-read bags.

It may be argued that full height maintenance catwalks are a luxury, but for a new facility it is strongly recommended that provisions for good maintenance access should be provided. Regardless, it is necessary to provide full height access for personnel at the manual encode area (unless an alternative location can be provided).

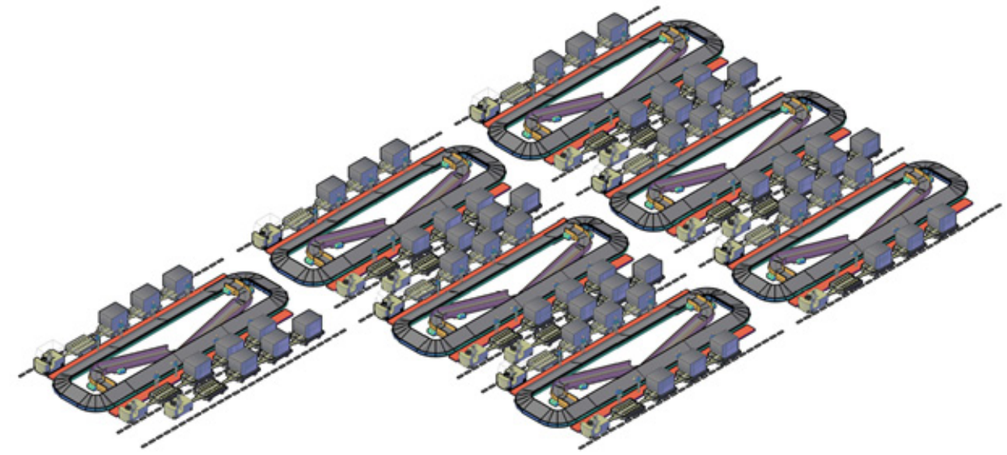
An assessment of unit load device (ULD) presentation indicates a need for presentation of 76 ULDs. Each make-up loop is able to stage 12 ULDs (six on each side). The proposed design with seven loops is able to accommodate up to 84 containers.

Ideally, the following system features should be provided to ensure good BHS system functionality:

- A run-out belt for miss sorts and problem bags (e.g. bags that belong on a flight that has already departed and therefore need to be re-flighted).
- A manual encoding subsystem, immediately upstream of the dual sort line(s). This feature is optional but recommended for this design where a single baggage make-up room serves the entire terminal. Without a manual encode system many bags will fail to be successfully encoded by the Automated Tag Readers (ATRs) upstream of the sort area (in particular transfer bags that have much lower read rates than originating bags). Bags which are not encoded, without a manual encode system, must be diverted either to the run-out belt, mentioned above, or to a default carousel (typically the last carousel(s) on the sort line – sometimes known as a "jackpot" carousel. This may result in some bags being loaded into incorrect containers or being delayed in processing, possibly resulting in short shipments of bags.
- A transfer input belt, possibly two, since typically domestic to international bags do not need screening. These bags could bypass CBIS (domestic to international transfers) and merge directly with the sort line(s). It is understood that transfer bags from domestic flights to British Airways departures need to be screened due to United Kingdom regulations. These bags need to be input to the CBIS before going to the baggage make-up room.

It is proposed that a one-way driving system should be adopted in the baggage make-up room. A partial view of the make-up area is illustrated in **Figure 4.8**. The Apron Level Conceptual Floor Plan includes approximately 40,500 sf of outbound baggage space. This estimate will need to be reviewed once a decision about flat plate or incline make-up devices has been made and the structural grid for this area has been defined.

Figure 4.8 – Bag Room Vehicle Flow (partial view)



Source: Logplan, LLC, May 2014
Prepared by: Logplan, LLC, May 2014

4.9 Inbound Baggage Drop-off

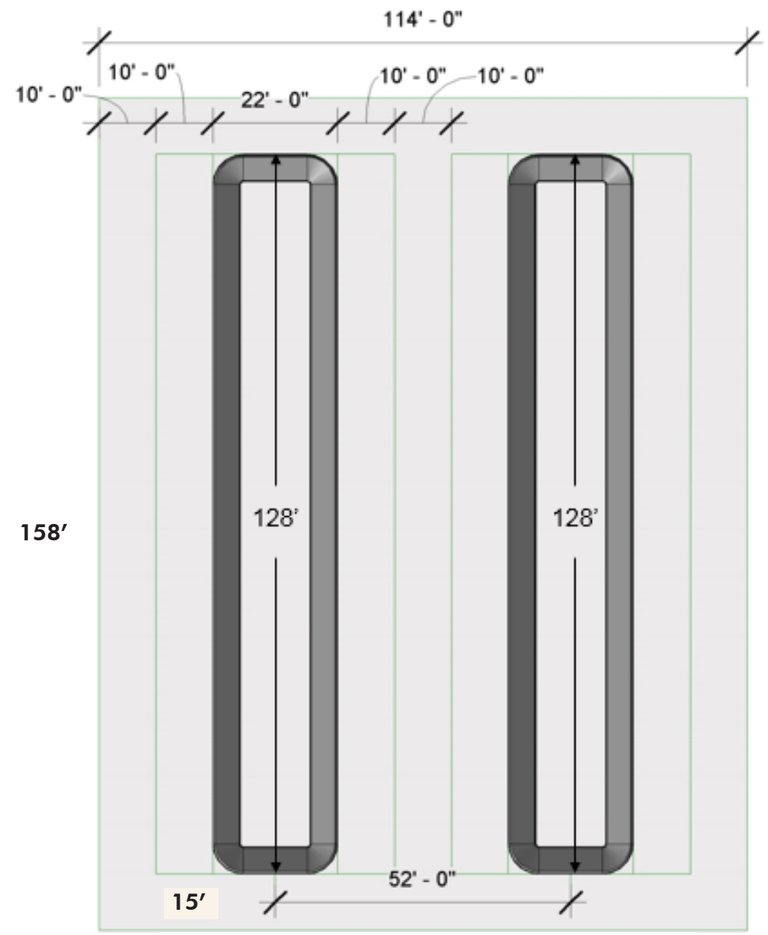
Space for six inbound baggage delivery belts is proposed on the Apron Level. Two inbound piers for each baggage claim device are required to transfer baggage from international pre-cleared flights to the baggage claim devices. Initially, only one pre-clearance claim device and two associated inbound piers will be provided. However, apron level space and conveyor right-of-way should be reserved for up to four additional inbound piers. In total, approximately 9,000 sf is proposed for inbound baggage space.

The majority of baggage from inbound flights is transported to the existing Federal Inspection Services (FIS) facility located between Terminal D and Terminal E. Baggage is transported in baggage carts and/or ULDs pulled by tugs along ground service equipment roadways on the airside. All arriving international passengers that are not pre-cleared claim their baggage at the FIS facility.

4.10 Pre-clearance Baggage Claim

Area should be provided to the east of the east ticketing area for up to three slope-plate baggage claim devices capable of handling up to three simultaneously arriving A380 international pre-cleared flights. The conceptual floor plan in **Figure 4.9** shows the typical area and spacing required for two baggage claim devices. Initially, only one device will be installed and shell space will be provided for up to two additional baggage claim carousels. Each device is connected by a pair of delivery belts from the Apron Level. The baggage claim layout requires approximately 27,000 sf for the three carousels. In addition to that space provisions for oversize and non-conveyable delivery should be provided. The delivery may be done manually with an elevator and a stainless steel slide adjacent to the claim devices. A 5 foot deep by 6 foot wide slide requires approximately 60 sf.

Figure 4.9: Pre-Cleared Flight Reclaim Carousels (Standard Bags)



Minimal footprint of 2 claim devices
Approximately 114 feet x158 feet (approximately 18,000 sf)

Source: Logplan, LLC, May 2014
Prepared by: Logplan, LLC, May 2014

The following spaces are also associated with the operation of the baggage handling system:

- In addition to the make-up area, a staging area of approximately 1,500 sf for empty and full ULD or baggage carts should be provided. It is not required that this space is provided as one consolidated area or inside the building.
- Additional spaces of approximately 800-1,500 sf should be provided for BHS ground handler locker rooms, showers, golf cart parking and charging, tug and cart parking and charging. The final size depends on the number of used ground handlers for this facility. Depending on the final location of these amenities bathroom access has to be verified.
- The operation of the baggage handling system requires a BHS control room (approximately 240 sf), server room (approximately 150 sf), common room (approximately 240 sf), and baggage maintenance facility (approximately 900 sf) for spare parts and tools. Restroom access should be provided nearby.

4.11 Airline Clubs

VIP clubs are becoming increasingly important to foreign flag carriers and are frequently used to distinguish an airline's premium services from the competition. As the number of premium seats on international aircraft increases, so does the desire for airlines to provide more and better premium passenger amenities in the terminal.

There are currently four active clubs on the Terminal D 121 Level:

- Common Use VIP Lounge 6,252 sf
- Air France 2,666 sf
- British Airways (1st Class and Business Class Clubs) 5,563 sf
- KLM 3,962 sf

There is also 3,664 sf of vacant club space on the 121 Level. Airline clubs include exclusive-use membership and common-use clubs; as well as premium lounges for international passengers that may be operated by or on behalf of individual airlines or airline alliances. **Table 4.8** summarizes the requirements for airline clubs as well as a 10,000 SF American Express Centurion Lounge. The designer should explore ways for passengers to directly access two A380 gates and preferably at least one additional widebody gate directly from the airline clubs

Table 4.8: Airline Club Requirements

TERMINAL FACILITIES	EXISTING	PAL 33 REQUIREMENTS
Airline Clubs		
Sky Team	-	10,000
Lufthansa	-	10,000
British Airways or One World	-	10,000
Emirates	-	10,000
Common-Use Club	6,252	10,000
New Entrant Space	-	10,000
American Express Centurion Lounge	-	10,000
Air France	2,666	-
British Airways	5,563	-
KLM	3,962	-
Unassigned	3,664	-
Total Airline Club Area (sf)	**22,107**	**70,000**

Note: USO Requirements are found on line 3.15 in Table 4.1 Program Requirements Summary (2 of 3 continued)

Source: Ricondo & Associates, Inc., May 2014

Prepared by: Ricondo & Associates, Inc., May 2014

4.12 Airline Support Space

Airlines require support spaces such as offices, customer service areas, and maintenance or operational facilities. **Table 4.9** summarizes and compares the existing inventory and future facility requirements for airline support spaces. The requirements at PAL 33 are reflective of airline, stakeholder, and HAS input.

4.12.1 AIRLINE OFFICES AND SALES COUNTERS

Airline support spaces associated with the check-in function not shown on the check-in space template are airline ticket offices (ATO) and sales counters, which include airline administrative office spaces and other check-in support spaces. ATOs are usually located immediately behind, or in proximity to, the airlines' check-in counter to provide support functions for the airline staff handling check-in. Other office space may include the airline station manager's office or a sales office. As airlines have moved toward more self-service for passenger check-in, the number of customer service agents has decreased, resulting in less demand for ATO space. The requirements for airline offices are based on existing carrier leased space and the assumption that there will be three new entrant carriers, each leasing 1,000 sf of space.

4.12.2 COMMON-USE AIRLINE SERVICE COUNTERS

A pair of common-use airline service counters should be provided on the secure-side to serve passengers that need to rebook flights due to irregular operations. The counters require a space approximately 12 feet wide by 15 feet deep (4 feet from back wall to face of counter, a 3 foot deep counter and around 8 feet for a small queue area and for passengers to stand at the counters without impeding circulation in the corridor.

4.12.3 AIRLINE BAGGAGE SERVICE OFFICES

Baggage service offices (BSO) include passenger service counters, waiting areas, and storage for delayed or unclaimed bags. Increasingly, airlines are using self-service kiosks that enable passengers to enter delayed bags and, in many instances, determine delivery status. The intent is to limit increases in staff otherwise needed to serve passenger growth. One common-use BSO of 300 sf (10 ft x 30 ft) located near the pre-clearance baggage claim is required at the future demand level.

4.12.4 RAMP LEVEL FACILITIES

Ramp Level facilities contributing to airside space requirements are usually comprised of two types: covered enclosed spaces and covered unenclosed spaces. The latter is used for various types of storage not requiring protection from the environment (i.e., equipment parts storage). Typical uses for covered enclosed spaces include offices, break rooms, lockers and storage areas for terminal service crews, aircraft line maintenance offices, workshops and storage, pre-flight ready and checkout facilities for flight crews, and even airline ramp control centers. Future requirements for ramp level operations and storage are based on existing carrier leased space and three new carriers, each with similar lease agreements.

Table 4.9: Airline Office and Support Space Requirements (1 of 2)

TERMINAL FACILITIES	INVENTORY	PAL 33 REQUIREMENTS
Ticket Lobby Sales Counters		
Emirates	155	200
Qatar	158	158
Subtotal Ticket Lobby Sales Counters (sf)	**313**	**358**
Airline Office and Support		
Aeromexico	942	942
Air China	788	985
Air France/KLM	1,818	1,818
Atlas Air	140	500
British Airways	1,491	1,800
Emirates	1,416	2,500
Japan Airlines	-	1,000
Korean Airlines	-	1,000
Lufthansa	1,443	1,443
New Entrant (Asia)	-	1,000
New Entrant (Europe)	-	1,000
New Entrant (South/Central America)	-	1,000
Qatar	1,075	1,075
Scandinavian Airlines	-	1,000
Singapore Airlines	1,079	1,079
SITA	376	376
TACA	654	654
Turkish Airlines	789	1,500
Commone Use (corridors, restrooms, break areas)	10,215	
Subtotal Airline Office and Support (sf)	**22,226**	**20,672**

Source: Ricondo & Associates, Inc., May 2014

Prepared by: Ricondo & Associates, Inc., May 2014

Table 4.9: Airline Support Space Requirements (2 of 2)

TERMINAL FACILITIES	INVENTORY	PAL 33 REQUIREMENTS
Ramp Operations and Storage		
Aeromexico	329	330
Air China	-	200
Air France/KLM	819	1,150
Atlas Air	355	355
British Airways	1,367	1,500
Emirates	-	155
Japan Airlines	-	200
Korean Airlines	-	200
Lufthansa	154	154
New Entrant (Asia)	-	200
New Entrant (Europe)	-	800
New Entrant (South/Central America)	-	200
Qatar	-	-
Scandinavian Airlines	-	800
Singapore Airlines	-	-
TACA	166	166
Turkish Airlines	-	800
United	3,071	
Common Use (corridors, restrooms, break areas)	3,113	
Subtotal Ramp Operations and Storage Areas (sf)	**9,374**	**7,210**
Total Airline Support Spaces (sf)	**15,140**	**27,860**

Notes:
1/ Total requirements rounded to the nearest 10 sf
Source: Ricondo & Associates, Inc., May 2014
Prepared by: Ricondo & Associates, Inc., May 2014

4.13 Department of Homeland Security

As a result of the November 2001 Aviation and Transportation Security Act, the U.S. Department of Homeland Security (DHS) maintains in-terminal facilities to conduct airline security screening principally related to operating the security screening checkpoints, baggage screening areas, and border and port of entry security. Customs and Border Patrol facility requirements are described in a separate section. DHS terminal facility requirements are based on two principal DHS publications:

- The Transportation Security Administration's (TSA) *Recommended Security Guidelines for Airport Planning, Design and Construction*, June 15, 2006
- The Transportation Security Administration, *Checkpoint Design Guide* (CDG), Revision 5.1, May 07, 2011

Computer modeling was utilized to develop passenger demand based on forecast DDFS. Equipment unit requirements were based on TSA goals for expected passenger processing rates. Space requirements needed to accommodate equipment and passenger queuing and support areas were then developed using DHS published facility templates and guidelines.

4.13.1 PASSENGER SECURITY SCREENING CHECKPOINT AND TSA SUPPORT

While the TSA has direct responsibility for determining the size and configuration of the passenger security screening checkpoints at the airport, TSA typically collaborates with airport management to plan checkpoint locations and programs. The Checkpoint Design Guide (CDG), Revision 5.1, May 07, 2011, provides guidelines for developing the requirements for checkpoints in the terminal, along with the following criteria:

- TSA prescribed planning screening rate of 150 passengers per hour per lane was used for standard lanes, while TSA Pre √ ™ lanes have a screening rate of 240 passengers per hour.
- The required number of checkpoint lanes were developed to provide the throughput needed to maintain the TSA wait time goal of 10 minutes during the peak 10 minute demand interval of the peak hour.
- The queue area provided per lane is 540 sf in accordance with TSA's guidelines. The queue area assumes 10.8 sf per passenger in queue, and provides the capacity to hold passengers for 20 minutes.
- It is anticipated that there will be future growth in the utilization of the expedited program with 50% of passengers eligible at the future planning level.
- Concept assumes a centralized checkpoint.

Figure 4.10 illustrates a passenger security screening checkpoint space template as recommended by TSA and CDG for a two lane checkpoint.

Figure 4.11 illustrates diurnal demand at checkpoint facilities after metering by check-in facilities versus the number of TSA screening lanes in operation.

TSA Security Screening Checkpoint Space Template

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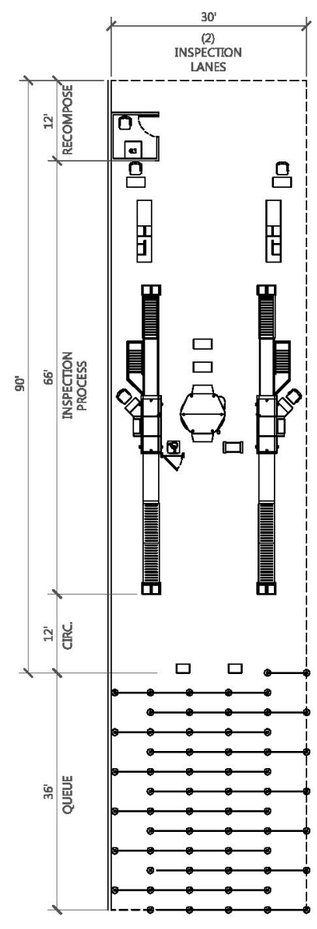


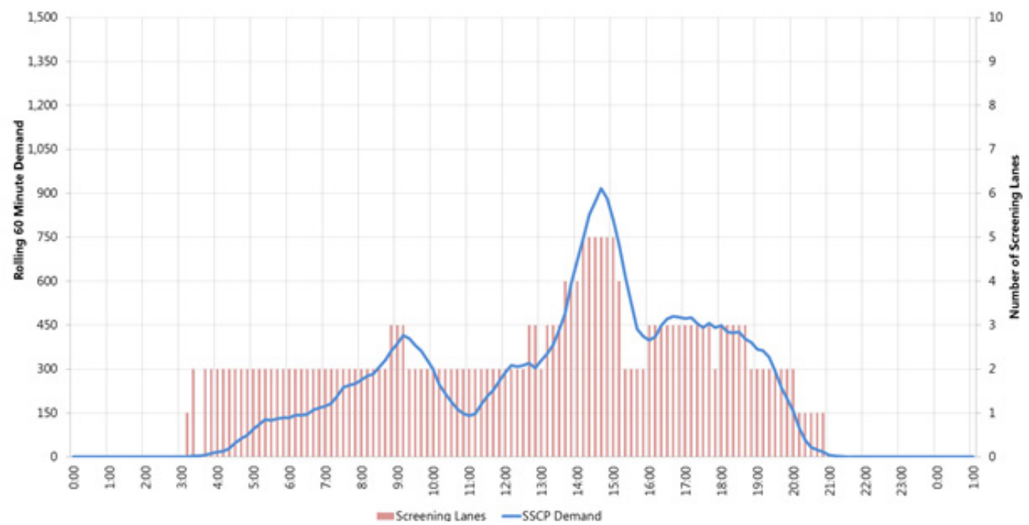
Processing Area
per Agent Position:
1,350 SF

Queue Area
per Lane:
540 SF

0' 20'

Figure 4.10: TSA Security Screening Checkpoint Space Template

Figure 4.11: PAL 33 Checkpoint Demand Activity



Notes:

1/ Assumes in PAL 33, 50% of passengers are eligible for expedited checkpoint lanes.

Source: Ricondo & Associates, Inc., May 2014

Prepared by: Ricondo & Associates, Inc., May 2014

4.13.2 TSA CHECKED BAGGAGE INSPECTION SYSTEM (CBIS)

The Checked Baggage Inspection System (CBIS) bag screening area is located to the southeast of the new D East Pier Concourse. The existing Baggage Handling System (BHS) configuration requires a building footprint of approximately 20,000 sf for the existing east and west CBIS systems. This is compared with approximately 40,000 sf for the recommended CBIS basement layout. This new facility is approximately twice the size of the existing one. It is suggested that the proposed dimensions be adopted pending development of design layouts for the CBIS bag screening system, taking into account that the screening capacity of the existing east matrix appears to be adequate for the design horizon currently under consideration. There are, however, some limitations regarding the existing systems that should be addressed in a new design. These limitations include single point of failure issues, preference for dual delivery lines to and from the CBIS, and compliance with TSA Planning Guidelines and Design Standards (PGDS).

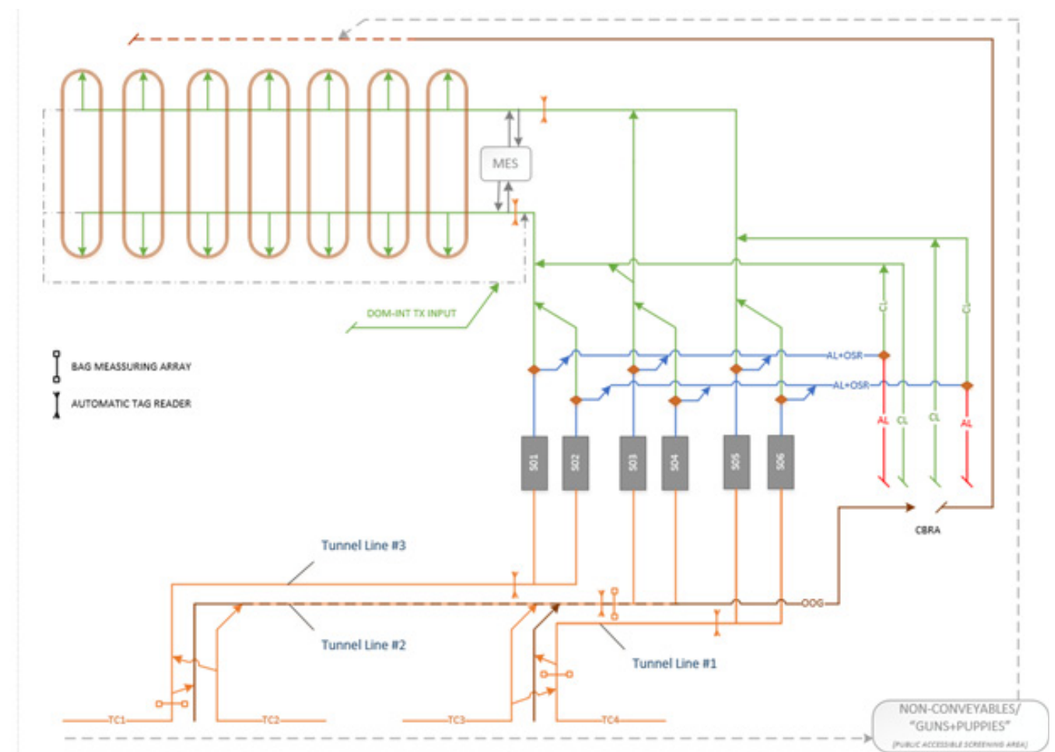
It is also necessary to consider the vertical height of the basement in preparation of the CBIS design since it is often necessary to provide space above TSA screening machines for conveyor rights-of-way and maintenance access while also providing sufficient right-of-way space above the screening machines for hoists used to access and maintain explosive detection system (EDS) components.

One major consideration that should be studied is access to the basement for installation purposes, including future needs to remove EDS equipment such as complete screening machines (or at least major elements of these machines), as these are beyond the capability of the elevator proposed at the northwest corner of the basement. In some installations floor penetrations are provided above (or below) screening machines to allow removal/installation without need for major conveyor removal, but this may not be practical in the case of the proposed layout, where the CBIS is immediately below the apron and airside roadway system.

It will be necessary to develop functional/schematic diagrams for the BHS system (one line diagram format) and, after confirmation that the functionality meets with client needs and TSA PGDS guidelines, prepare a preliminary design layout to confirm the required basement dimensions. Care should be taken to accommodate TSA office space, break rooms, restrooms, parts storage, and similar spaces required for TSA operations, maintenance, and other activities.

The layout for the CBIS is expected to be generally in line with the functionality shown in **Figure 4.12**.

Figure 4.12: Single Line Diagram of CBIS



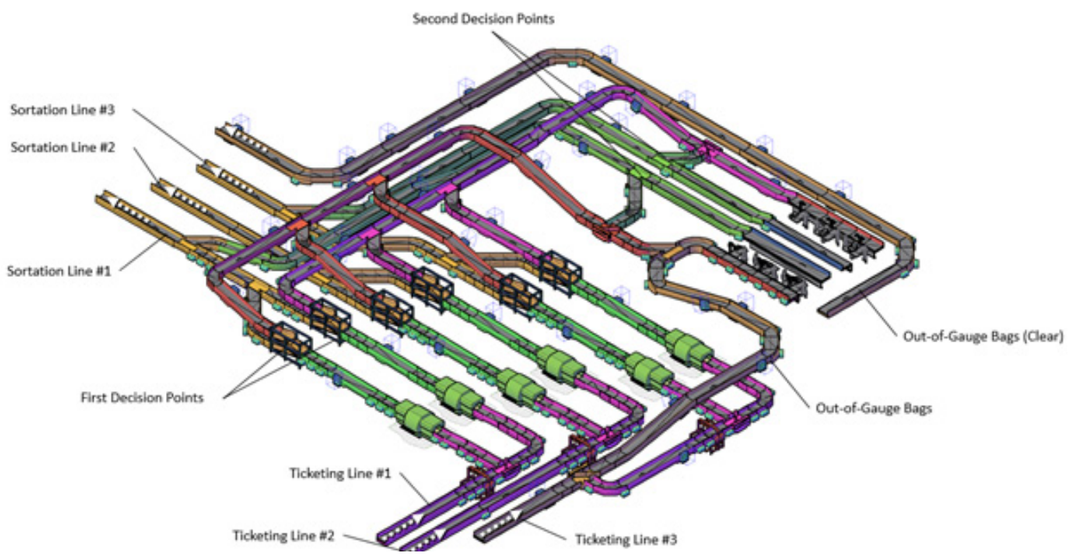
Source: Logplan, LLC, May 2014

Prepared by: Logplan, LLC, May 2014

Figure 4.12 shows dual inputs from ticketing, with crossover capability to permit flow balancing between the downstream screening machines and to permit flow diversion (in either direction) allowing operations to continue when a screening machine is not operational or is being repaired or maintained.

A bag measurement array (BMA) is provided on each input line with a divert point immediately downstream to divert Out-of-Gauge (OOG) bags (i.e., conveyable bags that are too large to be accommodated by the screening machine's screening tunnel dimensions. Diverted bags are transported to the Checked Bag Resolution Area (CBRA) for screening, together with oversize bags (non-conveyable), typically using Electronic Trace Detection (ETD) equipment. Standard size bags are screened using Computed Tomography (CT) machines, and are processed in a similar manner to the existing screening matrix at Terminal D (east zone). The schematic diagram indicates multiple delivery lines both upstream and downstream of the CT machines, to avoid the single point-of-failure condition currently existing in the Terminal D screening matrix, both upstream and downstream of the CT machines. A sample layout of the CBIS is shown in **Figure 4.13**.

Figure 4.13: CBIS Layout



Source: Logplan, LLC, May 2014
Prepared by: Logplan, LLC, May 2014

The following spaces are also associated with the operation of the CBIS:

- A remote on-screen resolution room for TSA operations of approximately 500 sf, preferably in the vicinity of the CBRA.
- Adjacent to the CBRA, space for TSA functions such as a TSA supervisor office, readiness room, and meeting/training room should be provided. These spaces require approximately 1,000 sf and need to be verified with local TSA.

4.14 Other Amenities

4.14.1 COMMERCIAL PROGRAM AND AMENITIES

The amount of future supportable concession space in the MLIT is based on a projection of potential consumer sales associated with a forecast of 5.237 million passenger enplanements for the MLIT, which is the total expected passenger volume at the PAL 33 level for IAH.

Sales projections estimate the potential sales per enplanement that could be captured for each type of concession. Key factors include: the historical performance of the concession program, the performance of comparable airport concession programs, the layout of the new terminal, and the market characteristics. The sales per enplanement assumptions used in the concessions analysis are presented in **Table 4.10**.

Table 4.10 – Projected Concession Sales per Enplanement (at PAL 33, in 2014 Dollars)

CONCESSION TYPE	EXISTING (2013) SALES/ENPLANEMENT	PROJECTED SALES/ ENPLANEMENT	VARIANCE
Food Service	$ 3.00	$ 6.00	100%
Retail Subtotal	$ 4.13	$ 5.40	31%
Convenience Retail	$ 2.17	$ 1.90	-12.4%
Specialty Retail	$ 1.96	$ 3.50	79%
Duty Free Retail*	$ 9.92	$ 14.00	41%
Total	$ 16.80	$ 20.38	21%

Source: AirProjects, Inc.
*Note: *Duty free sales per enplanement are calculated using international enplanements only.*

There are currently limited food service concessions in Terminal D. The significant projected increase in food service sales per enplanement in the future is attributable to the expected improvement in food service offerings. The lack of specialty retail in the existing Terminal D has likely increased the historical convenience retail sales per enplanement. The lack of food service offerings has also likely resulted in increased convenience retail sales as customers seek out pre-packaged food and beverage in the convenience retail concessions. With improved food service and specialty retail offerings in the MLIT, convenience retail sales per enplanement would logically decrease slightly to typical levels. The duty free sales per enplanement are projected to increase due to greatly expanded and enhanced offerings in the MLIT and additional air service to markets serving passengers with a greater propensity to spend on luxury goods.

Preliminary supportable MLIT concession space projections were developed based on the assumptions described above. The projections should be considered preliminary in nature, as planning work that may change the final MLIT configuration and passenger flows could impact potential demand. The supportable space projections by type of concession, driven by sales, are presented in **Table 4.11**.

Table 4.11 – Preliminary Supportable Concessions Space (PAL 33, in Square Feet)

LOCATION	FOOD SERVICE	CONVENIENCE RETAIL	SPECIALTY RETAIL	DUTY FREE RETAIL	ANCILLARY SERVICES	TOTAL
Pre-Security	1,900	400	500	0	0	2,800
Post-Security	26,800	5,600	15,700	15,900	up to 3,500	67,500
TOTAL	28,700	6,000	16,200	15,900	UP TO 3,500	70,300

Source: AirProjects, Inc.

Note: Ancillary services include services such as shoe shine, ATMs, mail/delivery services, internet access, business services, and advertising floor space. The ancillary space does not include any space that may be allocated for conference rooms, hotel, or other commercial services. The majority of ancillary services space is not demand-driven and therefore may not be supportable strictly on a financial basis. The allowance reflected above provides for a variety of uses that would greatly enhance the customer service offered to MLIT passengers.

Estimates of required concession support space were also developed. These estimates were based on the supportable concession space projections and will be refined as the concession master plan progresses. The estimates presented in **Table 4.12** include an allowance for concession support space for use by concessionaires in other airport terminals, as there is an overall shortfall in concession support space at the airport.

Table 4.12 – Concession Support Space Projections

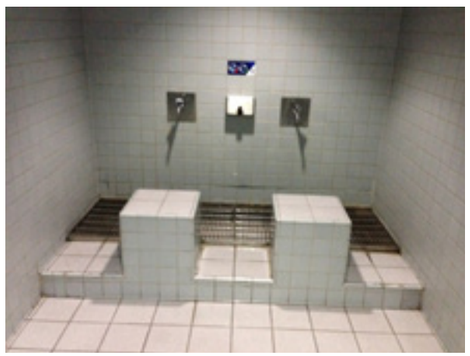
FOOD SERVICE	CONVENIENCE RETAIL	SPECIALTY RETAIL	DUTY FREE RETAIL	ANCILLARY SERVICES	TOTAL
5,700	900	2,400	2,400	100	11,500

Source: AirProjects, Inc.

(1) Ancillary services include services such as shoe shine, ATMs, mail/delivery services, internet access, business services, and advertising floor space. The ancillary space does not include any space that may be allocated for conference rooms, hotel, or other commercial services.

4.14.2 CHAPEL/FOOT WASH AREAS

HAS wants to provide a non-denominational chapel at the East Terminal Complex comprising of approximately 1,000 sf, providing prayer and meditation space for people of all faiths, but particularly for practicing Muslims on the increasing number of Middle Eastern flights. Separate rooms for men and women to pray are recommended. Additionally, separate religious foot washing areas should be provided for both men and women, ideally located near the chapel. Each foot washing area should be approximately 150 sf in area.



Example of Foot Washing Area – Dubai International Airport

Source: Ricondo & Associates

4.14.3 DIPLOMACY/DIPLOMATIC SUITE

A 5,000 sf Diplomacy/Diplomatic Suite is desired on the Club Level. This space will be used to host foreign dignitaries, politicians, VIPs, and media. The suite should include a kitchenette with separate service entrance and a men's and women's handicap accessible restroom.

4.14.4 HAS MAINTENANCE ROOMS

Two 10 ft by 20 ft HAS maintenance rooms should be provided, one at the ticketing level and one at the boarding level. Each room should have large double doors or an overhead roll-up door to allow storage of lift equipment and floor cleaning equipment.

4.14.5 AIR MARSHAL CONFERENCE ROOMS

Two air marshal conference rooms, 150 sf each, are needed for pre-flight briefings and post-flight debriefings. The pre-flight conference room should be located in a discrete location on the boarding level or club level. The post-flight conference room should be located along the Sterile Corridor system leading to the Customs and Border Protection facility.

4.14.6 CHILDREN'S PLAY AREA

One or two children's play areas totaling 600 sf should be provided on the boarding level near the holdrooms. If two play areas are provided, they should be located remotely from each other and centered near groups of holdrooms, if possible.

4.14.7 LOADING DOCK

A loading dock similar in size and capability to the existing 5,000 sf Terminal D loading dock is required. The loading dock should be capable of handling a minimum of two semi-tractor trailer trucks with levelers as well as a trash compactor and be located on the non-secure side of the terminal. Service corridors leading to service elevators will allow deliveries and trash removal to and from all levels with as little public interaction as possible.

4.14.8 WHEELCHAIR STORAGE AREAS

Three wheelchair storage areas, 150 sf each, should be provided; one at each end of the ticketing/check-in lobby with the third located on the Boarding Level.

4.14.9 ELECTRIC CART STORAGE

Two electric cart storage areas are needed with electrical outlets for recharging the carts when not in use and appropriate flooring that can resist battery acid spills. One cart recharging/storage area should be located on the Sterile Level and the other should be located on the Boarding Level.

4.14.10 EMPLOYEE BREAK ROOM

A 400 sf employee break room with a kitchenette for HAS staff and other employees is needed on the Ramp Level or behind the ticket counters on the Ticketing/Check-in Level.

4.14.11 SHARED AIRLINE STORAGE CLOSETS

Each gate area should have a 48 sf shared use airline storage closet for storage of signage, paper stock, baggage sizing equipment, and stanchions used in the holdroom area.

4.14.12 RESTROOMS

Public restroom facilities should be conveniently distributed throughout the public areas and spaced no further than 400 feet between facilities, providing a maximum walking distance of 200 feet to a restroom. Each location should include men's and women's restrooms, janitorial services, and a separate family or companion care restroom; a total of approximately 21,000 sf. The number of fixtures accommodated within each public restroom will be based on the occupancy or area functions that the restroom will support. A planning rule of thumb for terminal restrooms is to provide 4 sf of restroom area per peak hour passenger in the secure area and 2 sf of restroom area per peak hour passenger in the non-secure area.

4.14.13 AREAS DEPENDENT ON BUILDING CONFIGURATION

Some building areas are highly dependent on the terminal's configuration and difficult to define during the programming phase. Therefore, a percentage of the total building is specified for MEP, IT services, and circulation spaces. These percentages will be used as a guideline for evaluating concepts.

Table 4.13 shows the existing inventory and the projected program requirements for areas that are dependent on the final building configuration.

4.14.14 MEP AND IT SERVICES

A factor of 8.4% for mechanical, electrical, and plumbing (MEP) are assumed to occupy the total program area and 2% of the space will be dedicated to IT and communications rooms. Altogether, 10.4% of the terminal area is assumed to be allocated to MEP and IT spaces. This is comparable to industry standard planning factors and other large hub airport area facility programs.

4.14.15 PUBLIC AND NON-PUBLIC CIRCULATION

Circulation areas are also highly dependent upon building configuration and the final arrangement of terminal processors. Total circulation includes public, non-public, and sterile circulation as well as portions of future pedestrian bridges or tunnels inside the terminal. Recently designed and/or built large and medium hub airports typically have 22% to 25% of their floor plan dedicated to public and non-public circulation areas. Sterile corridors can add another 10% of building area. Total circulation for the MLIT is estimated to be around 35% of the total building area.

Table 4.13: MEP and Circulation Requirements

TERMINAL FACILITIES	EXISTING	PAL 33 REQUIREMENTS
MEP and IT Services	**53,130**	**83,351**
Mechanical, Electrical, and Plumbing	44,532	67,558
IT	8,598	15,793
Circulation	**180,023**	**280,762**
Total Areas Dependent on Building Configuration (sf)	**233,150**	**364,110**

Notes:

1/ Total requirements rounded to the nearest 10 sf

Source: Ricondo & Associates, Inc., May 2014

Prepared by: Ricondo & Associates, Inc., May 2014

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Chapter 5 | Preferred Development Plan

5.0 Preferred Development Plan

This chapter presents the preferred development plan for the new Mickey Leland International Terminal (MLIT) at Houston George Bush Intercontinental Airport. This facility replaces the existing Terminal D along with the existing Terminal C North Pier. This facility will be a completely new building utilizing the latest in aviation design principles accommodating modern queue depths, drive lanes, world-class concessions, and enhanced flexibility in accommodating a diverse fleet mix of aircraft. At completion, the new facility will have an all new terminal processor and between 15 and 21 contact aircraft parking gates, depending on the fleet mix operating at any given time. The gates are accommodated on two new pier concourses as well as additional frontal gates. The new MLIT will have a total of five levels, with the floor elevations based on the existing elevations of the Ticketing and Apron Levels. **Figure 5.1** presents an overview of the new MLIT terminal area. The preferred plan discussed within this chapter is intended to serve as a guide to the selected A/E for developing design and construction documents.

5.1 Airside Infrastructure

In this section of the manual, airside infrastructure refers to the airside elements involved in servicing the aircraft and connecting the aircraft to the terminal building. These elements include the aircraft parking layout, gate layouts, ground service equipment placement and use, passenger boarding bridges, aircraft power/preconditioned air (PCA) provisions, ground vehicle circulation, and impacts to imaginary surfaces (Part 77 and Tower Line-of-Sight). Each of these elements is described in greater detail in the following subsections.

5.1.1 AIRCRAFT PARKING LAYOUT

The new MLIT provides additional linear frontage for gates and aircraft parking. The new facility totals over 6,000 linear feet (lf) of frontage, which replaces existing Terminal D (approximately 1,900 lf) and Terminal C North (approximately 2,300 lf). The preferred plan does not increase the total number of gate positions; however, the linear frontage has increased, which provides more flexibility to accommodate larger wide-body and super wide-body aircraft. **Table 5.1** presents the aircraft gating capabilities of each of the future gates at the new MLIT.

The existing hardstand positions and deicing location directly north of Terminal D needs to be relocated prior to the construction of MLIT. Future deicing locations are to be at runway ends per the HNTB Storm Water Pollution Controls Program Definition Document (PDD) developed in the Summer of 2014. Relocated hardstand positions are to be determined during the LeighFisher Airport Master Plan process.

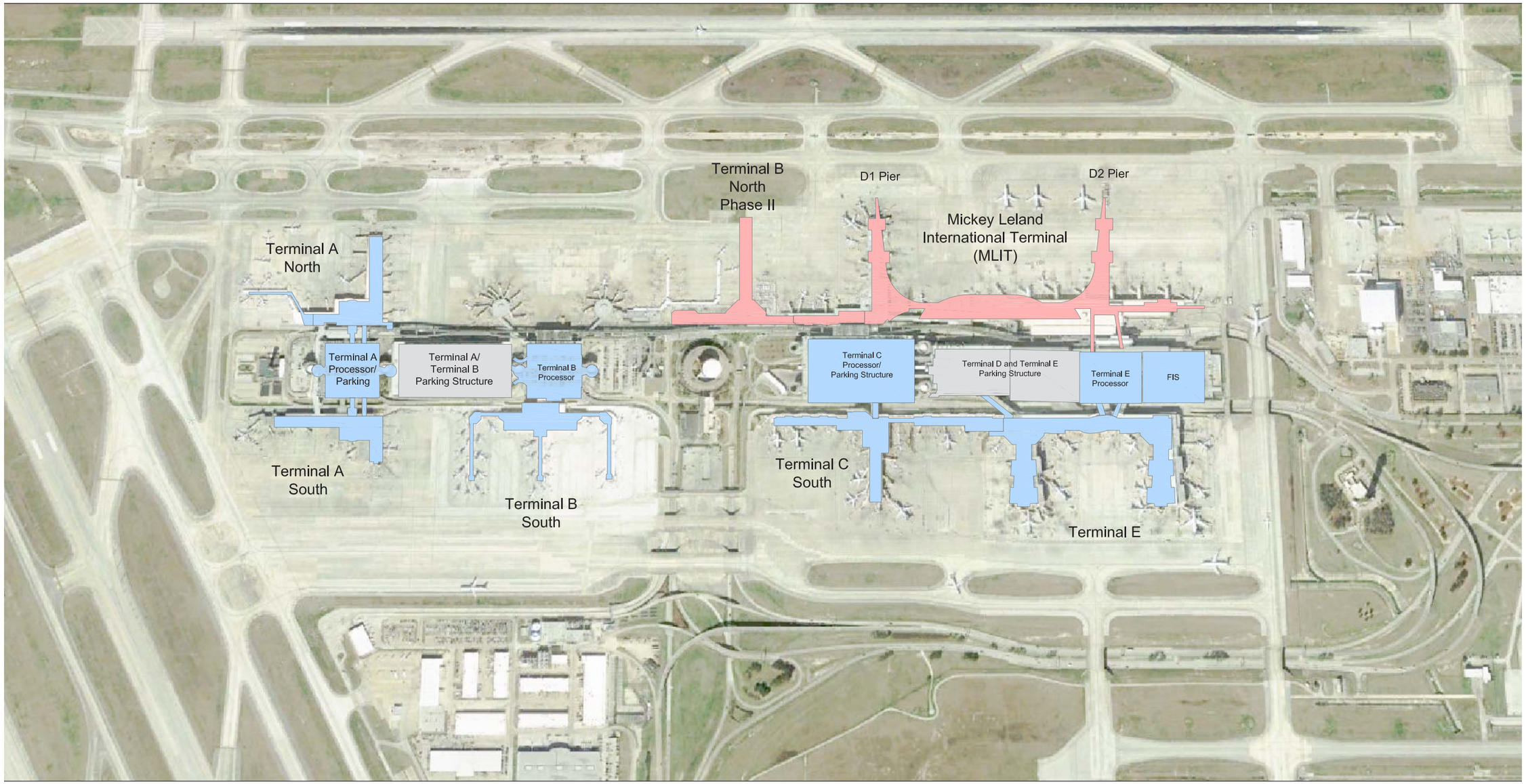
Table 5.1 – Future Terminal D Aircraft Gating Capabilities

GATE	MAXIMUM AIRCRAFT SIZE	GATE RESTRICTIONS
D1	Group V – Boeing 777-200ER	
D1A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D2	Group V – Boeing 777-200ER	
D3	Group V – Boeing 777-300ER	
D3A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D4	Group VI – Airbus A380-841	
D4A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D5	Group V – Boeing 777-200ER	
D6	Group V – Boeing 777-300ER	
D6A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D7	Group V – Boeing 777-300ER	
D7A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D8	Group V – Boeing 777-300ER	
D9	Group V – Boeing 777-300ER	
D9A	Group III – Boeing 737-900ER	Only available if alternate lead-in lines are used and adjacent gates are occupied by Group III or smaller aircraft
D10	Group V – Boeing 777-300ER	
D11	Group VI – Airbus A380-841	
D12	Group V – Boeing 777-300ER	
D13	Group VI – Airbus A380-841	
D14	Group V – Boeing 777-300ER	
D15	Group VI – Airbus A380-841	

Figure 5.2 presents the detailed future airside layout plan for the new Mickey Leland International Terminal with the maximum number of wide-body aircraft (15 positions). The recommended aircraft parking stall depth along the linear portion of Terminal D is 280 feet; however along the pier concourses the parking stall depth varies. The

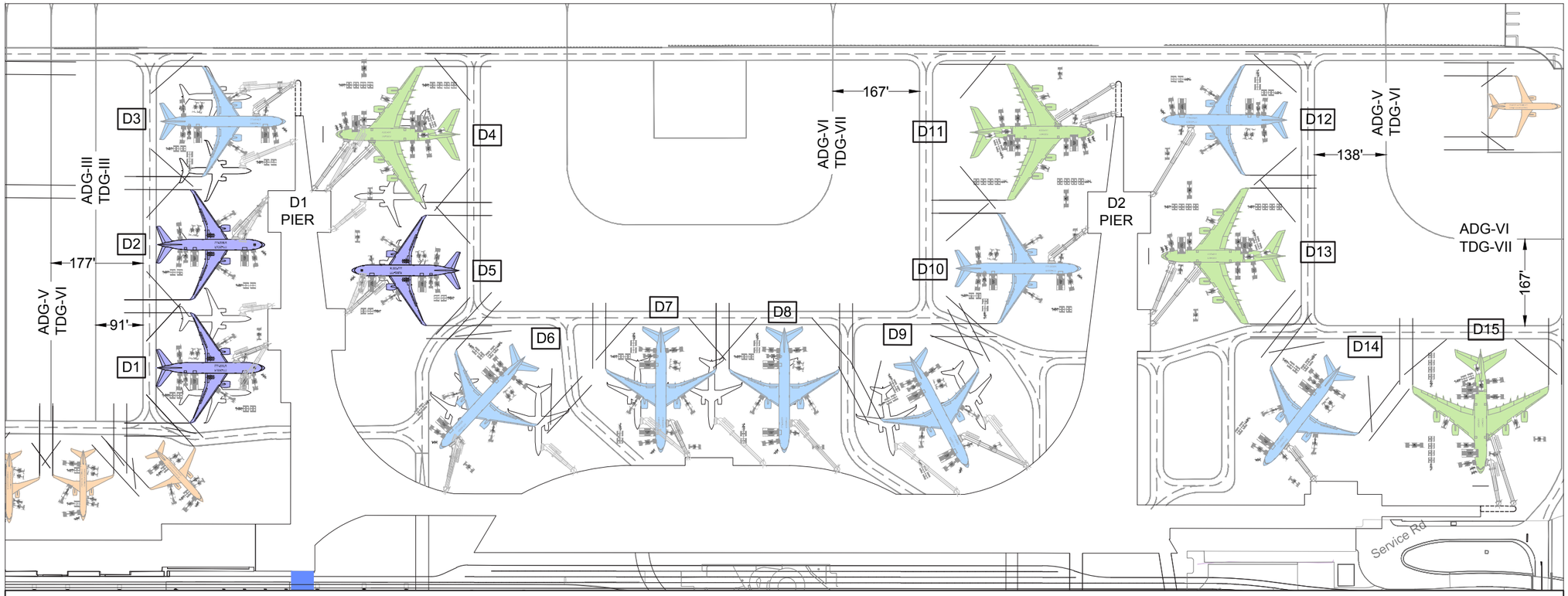
Future IAH Terminal Area

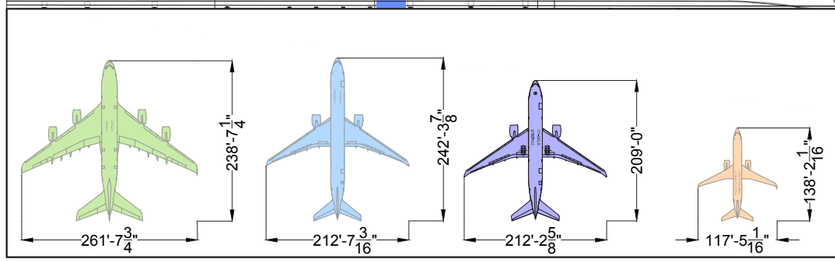
Site Plan



Not to Scale

Terminal D - Aircraft Parking and Gate Allocation





Aircraft Characteristics				
Color	A/C Type	ADG	TDG	Passengers
	A380-841	D-VI	VII	555
	B777-300ER	D-V	VI	451
	B777-200LR	C-V	V	440
	B737-900 ERW-Prelim.	D-III	III	189

Source: *AC 150/5300-13A ch 1; Burns & McDonnell Aircraft Characteristics 11th Edition*

Note: The number of passengers shown for each aircraft is the maximum capacity.

0' 200'

parking depth allows for two Group VI taxilanes between Pier D1 and Pier D2. The dual taxilanes are needed to support the high volume of aircraft operations in this area. On the east side of the Pier D2, a single Group VI taxilane provides access to the east side gates and the one Group III aircraft hardstand position. On the west side of the MLIT, in between the Pier D1 and the proposed new Terminal B pier under development by United Airlines, there is a dual Group III taxilane. The east taxilanes connect Taxiway NB with Taxiway SF. The proposed gate plan enables all aircraft to push back onto a taxilane in the non-movement area.

Figure 5.2a shows the maximum number of gates at the MLIT and the flexibility to utilize gates to park Group III Boeing 737-900 aircraft in the absence of wide and super-body aircraft. In this configuration the terminal can accommodate 21 positions. At some gates, three for two aircraft gating can be achieved for some existing gates with the addition of a third gate. At minimum, a two for one gating alternative can be achieved at most gates.

An important component of the MLIT design will be to provide common use gates that maximize the serviceability of as many different aircraft as possible at each gate. This increases the flexibility of the modernized facility and will increase its' serviceable life while fulfilling several of the objectives stated in Chapter 1 including the following:

- Provide gate capacity for all aircraft types
- Develop a terminal facility that utilizes space efficiently
- Maximize airside envelope to establish flexible and high gate utilization
- Preserve ability to expand incrementally as demand grows with addition of a future East Pier

5.1.2 GATE SEPARATION

Separation is the minimum distance between any parts of any two adjacent aircraft whether entering a gate, parked in the gate, or leaving the gate. Separation is sometimes referred to as "wingtip clearance" due to the fact that the separation distance is typically measured between the wingtips of adjacent aircraft. A minimum aircraft separation of 25 feet between the nearest points of two adjacent aircraft will be established for the project.

In practice, aircraft do not maneuver and park precisely where planned, and ground service equipment and personnel routinely maneuver between parked aircraft. This separation provides a safe distance for variation in aircraft maneuvering and parking and for Ground Service Equipment (GSE) movement. It also facilitates fire fighting access. Lastly, the separation standard is established based on the largest aircraft able to use the gate. Thus, when smaller aircraft are positioned at the gate, additional separation will result.

5.1.3 ANALYSIS

A preliminary Part 77 study was conducted to ensure the proposed Mickey Leland International Terminal concept does not penetrate the imaginary surfaces per FAA design standards. All elevation data for this analysis was gathered from the web-based Houston Airport System Airspace Map tool.

Figure 5.3 and **Figure 5.4** depict key points of interest where the transitional surface of Runway 8R-26L was used to determine the maximum allowable heights at these locations near Terminal D. The first potential impact is at the threshold which separates the Vehicle Service Road (VSR) from the Remain Over Night (RON)/hardstand parking positions (northeast). This is a critical area on the airfield that could be affected by a penetration of an aircraft tail (vertical stabilizer) parked at these positions. The second imaginary surface, defined by the limit of the proposed terminal pier, was used to verify that the potential height of the terminal building will remain clear of the transitional surface. Lastly, the center point between the edge of the terminal building and end of the transitional surface was also assessed as a tertiary checkpoint to measure against the height of the tails of wide-body aircraft parked along this longitudinal marker. There are no anticipated penetrations to Part 77 Surfaces based on this analysis of the proposed concept.

5.1.4 LINE OF SIGHT REVIEW

An air traffic control tower (ATCT) line of sight analysis was performed for the new MLIT. This analysis was created using 3D modeling software that projects the anticipated locations of obstructed viewing of the airfield from the ATCT due to the MLIT and aircraft parked at its gates. This analysis assumes the largest possible aircraft at each respective gate. **Figure 5.5** shows the results of the LOS analysis. The shadowed areas represent areas with a potentially obstructed view from the ATCT. The building and ground elevations used are listed in feet above mean sea level (MSL) and include the following assumptions:

- Elevation of sight from the ATCT – 395 ft. MSL
- Elevation of ATCT Cab – 390 ft. MSL
- Elevation of the apron area – 96.4 ft. MSL
- Leland International Terminal – 153.4 ft. MSL (highest points)

The MLIT processor, along with Pier D1 and Pier D2, are expected to reach 153 ft (MSL) as they will accommodate airline clubs and an international arrivals sterile corridor on a third level. Based on the elevations and dimensions of the proposed MLIT, the line of sight analysis shows that the terminal processor building restricts visibility of the aircraft parked along the frontal gates and northwest toward Pier D1. Pier D1 restricts visibility of the majority of the dual taxilanes between Pier D1 and the proposed Terminal B pier, while Pier D2 restricts visibility up to the VSR that runs behind the tails of the aircraft. The ends of Pier D1 and Pier D2 restrict visibility to the north obstructing portions of the VSR and into Taxiway NB, though the taxiway centerline remains in view, with the exception of visibility restricted due to the aircraft parked at the gates.

Aircraft parked at gates, particularly those at the ends of Piers D1 and D2, will also restrict visibility from the ATCT cab; however, these obstructions are only while a particular gate is occupied. The fuselages of these aircraft restrict visibility from the tower immediately behind the aircraft projecting toward the northwest. The tails of these aircraft also create long slender obstructed viewing areas that extend across Taxilane NB, and in the case of the Airbus A380 position at the west ends of Piers D1 and D2, as far north as Taxiway NA.

While the MLIT building creates relatively large areas of restricted visibility in the space immediately west of the piers, the majority of the obstructions created by the building and parked aircraft is within the non-movement area.

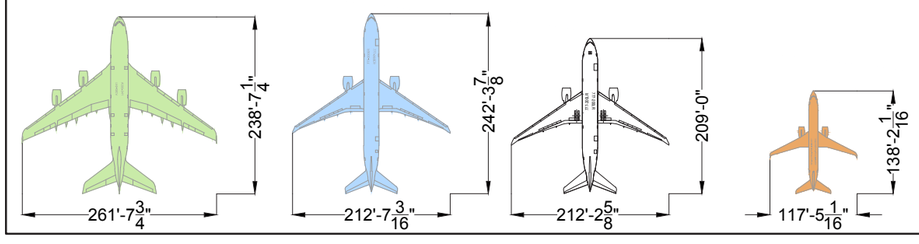
5.1.5 VEHICLE SERVICE ROAD NETWORK

The proposed service road network will comprehensively serve all aircraft contact gates and the aircraft hardstand positions. The reconfigured service road will be a two-lane 25 feet wide service road that runs parallel to the façade of the terminal processor and piers behind each aircraft parking position. The service road is constrained by the aircraft parking stall depth on the west, the Taxiway SF object free area on the east, the aircraft safety envelope on the south, and the pier length to the north. Access to all existing baggage tunnels under the terminal is preserved following the same constraints standards outlined above.

5.1.6 PASSENGER BOARDING BRIDGES

For efficiency, passenger safety, and comfort, airlines prefer that passengers enter and leave aircraft via passenger boarding (or loading) bridges. Bridges vary in construction from fixed tunnels with cabs that elevate or lower

Terminal D - Aircraft Parking of B737-900ERWs



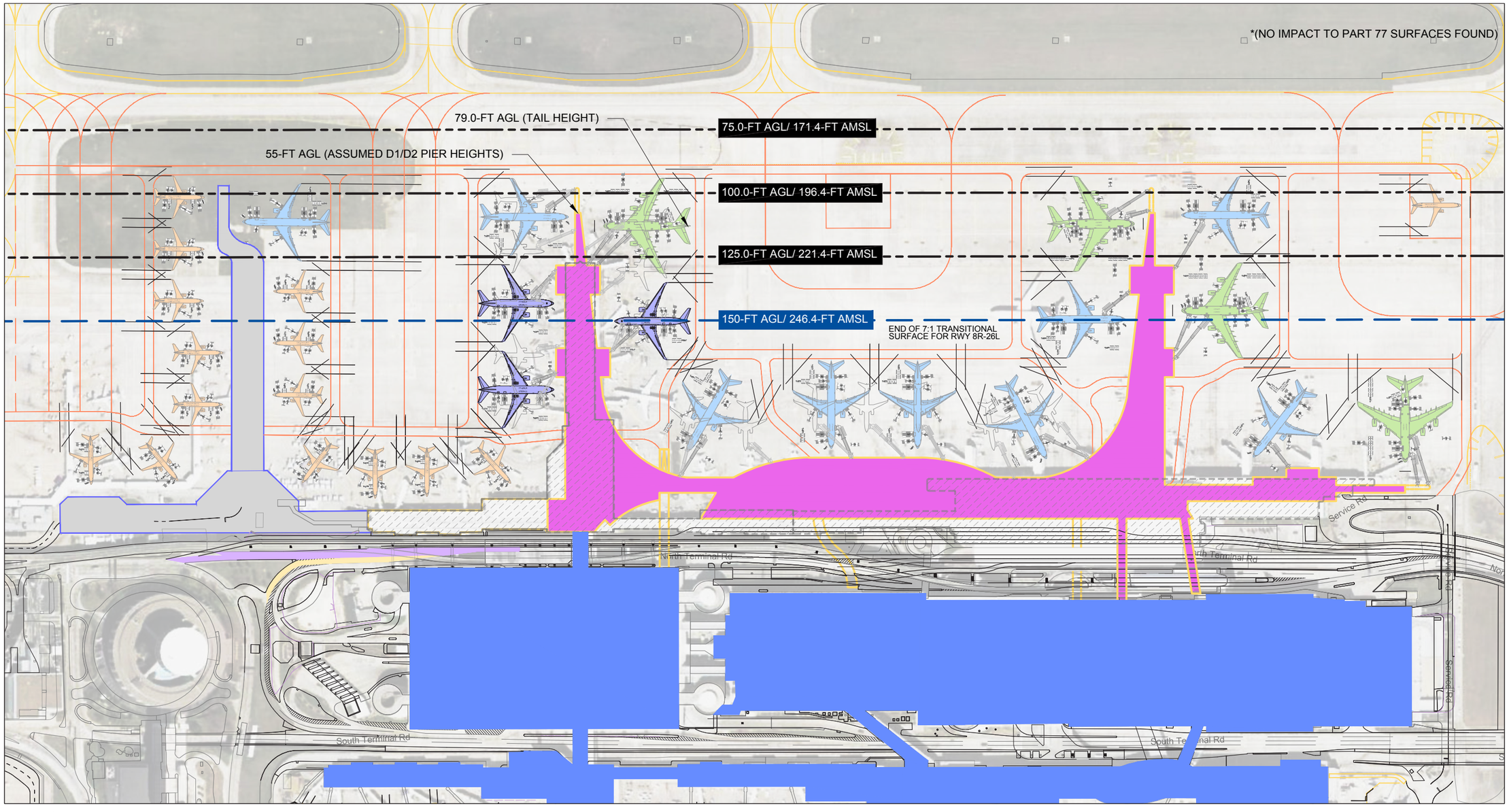
Aircraft Characteristics				
Color	A/C Type	ADG	TDG	Passengers
	A380-841	D-VI	VII	555
	B777-300ER	D-V	VI	451
	B777-200LR	C-V	V	440
	B737-900 ERW-Prelim.	D-III	III	189

Source: *AC 150/5300-13A ch 1; Burns & McDonnell Aircraft Characteristics 11th Edition*

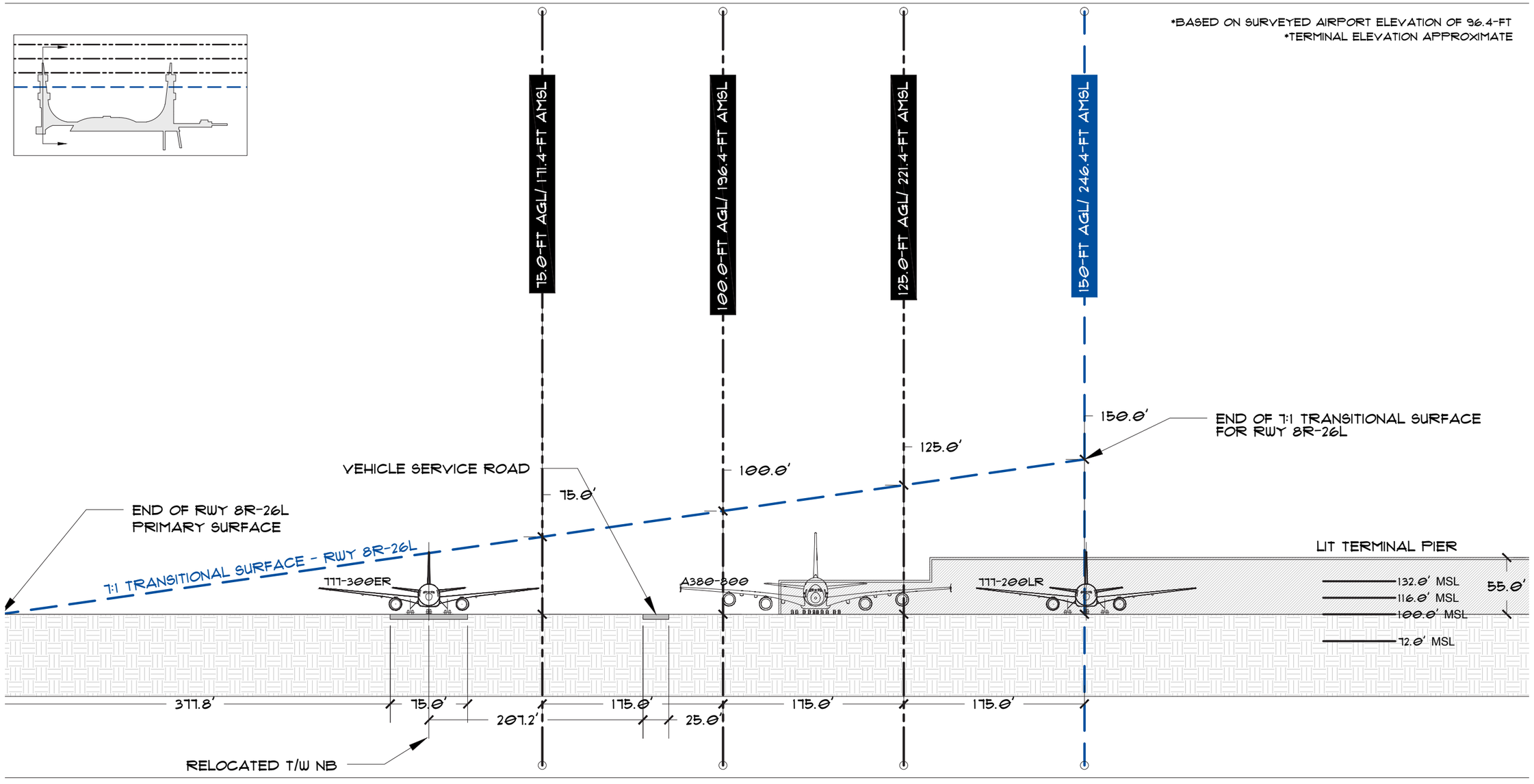
Note: The number of passengers shown for each aircraft is the maximum capacity.

0′ 350′

MLIT Rebuild - Part 77



MLIT Rebuild - Part 77 (Profile)



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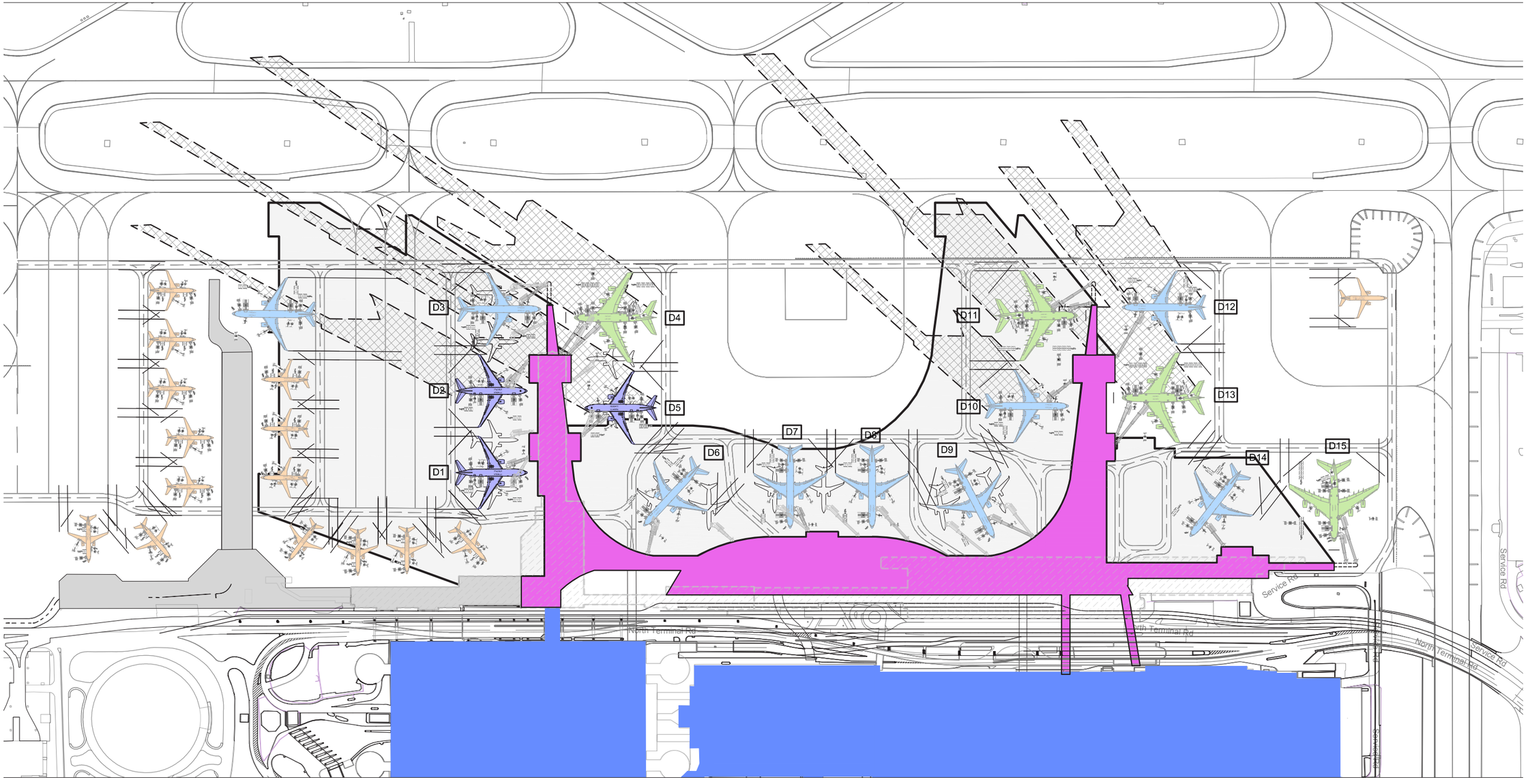
Line-of-Sight Study (Rebuild Option)



and rotate slightly to dock with aircraft, through complex bridges that operators may maneuver in any direction to position at the aircraft, including extending or shortening the tunnel section.

The most common design is the ramp drive, telescoping three-tunnel section that is rectangular in cross-section and hinged at the rotunda end for vertical motion. Maximum slopes in accordance with ADA requirements are approximately 8.33% (1 in 12 slopes). The telescoping tunnels should permit serving the most commonly found commercial aircraft from the narrow-body to the wide-body. The maximum height requirement is 4 inches below the lowest aircraft nominal sill height. The maximum achievable height above apron at cab floor level can be as high as 17 feet 9 inches and as low as 5 feet 6 inches.

Every gate in the MLIT will have at least one passenger boarding bridge (PBB). In addition, the four A380 gates will require at least two PBBs with one of the PBBs dedicated to servicing the upper deck at door U1. Additional PBBs may also be considered as appropriate, which provides more efficient loading and unloading of aircraft. Many facilities provide two PBBs for B747, B777, and other wide-body sized aircraft, while others are providing three PBBs for the A380 (two for the lower deck and one dedicated for the upper deck). Specific rotunda elevations and serviceability of aircraft will be defined during the final design of the new MLIT.

In addition to providing more flexibility in loading and unloading, additional PBBs may be considered to maximize the potential to service multiple smaller ADG III aircraft in two-for-one or three-for-two parking configurations. **Figure 5.2a** depicts a maximum gate utilization arrangement where bridges may be used to board smaller aircraft. Where more than two ADG III need to be accommodated, additional PBBs may need to be installed to board them simultaneously.

All jetbridges and fixed tunnel sections to include stand-alone rooftop pre-cool units.

5.1.7 GROUND SERVICE EQUIPMENT

Aircraft parked at the passenger terminal rely on ground service equipment (GSE) for important services ranging from auxiliary power to towing. All of this equipment is available in mobile form and stationary units may replace some of the equipment. Stationary equipment can reduce vehicular traffic around the aircraft and the space required for parking the equipment while in use and between uses. Safety improves when GSE traffic diminishes.

GSE includes equipment such as aircraft and baggage tractors, baggage handling conveyors, baggage carts, cabin service vehicles, and catering vehicles.

Airports endeavoring to reduce mobile source emissions from airline operations are working with their tenants to convert existing GSE to clean burning fuels and in some cases are mandating that new GSE use clean fuels or electrical power when practicable. Electric powered GSE demands considerable investment in space and infrastructure for recharging stations.

The new terminal design allows for ample GSE storage locations located below the concourse providing covered but non-conditioned space. These areas also allow for easy access and maneuverability across the MLIT campus.

It is recommended, in order to reduce over crowding at Gates, that a single double ended charging station be provided between each gate. In order to accommodate additional GSE, infrastructure shall be provided at the east and west ends of the MLIT Terminal, between Piers D1 and Terminal B1, as well as at the east end of Pier D2. These additional charging stations will be able to accommodate 14 GSE, by using 7 double ended charging stations. In order to save on capital costs, these 7 double ended charging stations can be added later, and at the discretion of HAS. However in order to ensure that electrical infrastructure is available in the future, upstream distribution equipment including conduit for future feeders, shall be sized to accommodate the full connected load of each of the charging stations.

5.1.7.1 Aircraft Tractor

Airlines typically use an aircraft tractor to push aircraft out of gates served by passenger boarding bridges. Many commercial airliners are capable of backing out of the gate, but using thrust reversers in the confined space of the gate poses a risk to ground personnel, buildings, equipment, and the aircraft if the engine exhaust stirs up debris on the apron. An aircraft tractor uses much less energy to achieve the same movement, is quieter, and offers more control of the aircraft movement.

Tractors vary in performance, means of connection to aircraft, and required clearances. To achieve traction, they are very heavy for their size, and have high torque capability. A tractor capable of moving a Group V airplane can easily breach a wall or a structural column of a building. Gate planning provides a margin of safety for movement of the aircraft tractors to avoid such unfortunate events. In general, the tractor should have free space equal to its length behind it when coupled to the nose wheel of a parked airplane. **Table 5.2** lists typical aircraft tractors.

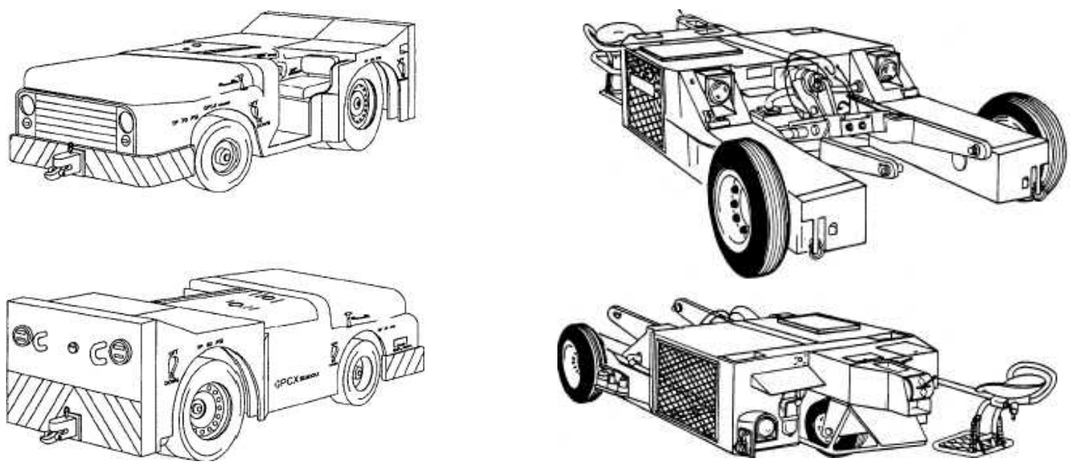
Table 5.2 – Typical Aircraft Tractors

MANUFACTURER	MODEL	AIRCRAFT Served	GVW (LB)	LENGTH (IN)	WIDTH (IN)
FMC	B400	ADG III, B757	40,000	178	90
FMC	B600	ADG III, IV	60,000	199	102
FMC	B1200	ADG IV, V	120,000	273.5	114
FMC	Expediter 400	ADG IV, V	45,400	305	165
NMC-Wollard	200	ADG III, IV	42,000	156	85
Tug	GT110	ADG IV, V, VI	120,000	258	110

Source: Manufacturer Data

Figure 5.6 illustrates one tractor that couples directly to the nose gear of the aircraft (towbarless) and one that uses a towbar to link to the nose gear.

Figure 5.6 – Aircraft Tractors



Towbar-style *Towbarless style*

5.1.7.2 Baggage Handling

Airlines and contractors move baggage and cargo between the terminal and aircraft with a collection of equipment that includes tugs, carts, dollies, containers, pallets, and loaders. This equipment is stored in and around the terminal when not in use, must move between the aircraft and the terminal, and is positioned at specific locations around the aircraft when loading or unloading. **Table 5.3** lists the principal types and attributes of mobile baggage handling GSE.

Table 5.3 – Ground Service Equipment Characteristics

TYPE	MFR.	MODEL	GVW (LB)	LENGTH (IN)	WIDTH (IN)	OTHER	NOTE
Baggage Tug						Turning Radius	
	Tug	MT8	10,000	128	74	173	IC1
	Tug	MT12	14,000	128	74	173	IC
	Tug	MX4	7,400	117	57	150	Electric
Baggage Cart						Capacity (lbs)	
	Adaptive	Express	220	100	44	1,000	RJ
		Valet					Apron Use
	Wasp	Torsion Axel	1,750	116	60	8,000	Towed
Container Dolly							
	Wasp	A04230D	1,300	107	67	3,500	Towed
	Wasp	A02847D	1,800	152	73	7,000	Towed
Baggage Loader Belt							
	Air-Mak	MCBL10SP	5,952	303	71	2,000	IC
	Charlatte	CBL2000E	9,750	300	86	2,000	Electric
	NMC-Wollard	TC-888	5,900	298	82	2,000	IC
Baggage Loader Main Deck							
	Air-Mak	MDL-15	26,455	337	156	15,000	IC
	FMC	MDL-60	65,500	473	176	60,000	IC

Source: Manufacturer Data. IC denotes internal combustion engine for propulsion and operation.

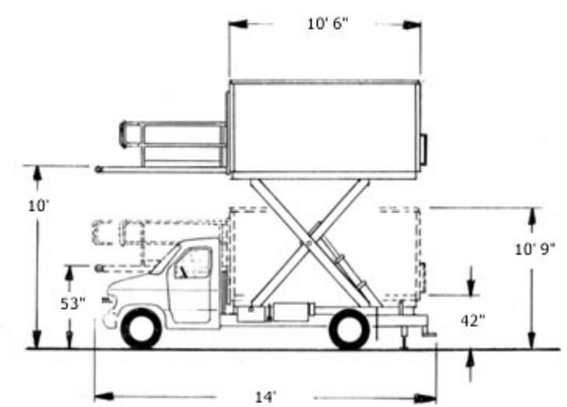
5.1.7.3 Cabin Service

Cabin service includes cabin cleaning and other provisioning for flights that are not being catered such as emptying sanitary hold tanks (lavatory service). Lavatory service may be provided from towed carts (common at RJ facilities) or trucks. The characteristics of a truck for cabin cleaning are similar to the catering truck described below. A lavatory service truck is typically a long bed pickup truck fitted with two tanks – one to replace fluid, and one to hold waste. For wide-body aircraft, the truck will have a lift platform to permit connecting the hoses to the aircraft.

5.1.7.4 Catering

Airlines and contractors cater flights (even flights with no meal service) to remove soiled service items and trash and to provide beverages, ice, and snacks. The typical method is to dock a catering truck with an elevating body at one or more doors serving an onboard galley. **Figure 5.7** below depicts a typical catering truck.

Figure 5.7 – Typical Catering Truck



5.1.7.5 International Waste

An international waste collection dumpster should be located near the base of the pier (this location is centralized and there is more ramp area between aircraft). Waste collected from international flights must be collected and sterilized separately from waste collected from domestic activity at MLIT. Consideration should be given for the location of trash compactors.

5.2 Apron Utilities

Apron utilities include all of the utilities that service the aircraft parking positions and the apron area. These utilities include the fueling system, ground power, potable water, and pre-conditioned air. These are discussed further in the following sub-sections.

5.2.1 AIRCRAFT FUELING SYSTEM

Commercial aircraft fueling requires either a fuel tender, which is a self-contained mobile fuel delivery unit, or the combination of a hydrant fueling system (usually with underground piping) and a much smaller fueling cart that provides the link from the hydrant system to the aircraft. Currently, aircraft are fueled via hydrant fueling and hydrant fueling will be used for fuel delivery to the aircraft at the proposed new MLIT.

The preferred aircraft fueling plan is to continue using the underground hydrant distribution system. However, the existing fuel mains run within the new building footprint (processor facility) and will need to be demolished and new fuel mains installed. The proposed new Terminal B North Pier will be the enabling project for the MLIT because the fuel main points of connections will need to be located on the west side of Terminal B. In addition, new 16 inch fuel mains are recommended to be routed airside, to the north of Piers B North, D1, and D2. Refer to **Figure 5.8** for the preferred fuel distribution system plan.

From time to time it may be necessary to employ fuel tenders for certain irregular fueling operations. Tanks on the tenders range in size from 1,000 to 4,000 gallons and fully loaded trucks may weigh as much as 40,000 pounds. Special equipment on aircraft fuel trucks includes filters, pressure fittings for underwing refueling, grounding leads specialized for aviation use, and radio communications for movement on the airfield. Large fuel trucks have large turn radii and limited driver vision, mandating the use of other ground personnel to ensure safe maneuvering at aircraft parking positions.

5.2.2 GROUND POWER

The preferred ground power (400 Hz) systems are recommended to be a zone set of motor generators. Commercial aircraft electrical systems use high frequency power (400 Hz), unlike the 60 Hz power distributed on public power grids. To conserve fuel and reduce emissions, airlines use 400 Hz electricity produced by fixed or mobile equipment to power aircraft at the gate until departure time. Fixed equipment, whether point-of-use equipment installed on the passenger boarding bridge or centralized with distribution over the passenger boarding bridge, requires no space at the gate for the unit.

Mobile equipment, Ground Power Units (GPU), may be self-propelled or towed, but require storage when not in use and space positioning for use. Towed GPUs weigh approximately 3,000 pounds (lbs), and are approximately 5 feet tall. **Table 5.4** presents physical characteristics of typical ground power units. GPM should be sized to accommodate B787. Note: All wide-body aircraft require dual receptacles for GPU.

Table 5.4 – Typical Ground Power Unit Characteristics

MANUFACTURER	MODEL	GVW (LB.)	LENGTH (IN.)	WIDTH (IN.)	OTHER	NOTE
Hobart	JET-EX 5D	2,669	76.3	67		IC/towed
Unitron	GFC Series	1,750	45 (two such)	32 (two such)	≤ 180 kVA	Fixed to Passenger Boarding Bridge

Source: Manufacturer Data

5.2.3 POTABLE WATER

At passenger terminals with boarding bridges, airlines will most often obtain potable water from a supply carried on the boarding bridge. Alternatives include hydrant installations in the apron and portable carts or trucks.

For the proposed MLIT, all passenger loading bridges are to be equipped with potable water systems connected to the building water supply system that are compliant with current regulatory requirements for aircraft service (i.e., EPA, USDA).

5.2.4 PRE-CONDITIONED AIR (PCA)

PCA is important to conserve aviation fuel in aircraft while parked at the gate and to reduce emissions. Fixed installations have the highest initial cost and offer life-cycle cost savings, as they may meet all needs with less total heating or cooling capacity than point-of-use installations. They typically circulate refrigerant through piping in the terminal building and down the passenger boarding bridge to heat exchanges mounted on the bridge. Conditioned air then reaches the aircraft through flexible ductwork from below the bridge.

Airlines occasionally use ground air conditioning units for large jets and frequently for commuter aircraft. These units are internal combustion powered, typically towed into place, and emit noise and exhaust that impacts ground personnel and passengers if they use the apron to board.

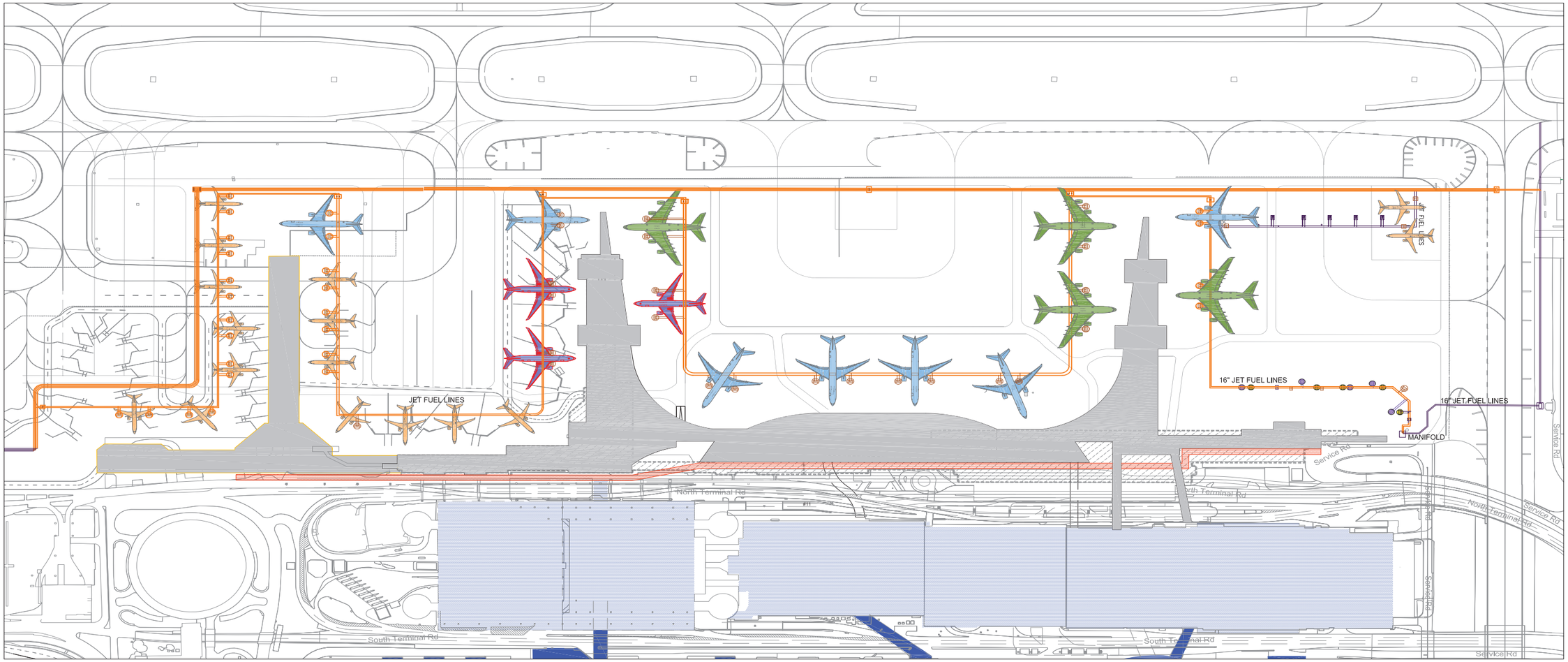
Alternative PCA systems include point–of-use and zone type. The zone system to consider is screw chillers with ice storage to deliver 20 degrees Fahrenheit sub-cooled glycol mix solution to each gate. The system will serve both the aircraft and the passenger loading bridges at each gate.

The preferred PCA system is recommended to be either zone or point–of-use (POU). A life cycle cost analysis will be needed during design to facilitate selection of the most sustainable PCA system. UA prefers POU system, not zone type.

5.2.5 AIRCRAFT SANITARY WASTE

The preferred plan to dispose of aircraft restroom waste is to collect it in trucks and transport to a triturator, where it will be disposed of to the sewer through grinder pumps. The triturator is planned to be located on the east side of MLIT and is anticipated to include a two bay service building with a basement. The grinder pumps will be located in the basement allowing truck deliveries to dump their tanks by gravity. The waste runs through the grinder pumps and runs into the existing sewer line.

MLIT Proposed Hydrant Fueling Preferred



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5.2.6 GENERAL NOTE

D1 Pier jetbridges, PCA and GPU units shall be connected to UA's CAMMS system for monitoring. Further, each D1 gate shall have a Ramp Information Display Systems (RIDS) and CCTV connected to UA infrastructure.

5.3 Terminal Building

The Houston Airport System (HAS) realized the need to address issues with an aging Terminal D and the demand for increased international passenger service. Work began on the MLIT PDM in February 2014 under the HNTB On-Call Planning Services contract. The Design Day Flight Schedule described in **Chapter 2** was developed by the LeighFisher Master Plan team and used to determine program requirements (see **Chapter 4**) developed by Ricondo & Associates, Inc. Extensive collaboration and weekly workshop presentations were used to obtain input from HAS staff and airport stakeholders as the team initially evaluated plans to modify Terminal C North to accommodate arriving international passengers. The initial plan was to add a Sterile Corridor to the existing pier concourse along with a new airline club above the roof (see **Figure 5.9**). The initial plan for Terminal D was to move forward with the "Rebuild" option developed during the Mickey Leland International Terminal (MLIT) PDM dated June 7, 2013 (see **Figure 5.10**).

During the first few weeks of MLIT planning, several terminal layout alternatives and aircraft parking combinations were evaluated. A unified MLIT terminal footprint with two pier concourses and a centralized processor became the preferred alternative. The only remaining question was whether to tear down the existing Terminal C North to the structure and "Renovate" or demolish the entire building and "Rebuild". **Figure 5.11** shows the "Rebuild" vs. "Renovate" summary. Rough Order of Magnitude (ROM) cost estimates were developed for both alternatives. In June 2014 the decision was made to "Rebuild" both Terminal C North and Terminal D within a "design to budget".

This section presents the recommended development for the new Mickey Leland International Terminal (MLIT). Using the program requirements outlined in **Chapter 4**, a detailed space plan is presented by functional component for each level of the terminal building.

The MLIT consists of the reconstruction (i.e., rebuild) of the existing Terminal C North and Terminal D structure as well as the Terminal C Connector or C Link. The reconstruction (rebuild) occurs in phases while maintaining a certain level of operational functionality to accommodate flights and passengers during demolition and construction of the C-Link, new pier concourse, ticket lobby, and east end of the building. Program phasing is discussed in detail in **Chapter 7**.

The program requirements, based on the PAL 33 flight schedule, call for an optimized terminal building of approximately 801,520 sf as identified in **Chapter 4**. The floor plans presented in this section total 801,530 sf; a difference of 10 sf. While the building overall is right at the recommended program square footage, there are individual areas that are above or below program that will need to be addressed further during design.

The following sections describe in detail the proposed floor plans for the MLIT. The descriptions are organized by level including: Baggage Level, Ticketing Level, Apron Level, Departures Level, and Club Level.

5.3.1 BASEMENT PLAN (LEVEL 74)

The Basement/Baggage Level Plan includes elements of the Checked Baggage Inspection System (CBIS), a baggage tunnel to connect ticketing to the CBIS, a utility tunnel, two existing tug drive tunnels, and an existing pedestrian tunnel. This level is all subterranean, one level (14 feet) below the Ticketing Level, and two levels (26 feet) below the Apron Level. The Basement/Baggage Level floor plan totals approximately 43,400 sf and is illustrated in **Figure 5.12**. This excludes the area of the existing tug drive and pedestrian tunnels, which will remain in the proposed concept, as well as the proposed baggage and utility tunnels.

5.3.1.1 Checked Baggage Inspection System

The CBIS bag screening area is proposed on the west side of the MLIT under the D2 Pier. The existing Terminal D Baggage Handling System (BHS) configuration requires a building footprint of approximately 20,000 sf for the existing east and west CBIS systems. This is compared with approximately 40,000 sf for the recommended CBIS basement layout in the MLIT. This new facility is approximately twice the size of the existing one. It is suggested that the proposed dimensions be adopted pending development of design layouts for the CBIS bag screening system, taking into account that the screening capacity of the existing east matrix appears to be adequate for the design horizon currently under consideration. There are, however, some limitations regarding the existing systems that should be addressed in a new design. These limitations include single point of failure issues, preference for dual delivery lines to and from the CBIS, and compliance with Transportation Security Administration (TSA) Planning Guidelines and Design Standards (PGDS).

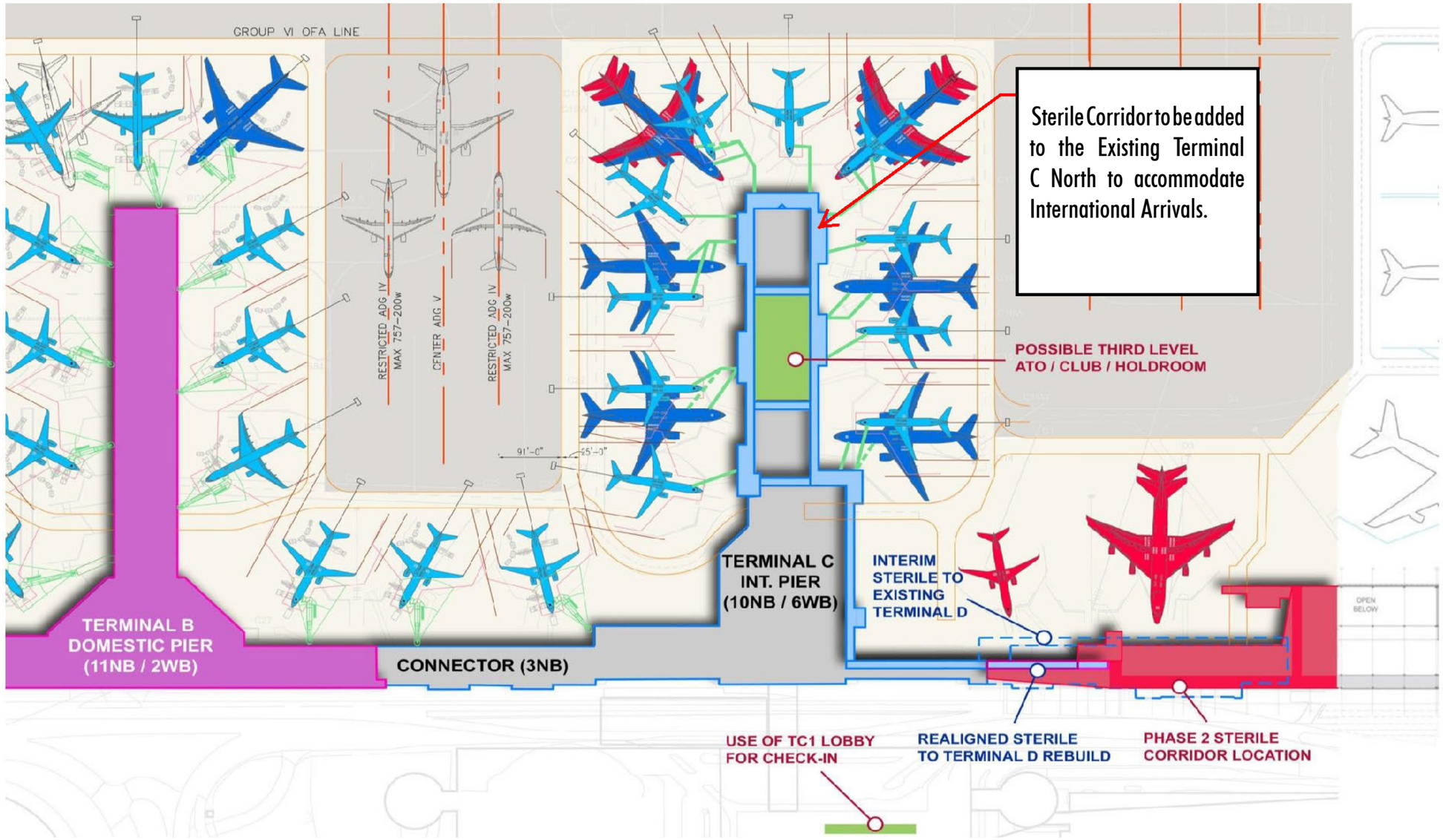
It is also necessary to consider the vertical height of the basement in preparation of the CBIS design since it is often necessary to provide space above TSA screening machines for conveyor rights-of-way and maintenance access, while also providing sufficient right-of-way space above the screening machines for hoists used to access and maintain explosive detection system (EDS) components.

One major consideration that should be studied is access to the basement for installation purposes, including future needs to remove EDS equipment such as complete screening machines (or at least major elements of these machines), as these are beyond the capability of the elevator proposed at the northwest corner of the basement. In some installations floor penetrations are provided above (or below) screening machines to allow removal/installation without need for major conveyor removal, but this may not be practical in the case of the proposed layout, where the CBIS is immediately below the apron and airside roadway system.

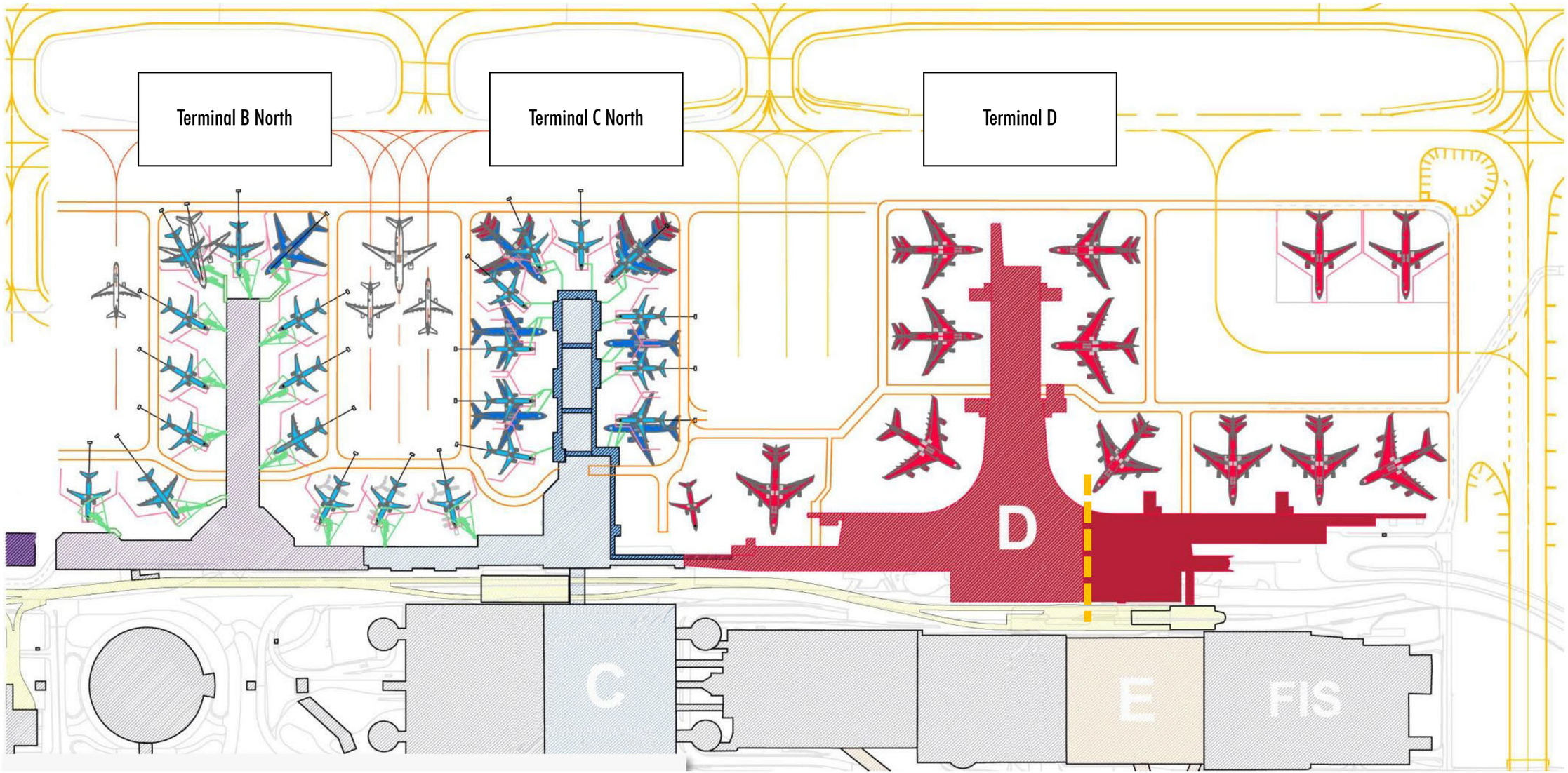
It will be necessary to develop functional/schematic diagrams for the BHS system (one line diagram format) and, after confirmation that the functionality meets with client needs and TSA, PGDS guidelines, prepare a preliminary design layout to confirm the required basement dimensions. Care should be taken to accommodate TSA office space, break rooms, restrooms, parts storage, and similar spaces required for TSA operations, maintenance, and other activities.

The layout for the CBIS is expected to be generally in line with the functionality shown in **Figure 5.13**.

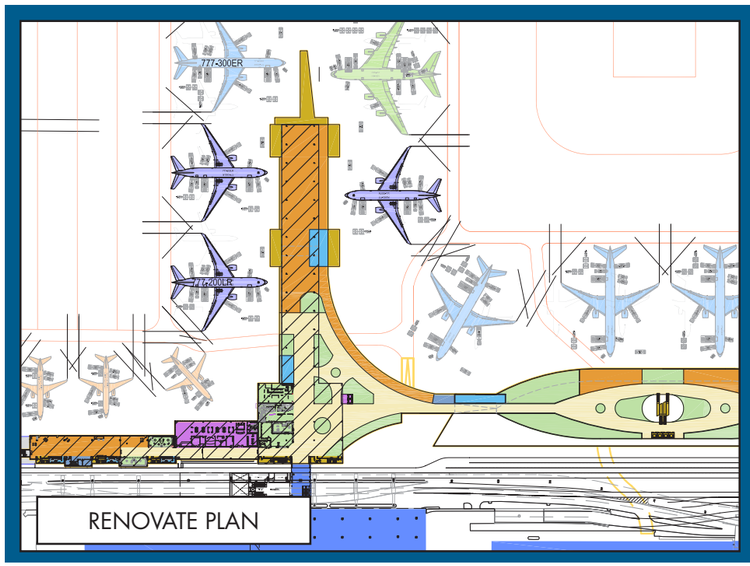
Original Terminal C North Concept

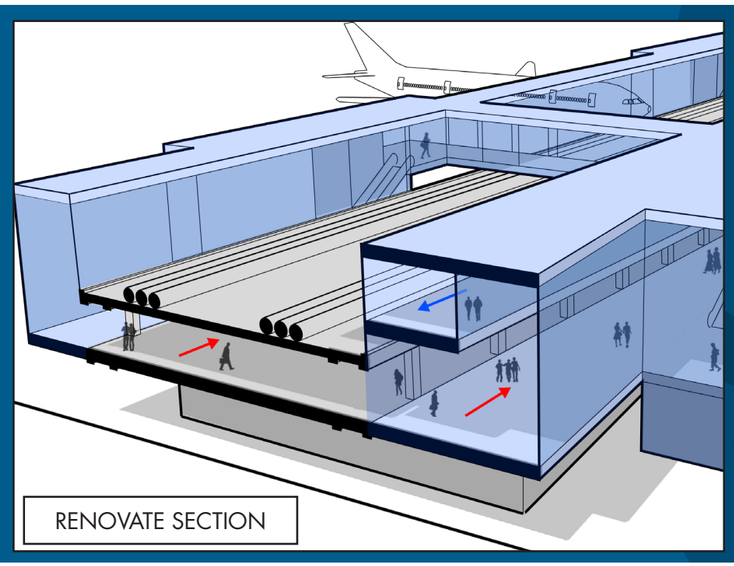


Original Terminal C North and Terminal D Concept



Renovate vs. Rebuild Summary

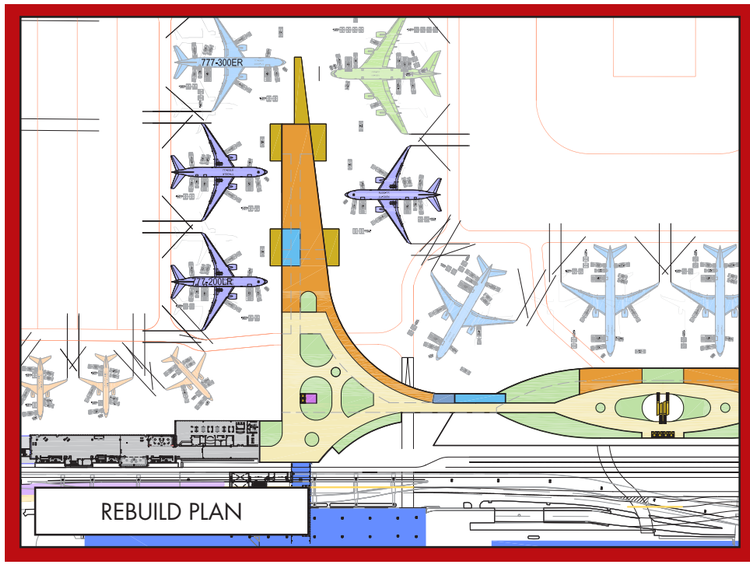


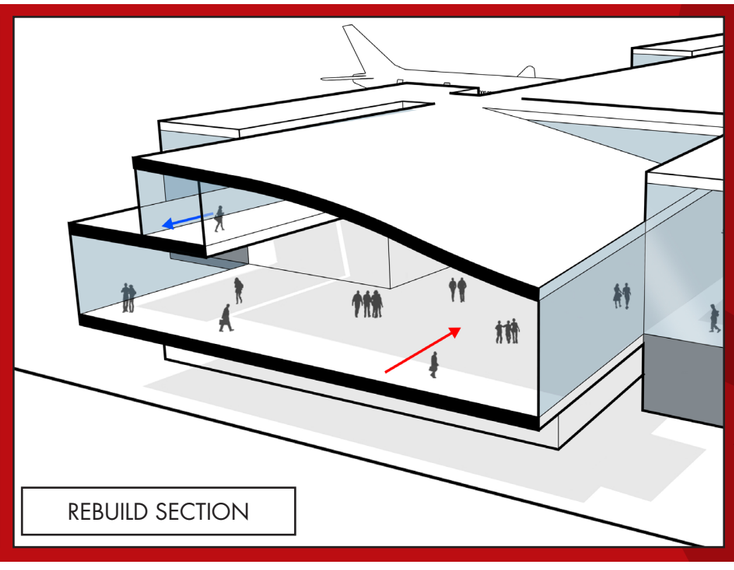


RENOVATE

NUMBER OF Int'l GATES: 14-15 (INCL. 4 A380)
NUMBER OF PROCESSORS/SSCP: 1
LANDSIDE WIDTH TO FIS: 210' (INCLUDES BYPASS)
CONCOURSE C FLOOR ELEVATION: 13' ABOVE APRON
PIER VOLUME:
EXISTING ROOF CONSTRAINTS/LESS FLEXIBLE
SSCP LANES: 8-12 @ CENTRAL PROCESSOR

WALKING DISTANCES:
STERILE C PIER (FARTHEST GATE) TO FIS: 2,500 LF
STERILE D PIER (FARTHEST GATE) TO FIS: 980 LF
SECURITY TO C PIER (FARTHEST GATE): 1,200 LF





REBUILD

NUMBER OF Int'l GATES: 14-15 (INCL. 4 A380)
NUMBER OF PROCESSORS/SSCP: 1
LANDSIDE WIDTH TO FIS: 210' (INCLUDES BYPASS)
CONCOURSE C FLOOR ELEVATION: 16' ABOVE APRON
PIER VOLUME :
OPEN/DAYLIT/FLEXIBLE/PIER UNITY
SSCP LANES: 8-12 @ CENTRAL PROCESSOR

WALKING DISTANCES:
STERILE C PIER (FARTHEST GATE) TO FIS: 2,500 LF
STERILE D PIER (FARTHEST GATE) TO FIS: 980 LF
SECURITY TO C/D PIER (FARTHEST GATE): 1,200 LF

MLIT Rebuild Option L074 - Baggage Level

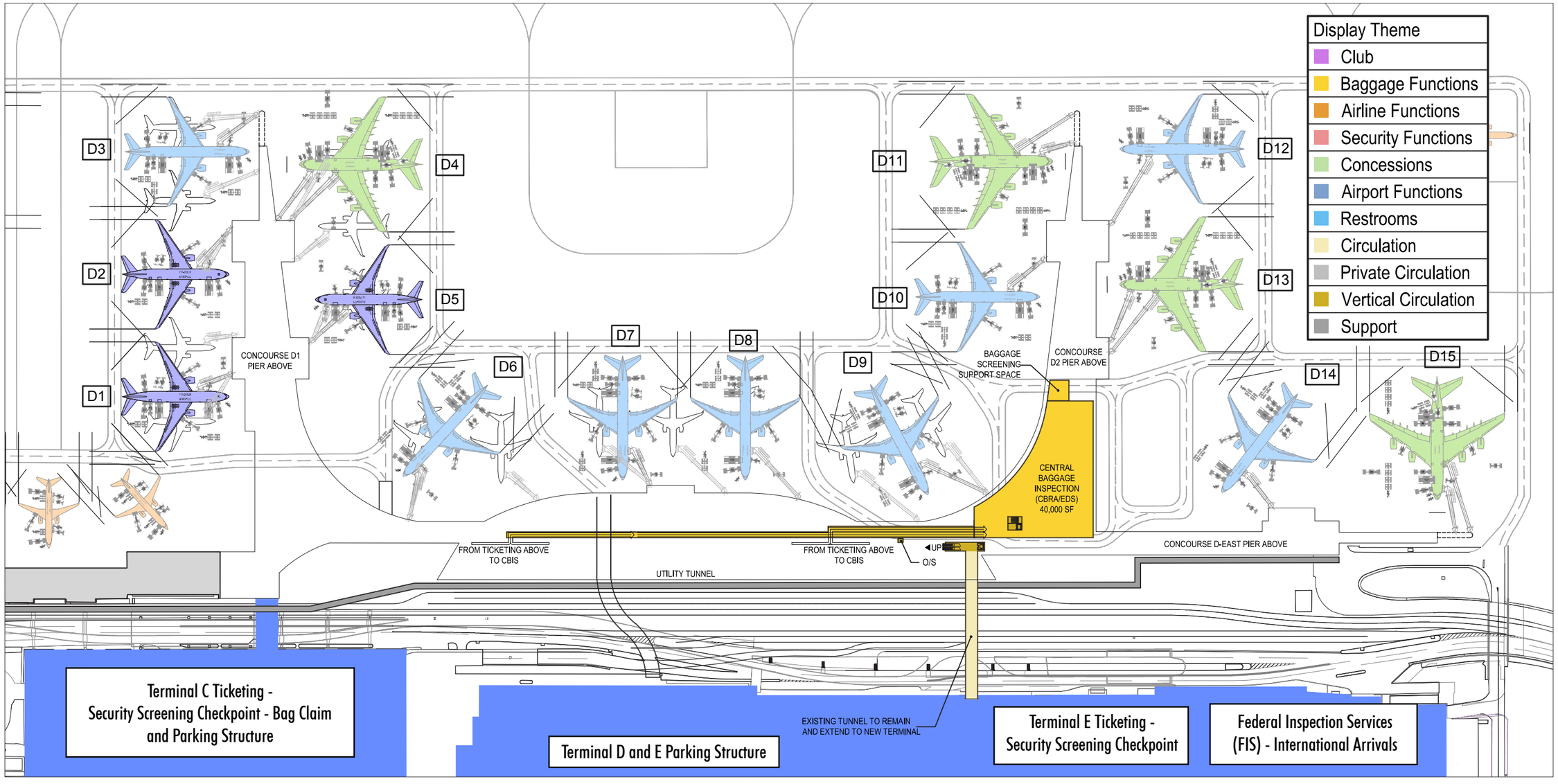


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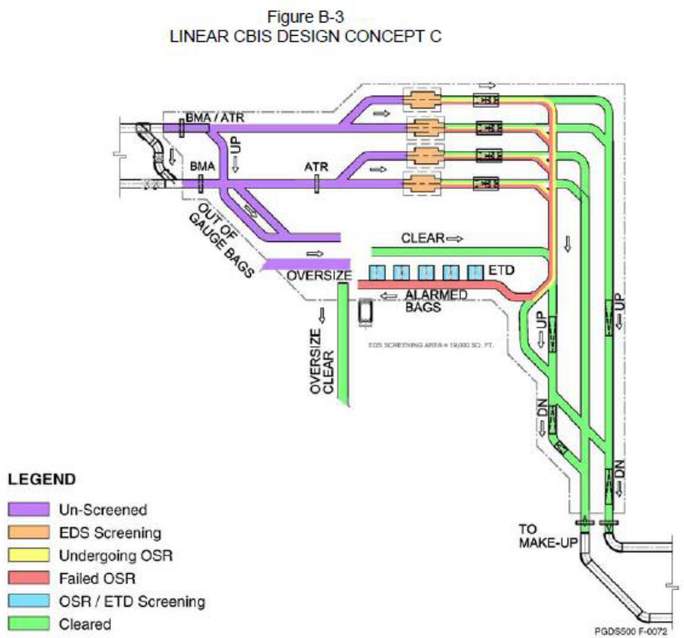
Figure 5.13 – Example of a Linear CBIS Design



The layout for the CBIS provides dual inputs from ticketing, with crossover capability to permit flow balancing between the downstream screening machines and to permit flow diversion (in either direction) to permit operations to continue when a screening machine is not operational or is being repaired or maintained.

A Bag Measurement Array (BMA) is provided on each input line with a divert point immediately downstream to divert Out-of-Gauge (OOG) bags (i.e., conveyable bags that are too large to be accommodated by the screening machine's screening tunnel dimensions). Diverted bags are transported to the Checked Bag Resolution Area (CBRA) for screening together with oversize bags (non-conveyable), typically using Electronic Trace Detection (ETD) equipment.

Standard size bags are screened using Computed Tomography (CT) machines, and are processed in a similar manner to the existing screening matrix at Terminal D (east zone). The schematic diagram indicates multiple delivery lines both upstream and downstream of the CT machines, to avoid the single point-of-failure condition that exists in the existing Terminal D screening matrix, both upstream and downstream of the CT machines.

The Checked Baggage Inspection System (CBIS) is connected to the ticketing areas in the east and west zones of the terminal at the Ticketing/Check-In Level, with tunnel connections from the ticketing main collector belts to the CBIS area. Three delivery belts from each ticketing zone (east and west) are proposed to accommodate peak period baggage flow rates and to provide redundancy in case one of the delivery belts suffers a malfunction or bag jam condition. Crossover diversion equipment should be provided between the two delivery belts (in both directions) in order to achieve the required level of system redundancy and resiliency.

An oversize bag belt is recommended to deliver bags from the ticketing area in the basement level CBIS for TSA screening. Oversize belts should be provided at both east and west zones of the ticketing area which can be used as a conveyance route for standard bags as well as to provide additional redundancy upstream of the screening machines. Some oversize bags cannot be handled by the oversize belt. Therefore, an alternative route to the CBIS area will be required using an elevator from the Ticketing Level to the CBIS basement, allowing non-conveyable, oversize items (e.g., surfboards, kayaks and similar) to be transported by porters using hand carts.

Conveyor tunnels should be adequately sized to allow good maintenance access and to clear baggage jams. A double stacked conveyor belt system may be preferred, particularly in the long tunnel connection between the west ticketing zone and the CBIS, with a maintenance walkway alongside the delivery belts to provide access to both levels. A wider section of space between the Airline Ticket Offices (ATO) will be required in order to provide for crossover diverters, as noted earlier.

5.3.1.2 Baggage Tunnel (to CBIS)

A tunnel running the length of the MLIT on the Baggage Level provides right-of-way for the outbound baggage belts to connect from the Ticketing Level above into the CBIS under Pier D2. This tunnel should be sized to provide appropriate redundancies of mainline feeds to the CBIS as well as providing adequate access for maintenance and service personnel.

5.3.1.3 Tug Drive Tunnels (to/from existing Terminal C North and FIS Processor)

Two existing tug drive tunnels connect from the apron into the central processor. The first connects just west of the existing Terminal C North Pier into the Terminal C Processor, while the second connects the Terminal D apron to the existing FIS facility. Both of these existing connections should remain in place as a part of the future MLIT. The area of these tunnels is not included in the proposed plans.

5.3.1.4 Pedestrian Tunnel

Passengers and employees can access the MLIT and Terminal E by way of an existing underground non-secure link tunnel. The tunnel provides access to the International Arrivals Hall, Terminal D/E parking structure and the Inter-Terminal Train. This tunnel allows movement throughout the airport without going through security. Access to this tunnel from the MLIT should remain to facilitate connectivity for passengers and employees. An extension of the existing pedestrian tunnel will be built under the new Ticketing Hall to provide connections from Ticketing/Check-in Level to tunnel via escalator, elevator, and stairs at the east end of the terminal near the proposed pre-cleared baggage claim carousel. By moving the vertical circulation core away from the curtain wall, it provides better circulation clearance around the baggage carousels and curbside areas.

5.3.1.5 Utility Tunnel

A utility tunnel is also proposed on the basement level of the terminal, running just along the outer footprint of the MLIT building. The use of this tunnel and the building systems within it are described in more detail in **Section 5.4**.

5.3.2 TICKETING/CHECK-IN LEVEL PLAN (LEVEL 088)

The Ticketing/Check-In Level includes the ticket lobby, pre-cleared baggage claim, security screening queue and checkpoints, TSA facilities, landside concessions, related airline and airport facilities, and various terminal support functions such as MEP building systems, circulation, and the loading dock. This level is at the same grade

as the existing curbfront roadway, and is one level (12 feet) below the Apron Level. The Ticketing/Check-In Level conceptual floor plan totals approximately 171,200 sf and is illustrated in **Figure 5.14**.

5.3.2.1 Ticket Lobby

The proposed ticket lobby is split into two zones at the east and west ends of the Ticketing/Check-in Level with a centralized security screening checkpoint separating the two zones. The proposed configuration provides approximately 17,200 sf for passenger queuing and ticket counters, consistent with the building program. The conceptual floor plan has a total of 300 linear feet (lf) of ticket counter frontage split evenly between the east and west zones providing approximately 54 agent positions (5.5 LF/position) meeting the program requirement of 48. A position consists of a ticket counter/agent/kiosk and baggage component. The proposed depth of the ticket lobby is 71 feet measured from the back of the ticket counter wall to the curtain wall.

The new design shall provide common-use enabled technology at all agent positions with a "two-step" check-in process. A "two-step" check-in process proposes a queue depth of 12 feet. Passengers enter the queue and then proceed to clusters of 4-6 self-service kiosks to print boarding passes and potentially "self" bag tags.

After printing boarding passes, passengers not checking bags may proceed directly from the kiosk to the security screening checkpoint, while passengers checking bags proceed to the bag drop area at the counters. There the baggage is loaded on the takeaway conveyor belt and is also weighed to confirm compliance with airline policy. An agent can check identification and assist them with placing bag tags on checked baggage, if necessary. The primary takeaway conveyor then activates and takes the bag back to the main line, which ultimately takes bags to the CBIS for screening. The agent does not need to manually pick up bags and move them to the main conveyor belt like in a traditional linear ticket counter configuration. The recommended ticketing layout deviates from the traditional bag scale positions in a linear ticket counter layout by providing primary baggage conveyor belts placed perpendicular to the main baggage conveyor. Typical two-step ticketing layouts are illustrated in **Figure 5.15**.

The design team should continue to monitor developments in self baggage-tagging, as this is an area quickly evolving in the industry and it has the potential to become more widely used and could dramatically change the baggage drop process. A number of different processes are used by different airlines and no standard approach is currently recommended. This layout was the preferred concept during various workshops but will need additional study and stakeholder confirmation during design.

It is recommended to place common use self-service kiosks along the ticket lobby curtain wall and in open floor space areas to allow passengers that are not checking bags to print boarding passes and proceed directly to the security screening checkpoint without waiting in the ticket counter queue. No fixed airline branding should be allowed along the back wall of the ticket counters in order to maintain the common use capability of this facility. Dynamic signage should be used to display airline check-in positions during ticketing operations.

To allow for flexibility in the ticketing counter and queue area, it is recommended to utilize an access flooring system. The "trough" allows for ultimate flexibility for kiosk layouts and has become very common in new terminal design.

5.3.2.2 Security Screening Checkpoint (SSCP)

The security screening checkpoint (SSCP) is centrally located between the east and west ticketing zones. The proposed layout has two entrances (east and west) that may be opened and closed as needed throughout the day depending on peak periods. The SSCP area on the Ticketing/Check-in Level Conceptual Floor Plan covers an area of approximately 12,600 sf, which includes both the checkpoint and the passenger queue. The SSCP area is shielded from direct public view with a non-secure concession and/or fixed or movable art displays in front of the checkpoint.

The proposed layout includes up to four lanes at both the east and west zones for a total of up to eight lanes. Each lane is sized at 30 feet of width for each pair of lanes to accommodate the latest advanced imaging technology. The queue should be subdivided for access via preferred passengers, crew, and typical passengers. The queue should utilize fixed stanchions with in-floor sockets and adjustable belts as opposed to moveable stanchions. This eliminates issues with queue management in the future and provides ultimate flexibility.

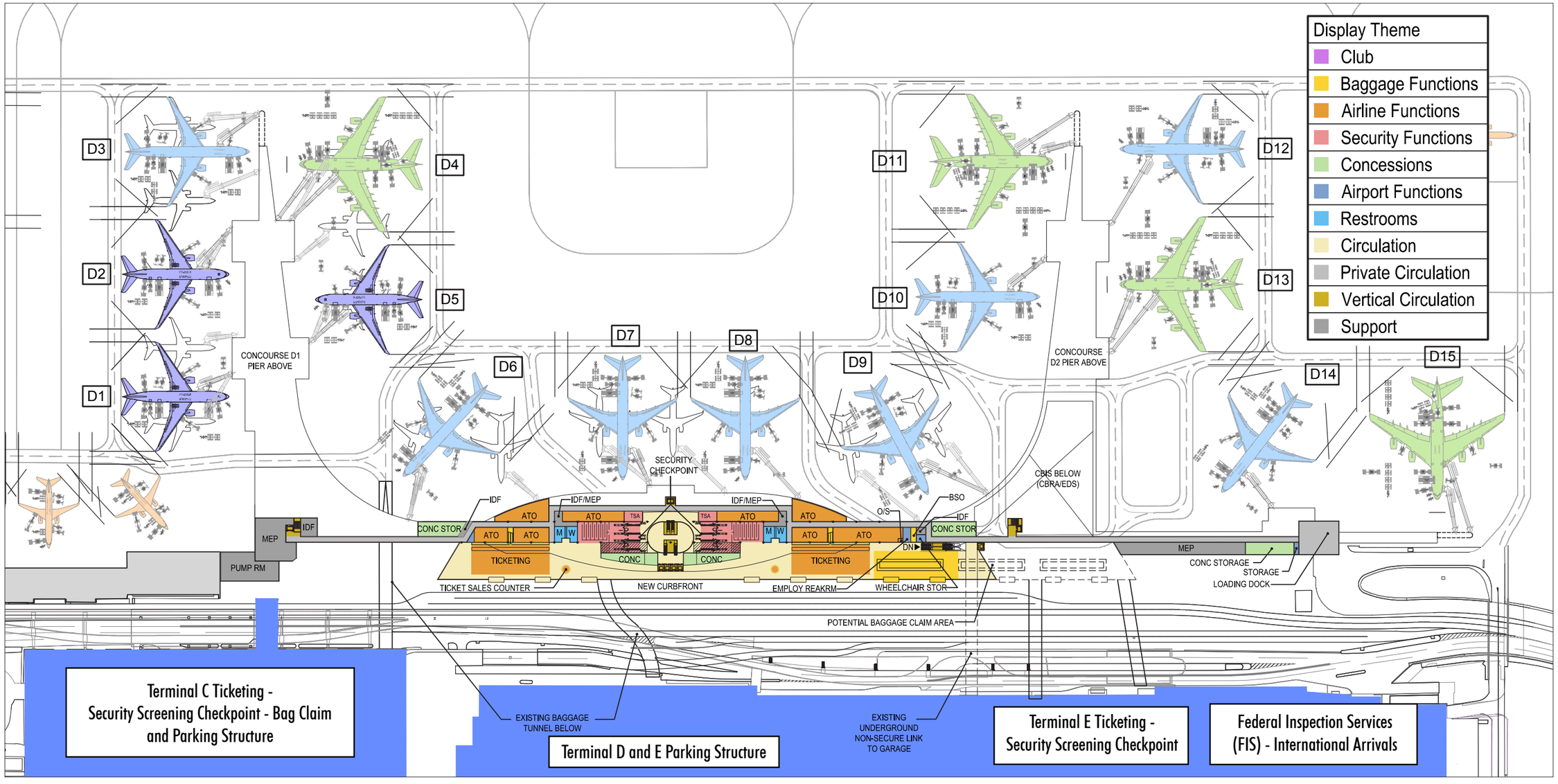
The final design of the checkpoint lanes should be approved by and coordinated with the TSA to ensure proper dimensions are provided. The final layout of the checkpoint should adhere to the requirements of the latest version of the TSA Checkpoint Design Guide.

The SSCP should be designed to accommodate the following conditions:

- Up to eight lanes; four in the west zone and four in the east zone
- Minimum of 10 feet from the first divesture table to the passenger queue for circulation
- Provide a divesting area after security for passengers to efficiently recollect items. The location of the divesting area should not impede operations of the TSA agents. This can include benches and other public seating for passenger use
- Search Rooms
- Surveillance Room
- TSA millwork (supervisor podium)
- Law enforcement millwork (observation podium)
- Support/Storage

After completing security screening, passengers proceed to the Departure Level by way of escalators and elevators in the vertical circulation core. The central location of the SSCP places passengers in the middle of the concession core area on the Departure Level. The SSCP is situated below an oval shaped skylight, or other form of natural daylight, providing intuitive wayfinding and connection amongst all levels of the facility.

MLIT Rebuild Option L088 - Ticketing Level



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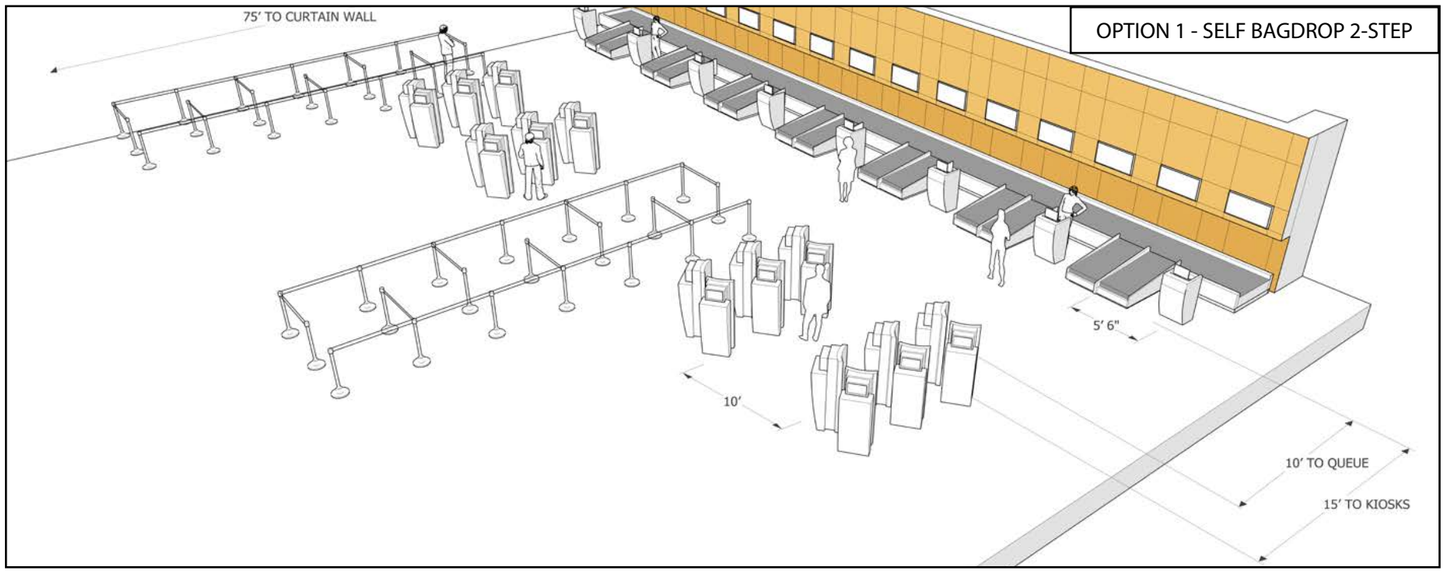
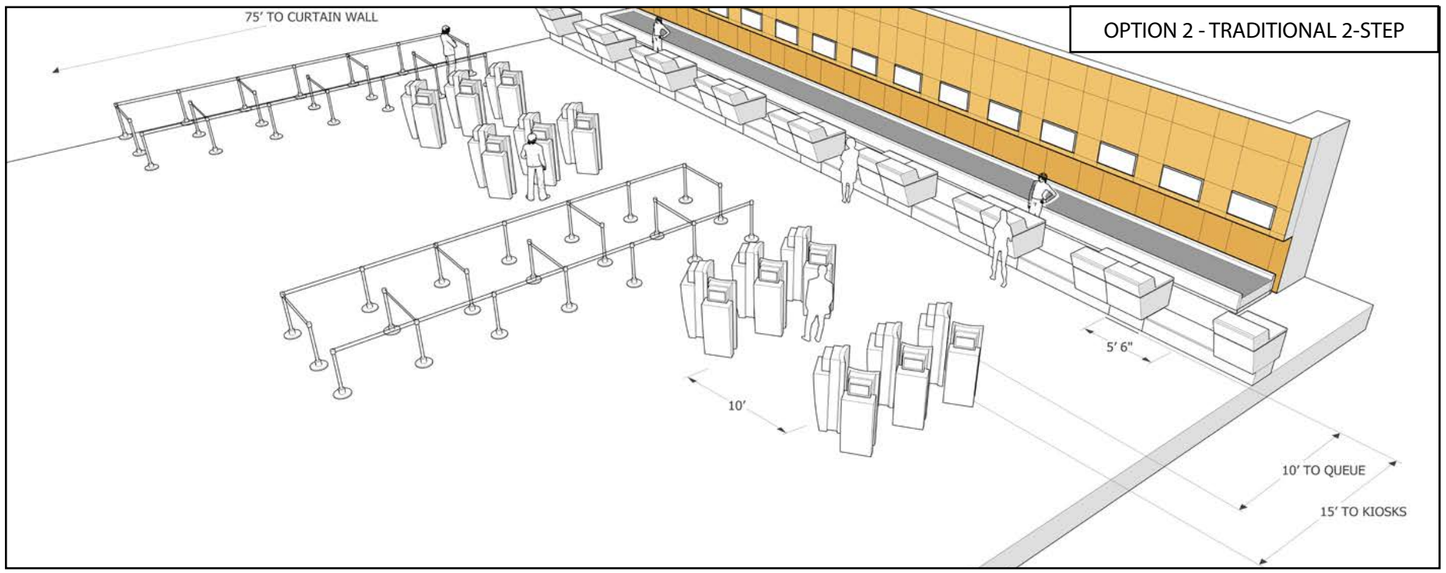
Ticketing Layout

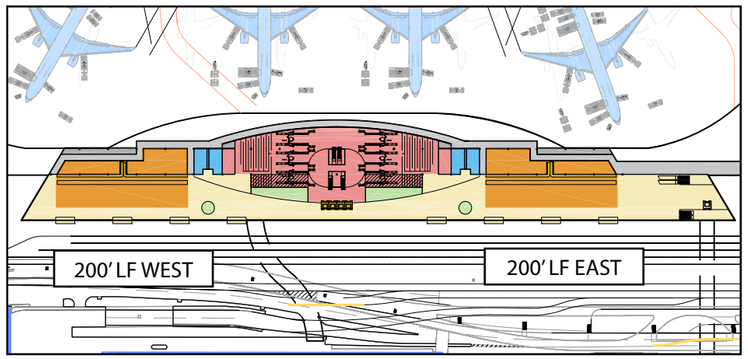


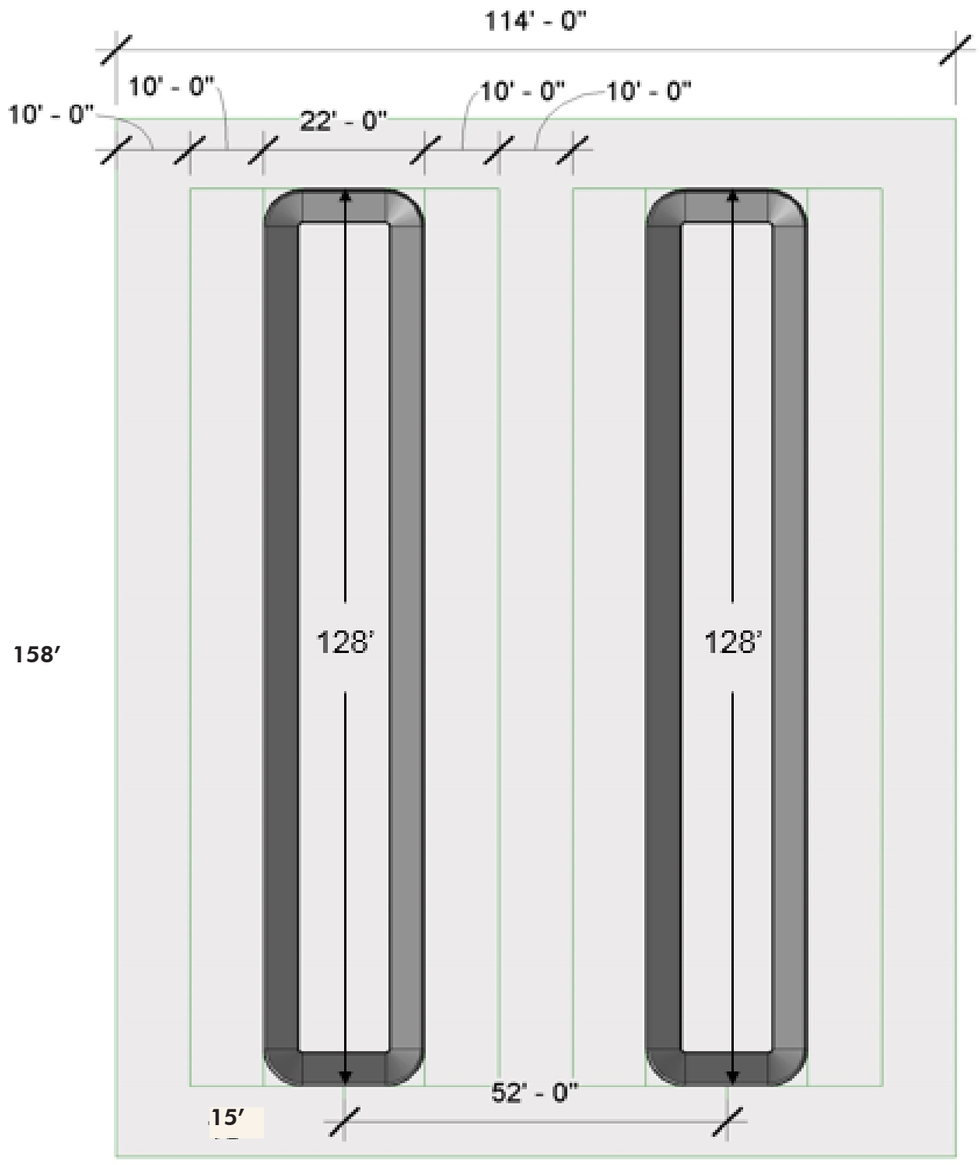


COMMON USE

Existing	Proposed
323' linear feet	400' linear feet
62 positions	72 positions

*TICKET LOBBY DEPTH
75' FROM CURTAIN WALL TO CONVEYOR
** PROPOSED = 5.5 LF PER POSITION





Minimal footprint of 2 claim devices
Approximately 114 feet x158 feet (approximately 18,000 sf)
Pre-Cleared Baggage Claim

5.3.2.3 Transportation Security Administration (TSA)

TSA offices, break rooms, and associated tenant spaces are located adjacent to the security checkpoint in approximately 1,500 sf per the space program. This space should be coordinated between the design architect and TSA during the design phase.

5.3.2.4 Pre-Cleared Baggage Claim

While the majority of the international arrival activity in the MLIT facility will be processed through the U.S. Customs and Border Protection International Arrivals Facility, some flights will arrive at the airport "pre-cleared", meaning the passengers were already cleared to enter into the United States at their origin point. Currently only a few destinations offer this clearance including most major airports in Canada, two airports in Ireland, and one in the United Arab Emirates. For passengers arriving from these locations, they will not be directed into the Sterile Corridor and will instead enter into the concourse as with any domestic flight.

To accommodate baggage claim for these flights, the plan provides for baggage claim carousels on the Ticketing/Check-in Level to the east of the east ticketing area. There is one carousel planned, with the ability to expand to three carousels in the future. These carousels could also be used to accommodate domestic flights, however the intention is that domestic flights will continue to use the carousels in Terminal C. The pre-cleared baggage claim functions occupy 9,000 sf on the Ticketing/Check-in Level. In addition to that space, provisions for oversize and non-conveyable delivery have to be provided. The delivery could be done manually with an elevator and a stainless steel slide adjacent to the claim devices. Such a configuration requires approximately 700 sf.

5.3.2.5 Circulation

Circulation is the space that allows for the flow of people and materials through the building. Airports are unique in that circulation is not solely for passengers. Circulation also includes employees and concessions, as well as trash removal and egress. Some circulation is public, while some is not. Some circulation is secured and some is open to the public. Airports also have to consider wheelchairs, electric carts in public areas, moving walks where there are long distances, and providing adequate width for carts and pallet jacks in non-public areas. The four primary areas of circulation include:

- Non-secure circulation: Circulation that is part of the public area located on the landside portion of the terminal that can be accessed without going through the security screening checkpoint.
- Secure circulation: Circulation that is within the terminal that requires being cleared by TSA through the Security Screening Checkpoint.
- Non-public circulation: Circulation that provides access to airline operations, airport operations, concession support, maintenance personnel, and other areas that are typically not accessed by the traveling public.
- Sterile Circulation: Circulation that provides the required separation between international arriving passengers and the general travelling public, generally leading to the U.S. CBP facility for clearing international passengers into the country.

Each of these types of circulation is also likely to have vertical circulation requirements in order to move in between the various floors of the terminal building. Vertical circulation most often includes elevators, escalators, and stairs. The convenient location of these vertical cores shall be in a manner that helps emphasize intuitive wayfinding. Public elevators should be sized to accommodate wheelchairs and luggage carts. Service elevators should be sized to accommodate delivery carts, trash containers, and pallet jacks. Redundancy should be considered where practicable. The vertical circulation shall also be sized appropriately for egress in the event of an emergency.

The primary circulation on the Ticketing/Check-In Level is the non-secure circulation along the outside face

of the terminal building that allows passengers entering the building to circulate between the major landside functions: check-in, security, concessions, and baggage claim. There is also a significant back-of-house non-public circulation corridor that connects the terminal support functions throughout the facility, including the ability to deliver goods to, and remove trash from, the concessions on the Departures Level above.

Key vertical circulation points on this level include: access up to the Departures Level following security, down from the Departures Level to the pre-cleared baggage claim carousels, and down to the underground pedestrian tunnel leading to the parking garage and Terminal E.

The Ticketing/Check-in Level conceptual floor plan includes approximately 70,100 sf of circulation, which includes non-secure and secure circulation. This also includes the respective vertical circulation of each type. There is no sterile circulation on this level.

5.3.2.6 Restrooms

Restrooms are a critical part of any building, particularly those with high volumes of people such as airports. In addition to general planning rules of thumb, restroom requirements are also dictated by codes, which need careful consideration during design. In an airport, passenger flows are an important consideration to make when determining the location of restrooms. Dual entry restrooms are preferred to ease congestion and to aid in maintenance and cleaning. The dual entry configuration allows closing one side for maintenance and cleaning while the other is still in use. Proper line of sight from the public to the interior of the restroom shall be designed to avoid the ability to see any function of the restroom from the outside circulation area. The restrooms should be enhanced with water efficient and waterless fixtures. The materials palette should focus on low-maintenance, yet durable, surfaces to facilitate cleaning.

The restrooms should include clear, intuitive wayfinding. Restrooms should incorporate passenger amenities including baby changing stations, shelves behind fixtures to store bags/purses, and handicapped accessible stalls. When practical, day lighting should be incorporated to enhance the ambiance of the space.

It is preferable that a family restroom be co-located with each set of restrooms. The restroom should include a lounge area upon entry that includes a baby changing counter with integrated refuse disposal. This area will help to keep children in a safe area while parents use the facility. A lounge seat or other furniture may be provided for nursing mothers. The toilet and sink fixtures are located through another door (only accessible by the family restroom lounge).

The Ticketing/Check-In Conceptual Floor Plan shows two sets of restrooms located adjacent to the SSCP entrance points. At a minimum, at least one family restroom should also be located on the Ticketing/Check-In Level, though it is preferable to have one at each restroom facility. The Ticketing/Check-In Floor Plan includes approximately 2,400 sf for restrooms.

5.3.2.7 Concessions

Minimal, non-secure concessions should be allocated near the highest concentration of passenger traffic on the Ticketing/Check-In Level. The optimal location is directly in front of the security checkpoint on the circulation path from ticketing and curbside to the security checkpoint. Likely concession uses include a small news and gift stand and/or a coffee shop. Seating for passengers should be located in close proximity to food and beverage concessions. The Ticketing/Check-In Conceptual Floor Plan includes approximately 2,800 sf for non-secure concessions.

5.3.2.8 Concession Storage

Secure back-of-house concession storage areas with secure service corridors leading to service elevators are provided in the east wing of the Ticketing/Check-In Level near the loading dock as well as near the base of the D1 and D2 Piers. Service elevators near the base of the pier serve all levels of the terminal. The delivery of concessions and the removal of trash should not occur within the public spaces of the terminal if at all possible. The Ticketing/Check-in Level includes approximately 7,000 sf of concessions storage space.

5.3.2.9 Loading Dock

A loading dock is located at the east end of the terminal providing slips for two box trucks and room for a trash compactor and recycling bins. Direct access is provided to two service/freight elevators by way of a back-of-house corridor running through the Ticketing/Check-In Level. Concession and airport storage should be located along the corridor between the elevator and loading dock for easy material flow. The planned location is very close to the existing loading dock area to avoid expensive infrastructure to access the facility from the roadway system. The loading dock is approximately 5,000 sf .

5.3.2.10 Employee Break Room

Consideration should be given to include a common use employee break room. Ideally, employee break rooms are located within back-of-house space for employees to have lunch breaks and store personal items. The room should include millwork with sink, cabinetry, refrigerator, vending, and lockers. A 400 sf break room is provided on the east end of the Ticketing Level near the pre-cleared baggage claim carousel.

5.3.2.11 Airline Ticket Offices

Airline Ticket Offices (ATO) are leasable space for airline tenants to use on the landside of the terminal. Ideally, these spaces are located within close proximity to the ticketing lobby but it is not necessary for them to be directly adjacent to the ticket counters. Typically, the ATO spaces include administrative offices and break room facilities for airline staff. Information Technology (IT) closets may also be included for the individual airline systems. The Ticketing/Check-in Level includes approximately 20,200 sf of airline ticket office space.

5.3.2.12 Mechanical/Electrical/Plumbing (MEP) Spaces

The size and location of MEP rooms has been refined through the advanced planning process and specific requirements of these rooms are located in **Section 5.4**. These functional spaces have been allocated on all levels of the conceptual floor plans. All electrical room walls should be lined with material allowing for ease of installation of wall mounted equipment.

MEP functions generally need to be evenly distributed at locations throughout the terminal. To accommodate this requirement, spaces on the Ticketing/Check-In Level are designated for MEP support and include a central location behind the SSCP at the base of the pier concourse, a west location, and an east location. The Ticketing/Check-In Conceptual Floor Plan includes approximately 18,700 sf for MEP spaces.

5.3.2.13 Airport Operations/Building Maintenance

Space should be allocated at the Ticketing/Check-In Level for airport operations/building maintenance. These spaces should support the storage of maintenance equipment, parts, and materials that aid in the daily operations of MLIT. The Ticketing/Check-In Conceptual Floor Plan includes approximately 400 sf for HAS support functions.

5.3.2.14 Pet Relief Areas

Pet relief areas are to be located on the exterior landside on both the east and west ends of the Ticketing/Check-In Level. These locations should include a permeable ground surface and a station for dog refuse bags and trash.

5.3.2.15 Wheelchair Storage Areas

Dedicated storage areas to store and secure wheelchairs during off-peak periods should be provided at each end of the Ticketing/Check-In Level. The Ticketing/Check-In Conceptual Floor Plan includes approximately 250 sf for wheelchair storage.

5.3.2.16 Art Program/Museum

The HAS Art Program is a rich, diverse collection of interior and exterior art pieces. MLIT will be enhanced with many locations for art that assist in intuitive wayfinding and branding. Art installations should be included throughout the terminal and can even tie multiple levels of the building together. Locations for art to be incorporated on the Ticketing/Check-In Level include the area in front of the SSCP, but will be determined in design with the appropriate stakeholders. Additional information regarding the art program is included in **Section 6.3**.

5.3.3 APRON (LEVEL 100)

The Apron Level includes inbound and outbound baggage operations, airline operation spaces, MEP spaces, and related airport terminal facilities. This level is primarily for support functions and does not include any major passenger facilities. The Apron Level is at grade of the airfield, one level (16 feet) below departures, and one level (12 feet) above the Ticketing/Check-in Level. The Apron Level Conceptual Floor Plan totals approximately 105,600 sf and is illustrated in **Figure 5.16**.

5.3.3.1 Outbound Baggage

A consolidated and centralized baggage sortation system and make-up facility is proposed to be located at the base of the D2 Pier. There are seven planned outbound carousels under the D2 pier and each device is 45 feet (flat plate) or 50 feet (incline make-up) on center and approximately 80 feet long. Each side of the device has a tug and dolly staging lane for container loading and a central drive-thru or passing lane allowing individual containers or dollies to be removed and/or inserted as container loading progresses during the flight buildup period.

Incline plate devices are preferred by airlines and handling agents; allowing short term storage of bags waiting to be loaded. Incline plate carousels will increase overall bag room area and will involve a wider column span, thus potentially increasing overall facility cost, if this alternative should be adopted.

Two delivery lines should be provided from the CBIS up to the sortation system delivering bags to the make-up loops at Apron Level. This assists in maintaining reasonable baggage flow rates on the delivery lines, for better sortation performance, as well as providing fallback redundancy, allowing sortation and make-up to continue even in the event of mechanical failure or a bag jam condition on one of the two delivery/sort lines.

Depending on height availability below the concourse structure, it may be feasible to provide an overhead sortation system using a high speed, or similar, sortation system. In this case, the delivery belts from the CBIS area incline from the basement into the ceiling space above the make-up loops delivering bags to dual sort lines that feed sorted bags to the loops from above. If insufficient height is available for an upper level sortation system, an alternative would be to provide a basement mounted sortation system delivery for bags via incline belts through Apron Level floor penetrations located inside the loop perimeter. This is likely to be significantly more expensive in terms of basement cost and floor penetrations than an overhead delivery system. Sufficient height should be provided not only for overhead delivery but also for installation of catwalks to provide access for maintenance of belts, diverters, etc.

It is estimated that the preferred height allowance for tug and dolly clearance is approximately 7.5 to 8 feet, minimum, plus allowance for catwalks, conveyors, and maintenance head room of approximately 7.5 feet. This indicates a need for 15.5 feet clearance height from the Apron Level to the underside of structure and services below the Departure Level. Further discussion will be needed on this issue to determine if this height can be achieved or if compromises with regard to maintenance access will be considered acceptable by HAS. In the event that sufficient height below the Departure Level is not achievable it will be necessary to provide for a delivery and sortation system located in a basement below the make-up area. In this case, the main cost for delivery from the basement level will be construction of a basement extension below the make-up area for sort lines with diverters to each of the eight loops.

As an option, the sortation system can be equipped with a manual encode subsystem to identify bags which could not be read by an Automatic Tag Reader (ATR) and sent to their correct loop. Without a manual encode system, one loop would be assigned the run-out destination for these “no read” bags.

It may be argued that full height maintenance catwalks are a luxury, but for a new facility it is strongly recommended that the necessities for good maintenance access should be provided. Regardless, full height access for personnel at the manual encode area should be provided, unless an alternative location can be identified.

An assessment of unit load device (ULD) presentation indicates a need for presentation of 76 ULDs. Each make-up loop is able to stage 12 ULDs (6 on each side). The proposed design with seven loops is able to accommodate up to 84 containers.

Ideally, the following system features should be provided to ensure good BHS system functionality:

- A run-out belt for miss sorts and problem bags (e.g. bags whose flights have already departed and therefore need to be re-flighted).
- A manual encoding subsystem, immediately upstream of the dual sort line(s). This feature is optional but recommended for this design where a single baggage make-up room serves the entire terminal. Without a manual encode system many bags will fail to be successfully encoded by the Automated Tag Readers (ATRs) upstream of the sort area (in particular transfer bags that have much lower read rates than originating bags). Bags which are not encoded, without a manual encode system, must be diverted either to the run-out belt, mentioned above, or to a default carousel (typically the last carousel(s) on the sort line) sometimes known as a “Jackpot” carousel. This may result in some bags being loaded into incorrect containers or being delayed in processing, possibly resulting in short shipment of bags.
- A transfer input belt, possibly two, since typically domestic to international bags do not need screening. These bags could bypass CBIS (domestic to international transfers) and merge directly with the sort line(s). It is understood that transfer bags from domestic flights to British Airways’ departures need to be screened due to United Kingdom regulations. These bags need to be input to the CBIS before going to the bag room. This requirement needs to be confirmed.

It is proposed that a one-way driving system should be adopted in the baggage make-up room, as illustrated in **Figure 5.17**, showing a partial view of the make-up area. There will be access points to the baggage area at both ends and sides of the makeup area via two-way tug lanes and then funnel one-way through the baggage units. The Apron Level Conceptual Floor Plan includes approximately 39,300 sf of outbound baggage space. This estimate will have to be reviewed once a decision about flat plate or an incline make-up device has been made and the structural grid for this area has been defined. In addition there is 1,500 sf provided to accommodate staging of empty carts and 1,700 sf of space for Baggage Handling Support Spaces, which includes ground handler locker rooms, the BHS control room, the BHS common room, the BHS server room, and the BHM maintenance facility.

In addition to the Outbound Baggage Make-up under the D2 Pier, United Airlines has requested additional transfer baggage make-up under the D1 Pier. The design process will need to work with United Airlines to define the specific requirements of this function and consider how bags can physically connect between the existing systems in the Terminal C facilities. This area while depicted conceptually at 12,600 sf on the plans is not currently in the building program or cost estimate and needs to be refined during the design process.

MLIT Rebuild Option L100 - Apron Level

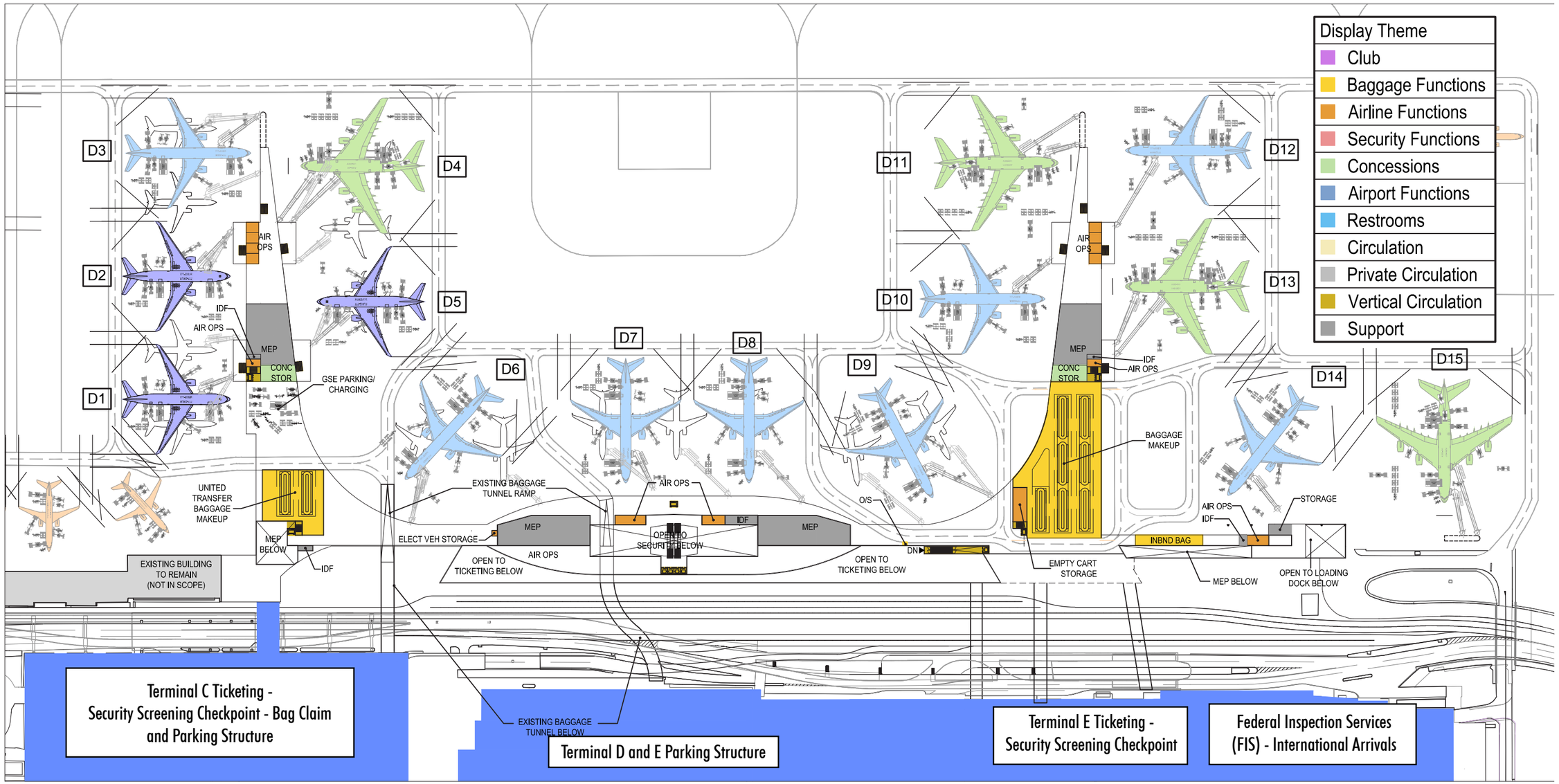
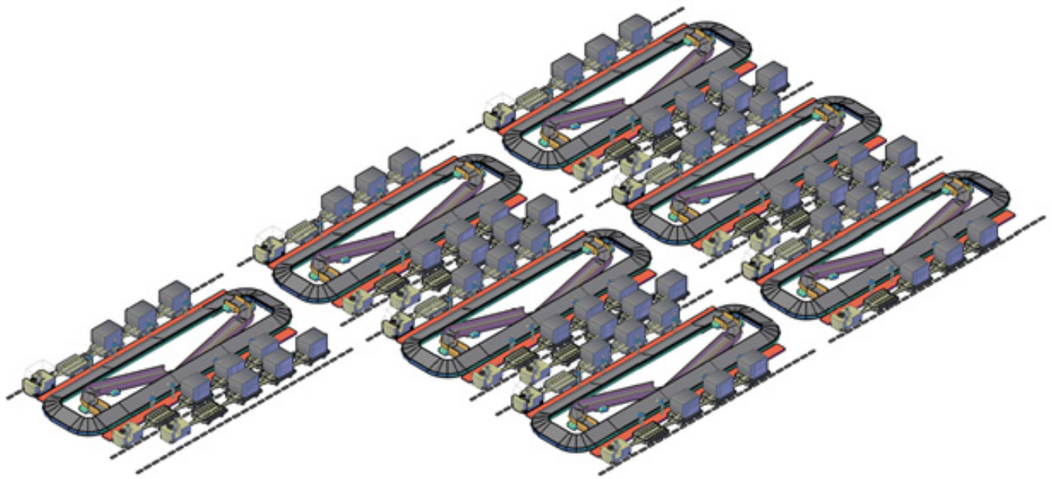


Figure 5.17 – Bag Room Vehicle Flow (partial view)



5.3.3.2 Inbound Baggage

A baggage delivery belt is proposed on the east side of the Apron Level to transfer checked baggage to the bag claim device located on the Ticketing Level for irregular operations, charter flights, pre-cleared and the rare domestic operation. The Apron Level Conceptual Floor Plan includes approximately 2,800 sf of inbound baggage space. This area is located under the concourse floor in a covered, but non-conditioned area.

The majority of baggage from inbound flights is transported to the existing Federal Inspection Station (FIS) facility located between Terminal D and Terminal E. Bags and/or ULDs are transported in baggage carts pulled by tugs along ground service equipment roadways on the airside. All arriving international passengers claim baggage at the FIS facility.

5.3.3.3 Airline Operations/Storage

Airline operations space is included at various locaitons on the Apron Level adjacent to the aircraft parking positions. There should be direct line of sight from airline operations to aircraft. The airline operations area is built as shell space and the airline will outfit the space independently. Coordination between architect and airlines must occur during design phases. There are approximately 7,200 sf of airline operations space on the Apron Level of the terminal and was determined based upon airline surveys during the planning phase. This square footage should be verified during design for the current airlines and their staffs.

5.3.3.4 Restrooms

Employee restrooms should be provided on the Apron Level. Ideally, employee restrooms are located within back-of-house space on the secure side of the terminal and in close proximity to employee break rooms and/or airline operations spaces. There are no public restrooms on this level.

5.3.3.5 Mechanical/Electrical/Plumbing (MEP) Spaces

The size and location of MEP rooms has been refined through the advanced planning process and specific requirements of these rooms are located in **Section 5.3**. MEP functions generally need to be evenly distributed at locations throughout the terminal. To accommodate this requirement, spaces on the Apron Level are designated for MEP support and include a location at the end of the pier concourse, a west concourse location, and an east concourse location. The Apron Level Conceptual Floor Plan includes approximately 40,800 sf for MEP spaces.

5.3.3.6 Information Technology (IT) Spaces

IT rooms should be located throughout each level of the terminal to evenly distribute cable feeds to appropriate spaces. The Main Distribution Frame (MDF) is proposed to be located at the base of the pier concourse. Intermediate Distribution Frame (IDF) rooms are smaller areas (250 sf) that can be designed easily after location needs are ultimately defined by the design team. Proposed IDF locations are illustrated on the Apron Level Conceptual Floor Plan. Additional IT requirements are located in **Section 5.4.7**. These spaces are included in the overall MEP space area noted in the section above.

5.3.3.7 Ground Service Equipment (GSE) Parking/Charging

A 10 ft overhang is included throughout most of the apron footprint providing covered tug and ramp equipment parking locations. Additional tug parking locations are in the vicinity of the baggage make-up area on the Apron Level. Consideration should be given to co-locating tug charging infrastructure to enable the use of electric GSE.

5.3.3.8 Circulation

The Apron Level Conceptual Floor Plan includes approximately 7,800 sf of non-public and vertical circulation space.

5.3.4 DEPARTURE CONCOURSE PLAN (LEVEL 116)

The Departure Concourse Level includes holdrooms, the concession core, and access to the Club Level and passenger services. The Departure Concourse Level Conceptual Floor Plan totals approximately 319,700 sf and is illustrated in **Figure 5.18**. MLIT 3D sections are illustrated in **Figure 5.19** and **Figure 5.20**.

5.3.4.1 Departure Lounges/Holdrooms

The departure lounges (holdrooms) are located directly adjacent to the passenger boarding bridge pods at each of the eleven gates. The preferred plan is an open-style holdroom configuration with concessions intermixed within the holdroom seating areas providing opportunities for revenue generation within view of most seat/gate areas. The gates should include a variety of holdroom seating options. Seating clusters for business, lounge and traditional use should be scattered among the holdrooms. Electrical and USB charging ports should be located within the seating pods for convenient use by passengers. One electrical outlet should be included for every two seats throughout. The Departure Concourse Level Conceptual Floor Plan includes approximately 87,100 sf for departure lounges/holdrooms.

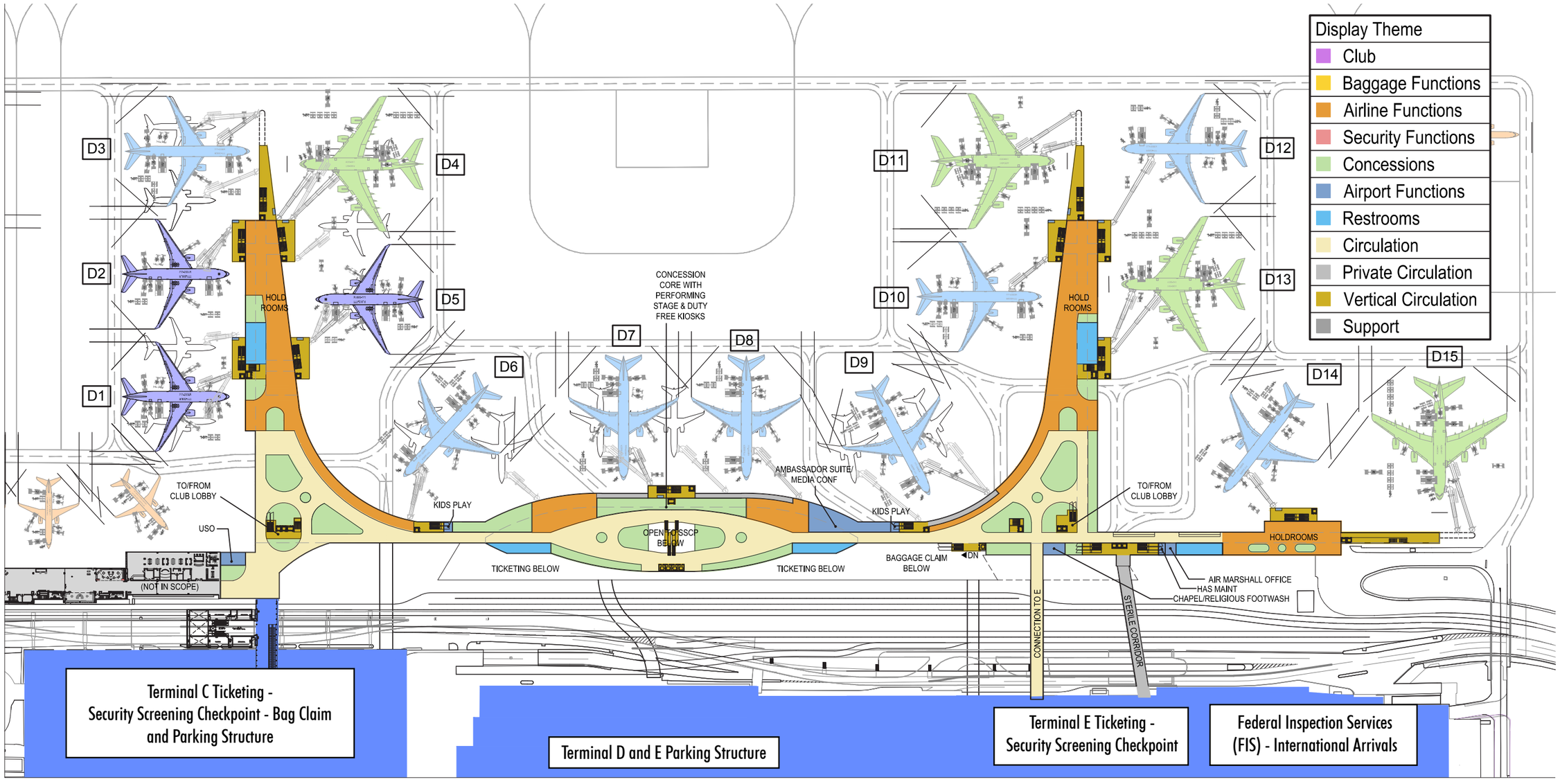
5.3.4.2 Club Lobbies

The Departure Concourse Level Conceptual Floor Plan shows two areas labeled as club lobby. These areas include vertical circulation elements for connection with the Club Level located above the Departure Concourse Level. The club lobbies are located within the concession nodes at the base of the D1 and D2 Piers. The area for the club lobbies is included within the overall circulation square footage.

5.3.4.3 Concession Core

The featured Concession Core is centrally located within the terminal building where the pier concourse, West Concourse and East Concourse converge. This space has been designated within the program criteria to contain a significant portion of the overall concession program. This central area is to be designed with a "Houston-centric" atmosphere to provide an excellent sense of place. Dynamic signage and Art installations will help to provide a modern and informative area of congregation.

MLIT Rebuild Option L116 - Departure Level



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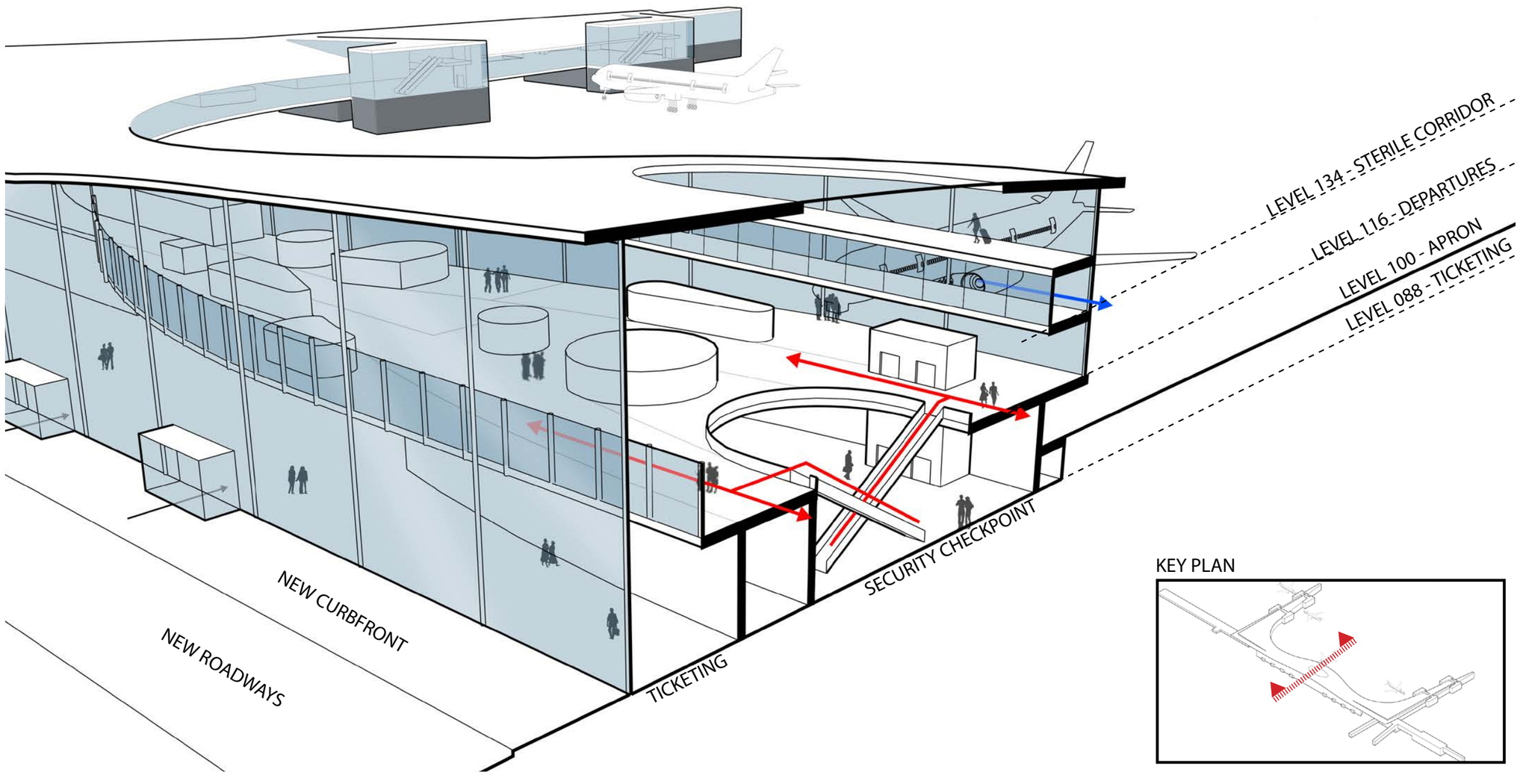
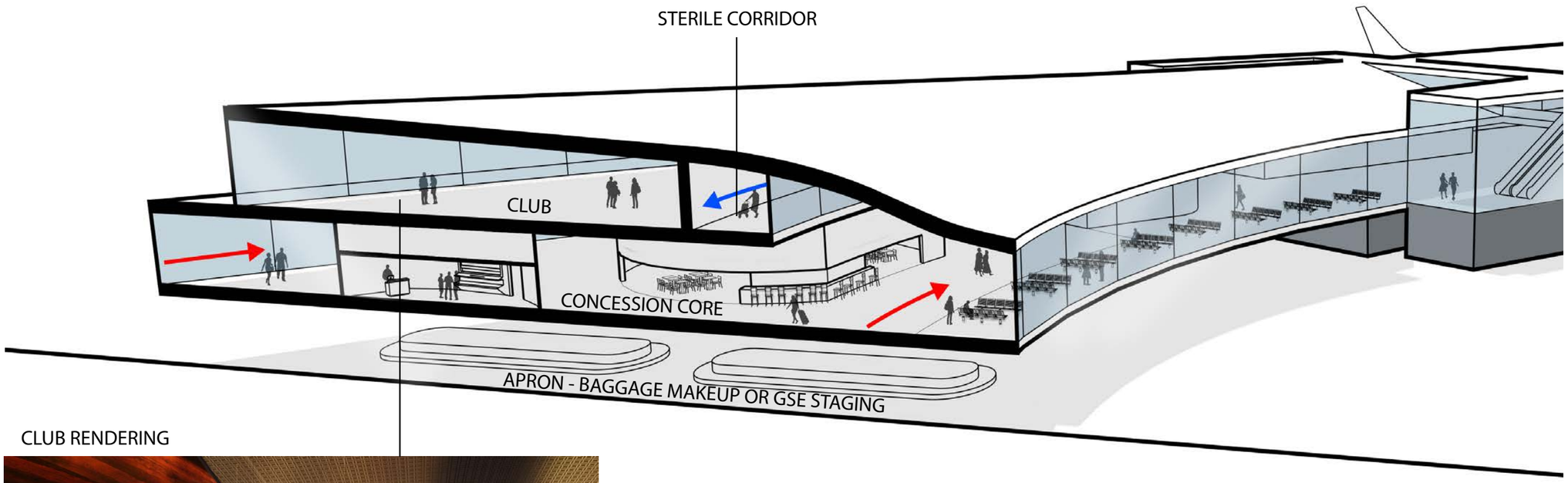
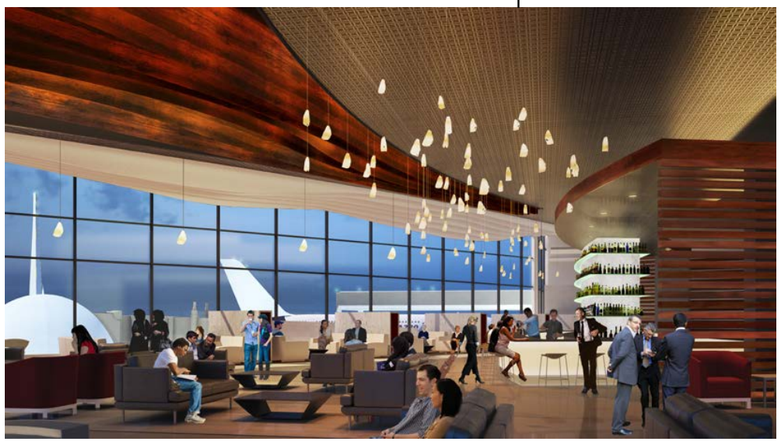
Section - Concession Core



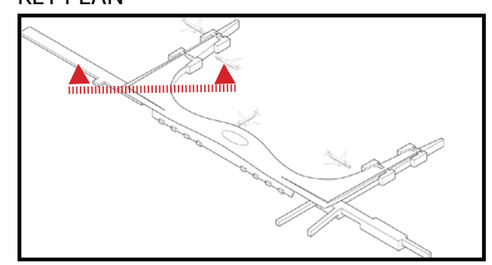
Section - Club/Pier - Concession Core



CLUB RENDERING



KEY PLAN



The central portion of the Concession Core is located around an opening in the Departure Concourse Level floor that overlooks the SSCP. Passengers leaving the security checkpoint find themselves in the middle of the Concession Core after transitioning up to the Departure Concourse Level from the checkpoint. The Club Level and Sterile Corridor above are in clear view as well as a large skylight or other form of natural light that acts as a signature element in the terminal design creating a memorable space. It is envisioned that the central area be made up of free-standing kiosks or flow-through duty free point-of-sale locations.

The Concession Core also expands along the exterior walls surrounding the Central Core. The specific configuration of the concessions, as well as the balance of news/gifts, specialty and food/beverage will be determined through coordination with HAS, its concessions consultants and the successful concessionaire proponents decided through a competitive procurement process.

Public seating is a critical component of the Concession Core. The peak hour enplaning passengers should be used to determine the number of tables and chairs provided within the Concession Core. Coordination with the master concessionaire and HAS will determine the exact sizes and number of tables, counters and chairs for public use within the Concession Core.

Consideration must be given to provide adequate emergency egress for passengers out of the Concession Core, as well as integration of mechanical, electrical and plumbing infrastructure within the core.

Additional news/gift and food/beverage concessions are located along the pier, and the East and West Concourses, away from the Concession Core. These types of locations may include a bar adjacent to holdrooms, grab-and-go meals, and so forth. The Departure Concourse Level Conceptual Floor Plan includes approximately 64,100 sf for concessions.

5.3.4.4 Concession Storage

A pair of service elevators that travel from the Apron Level to all levels above are centrally located along the base of the pier. This provides the facility a means of secure back-of-house concession circulation. Concessions storage is allocated within the ticketing/check-in levels of the MLIT facility. Concession pallet and trash removal transportation should not occur within the public spaces of the terminal if at all possible.

5.3.4.5 Restrooms

Throughout the Departure Concourse Level, restrooms should be located within 400 ft of each other to minimize the path of travel for passengers from all parts of the terminal. A pet relief room is also recommended at each pier within the restroom bank. The Departure Concourse Level Conceptual Floor Plan includes approximately 12,300 sf for restrooms.

5.3.4.6 Family Restrooms

As discussed in **Section 5.3.2.6**, it is recommended that each restroom cluster include at least one family restroom.

5.3.4.7 Airport Operations/Building Maintenance

Space should be allocated at the Departure Concourse Level for airport operations/building maintenance (currently not included in program or plans). These spaces should support the storage of maintenance equipment, scissor lifts, floor cleaning equipment, and parts and materials that aid in the daily operations of the MLIT. Requirements and locations should be identified during design.

5.3.4.8 Chapel/Meditation/Prayer Space

A dedicated space is provided for passengers and employees for private meditation, prayer, and religious purposes. Sound attenuation should be provided on all surfaces to help ensure the space will be quiet and peaceful for those using this space.

It is recommended that foot washing areas (including an integral bench) be located in close proximity to the chapel/meditation/prayer space. There should be two foot washing areas, one clearly labeled for men and one for women. Specific requirements of the foot washing areas should be coordinated with HAS and its stakeholders. This space is depicted adjacent to the node of the D2 Pier and provides 400 sf of space.

5.3.4.9 Children's Play Area

A Children's Play Area is included on the Departure Concourse Level to provide children with an area to unwind prior to a long international flight. Integrated play equipment could be branded to relate to the Houston region enhancing a sense of place. Equipment should be scaled for children's use. Lounge seating with electrical ports should be located within this space for parents to relax and watch the children while still enjoying themselves. There are two Children's Play areas depicted in the plans, one east and one west near the piers totaling 600 sf.

5.3.4.10 United Service Organization (USO)

The existing USO facility is located in the C Link between Terminal D and Terminal C. A USO typically includes general seating for military personnel as well as restrooms and changing areas for personnel who often are in transition between reporting for duty and leave. The facility should provide convenient access for service men and women to the USO from throughout the Central Terminal Complex.

Consideration should be given to the following functional requirements within the USO.

- Large communal lounge for viewing television or movies
- Book storage/Library area
- "Quiet Room" with space for reclining chairs
- Restrooms and locker/changing areas. These restrooms must also include showers.
- Video game arcade
- Kitchen and dining areas
- Offices for USO personnel and storage for baggage
- Conference and training room

The replacement facility should be sized similarly to the existing facility. Coordination with the USO and HAS will determine the exact needs of the facility. The USO is depicted near the connection between the MLIT and the North C Pier. It is approximately 1,100 sf.

5.3.4.11 Nursery

A nursery should be included for employee and passenger use. This facility will not be manned by airport staff, but provides a private space for nursing mothers. Coordination with the HAS and stakeholders should be conducted to solidify space requirements prior to design.

5.3.4.12 Performance Stage

A performance stage, which will draw people and enhance the ambiance of the terminal, should be considered in the Concession Core Area. A piano's music (human or mechanical) could fill the entire volume of the multi-story space with relaxing sounds. Many airports have music programs that invite local artists on a rotating basis to play in the airport. This is an idea that could be considered at Terminal D or airport-wide. This space is noted in the central concessions core adjacent to the vertical circulation up from the Ticketing Level.

5.3.4.13 Wheelchair Storage Areas
Dedicated storage areas to store and secure wheelchairs during off-peak periods should be provided, especially in the area of holdrooms and boarding pods.

5.3.4.14 Electric Carts/Transport Vehicles
HAS plans to continue the operation of electric carts for passengers needing assistance on the Departure Concourse Level and in the Sterile Corridors in the new terminal. Storage and charging locations should be provided for electric carts on the Departure Concourse Level.

5.3.4.15 "Texas Experience"
The "Texas Experience" space is intended to be an interactive space for the international traveling public to understand more about Texas culture. Interactive exhibits, goods, foods and activities can be envisioned for this space. Incheon Airport in South Korea has a similar experience that is quite popular. This "experience" center is to be located on the secure side on the Departure Concourse Level near the Central Core.

5.3.4.16 Ramp Control Tower/ Gate Control
A new ramp control tower (RCT) is required to facilitate aircraft movements into and out of the MLIT and Terminal B North. United Airlines currently handles all ramp control movements for Terminal B North, Terminal C North and Terminal D. Views of the airside are preferable but the functions of a RCT can potentially be facilitated with closed circuit television (CCTV) feeds from cameras. Coordination with HAS and United Airlines should be conducted to determine the exact needs and/or requirements of the RCT. For planning purposes United Airlines has communicated the need for approximately 1,000 sf (not included in MLIT program) of space and has suggested three possible replacement locations shown in **Figure 5.21**. UA, HAS, and designer shall analyze and agree on final location and requirements for RCT and gate control.

5.3.4.17 Art Program/Museum
The MLIT will be enhanced with many locations of art that can enhance intuitive wayfinding and branding. Art installations shall be included throughout the terminal and can even tie multiple levels of the building together. Locations for art to be incorporated on the Departure Concourse Level include holdrooms within the Concession Core. The Concession Core and/or the C Link between MLIT and Terminal C would be a good location for a free-standing, flow-through museum. Coordination between HAS and the design team should be initiated to find ways to incorporate art into the architectural design of the building. Additional information regarding the art program is included in **Section 6.3**.

5.3.4.18 Diplomatic Suite
Located on the secure side of the MLIT, the Diplomatic Suite is intended to be a high-finish space that can be used for important gatherings of HAS Staff, government officials, and international delegates for meetings and other engagements. A stage with speaking podium is included for media events. A pre-function space should include the stage/podium and space for lounge seating. Adjacent to the pre-function space, a large conference room with a view of the airfield should be provided for important meetings. A large wall mounted monitor or overhead projector and screen should be included in this room. A small service pantry with a separate entrance and a small handicap accessible restroom should be located within this suite. Approximately 5,000 sf is provided for this space on the east side of the Departure Concourse Level near the Central Concessions Core.

5.3.4.19 Circulation
The Departure Concourse Level Conceptual Floor Plan includes approximately 147,300 sf of secure, non-public, Sterile Corridor and vertical circulation space. Vertical circulation requirements including necessary size and location of emergency egress stairs and stair towers should be verified for compliance with all applicable codes. Circulation nodes at each gate need appropriate considerations to direct arriving passengers to the Sterile Corridor, or block off the access to the Sterile Corridor as appropriate during departure operations.

5.3.5 CLUB/STERILE CORRIDOR PLAN (LEVEL 132)

The Club/Sterile Corridor Level includes airline clubs, the diplomatic room and the Sterile Corridor. The Club/Sterile Corridor Level Conceptual Floor Plan totals approximately 161,700 sf and is illustrated in **Figure 5.22**.

5.3.5.1 Airline Clubs
The new MLIT includes six airline clubs each of 10,000 sf. Three clubs are provided above the node at the base of the D1 and D2 Piers.

The area calculations provided include support spaces, restrooms, kitchen, and airline storage/pantry. The restrooms should include shower facilities.

The airline clubs are envisioned as high-end spaces, providing ample natural daylight and a high level of finish. Natural daylight and views should be a major consideration in the layout of these spaces. A common corridor will lead passengers from the main circulation core to each of the clubs. Proximity between the airline holdrooms and clubs should be a consideration. Coordination with airline stakeholders and HAS should be conducted to determine exact requirements of each airline tenant.

Direct access to a minimum two A380 gates and one wide-body gate is required by the airline clubs. Several methods of potentially accommodating this requirement are depicted in **Figure 5.22** through **Figure 5.26**. Coordination between the design team and HAS and appropriate stakeholders is required during the design to identify the specific requirements and optimal methods of accommodating these requirements. Direct access corridors are not included in the MLIT budget; buildout/operation to be addressed in airline lease agreements.

5.3.5.2 Wheelchair Storage Areas
Dedicated storage areas to store and secure wheelchairs during off-peak periods should be located along the Sterile Corridor route.

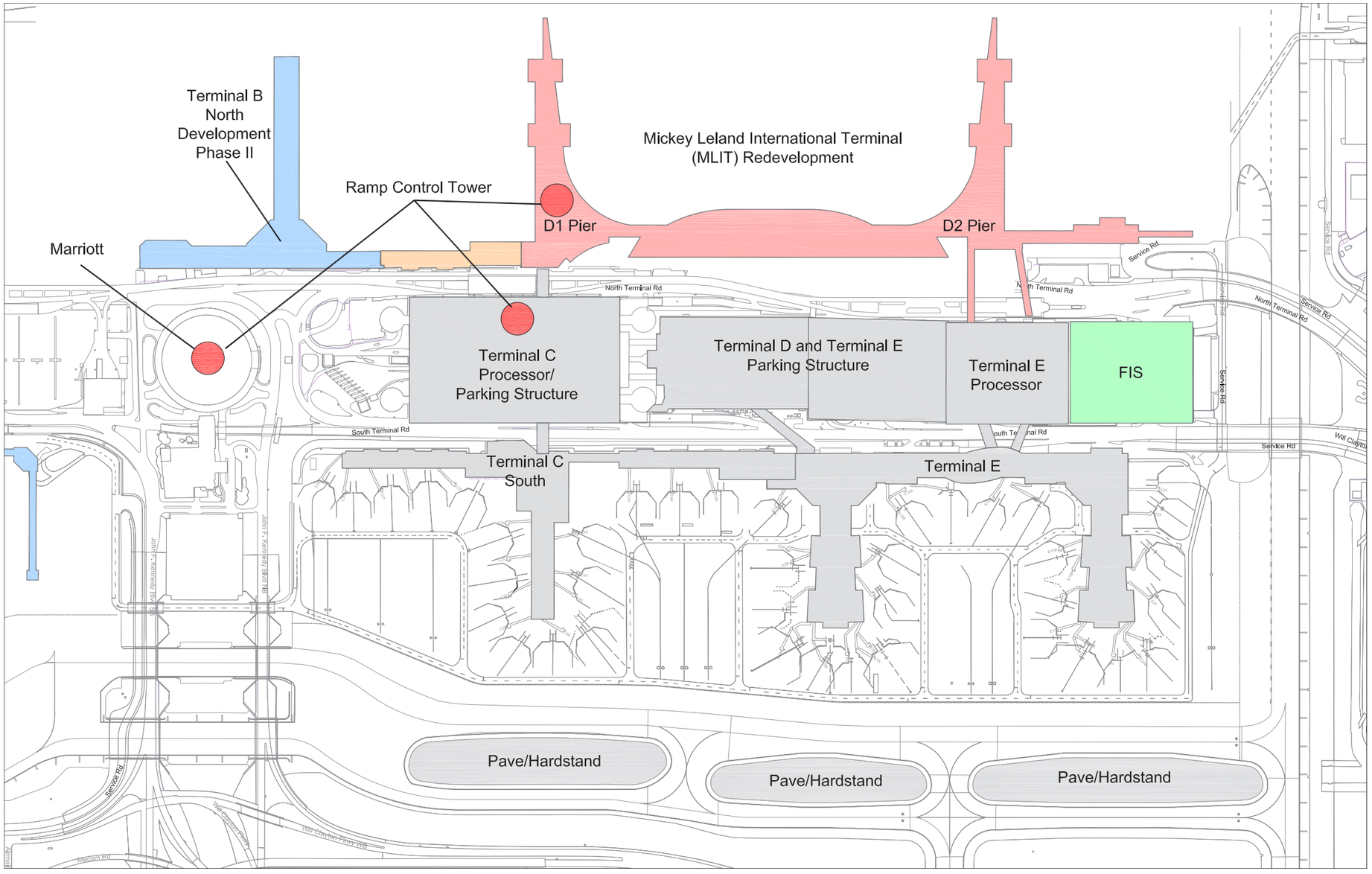
5.3.5.3 Electric Carts/Transport Vehicles
HAS will continue to operate electric carts for passengers needing assistance though the Sterile Corridors. Storage and charging locations for electric carts should be provided along the Sterile Corridor route.

5.3.5.4 Circulation
The Club/Sterile Corridor Level Conceptual Floor Plan includes approximately 101,800 sf of secure, non-public Sterile Corridor and vertical circulation space.

Note: Due to the long walking distances within the sterile corridor from the farthest gate to the FIS, the Advanced Planning process looked into sterile restrooms. The CBP was not in favor of passenger restrooms along the sterile corridor because of security concerns. Commonly, including at IAH, the sterile restrooms are located in the primary processing area of the FIS. This is consistent with plan layouts at peer airports.

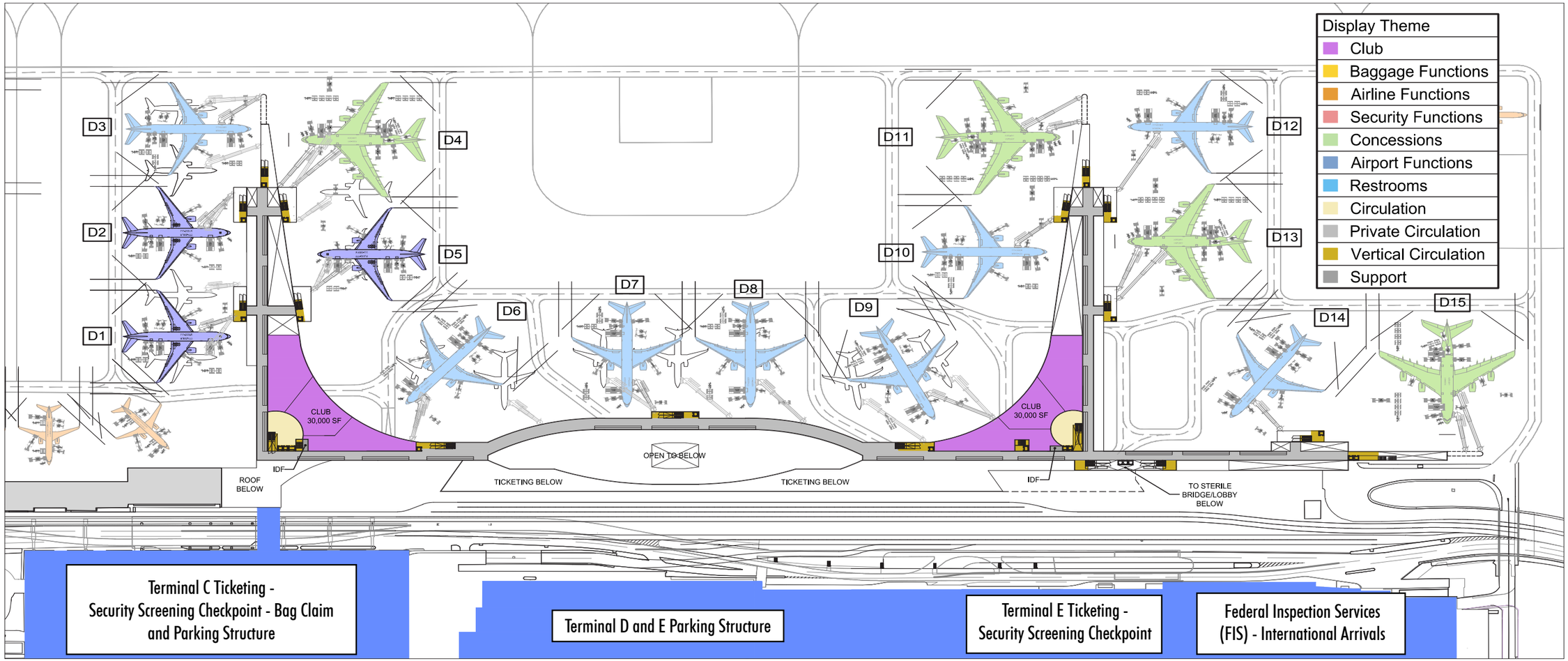
Currently, restrooms are located upon entering the FIS facility from both Terminals D (north) & E (south) before passengers enter the Primary Processing queue. These are the only set of restrooms the CBP would like within the sterile area. The proposed distance from farthest gate (at the D1 pier) to the existing north sterile restrooms is approx. 2525'. The walk from farthest Terminal E to south sterile restrooms is approx. 1425'.

Ramp Control Tower



Not to Scale

MLIT Rebuild Option L132 - Club Level



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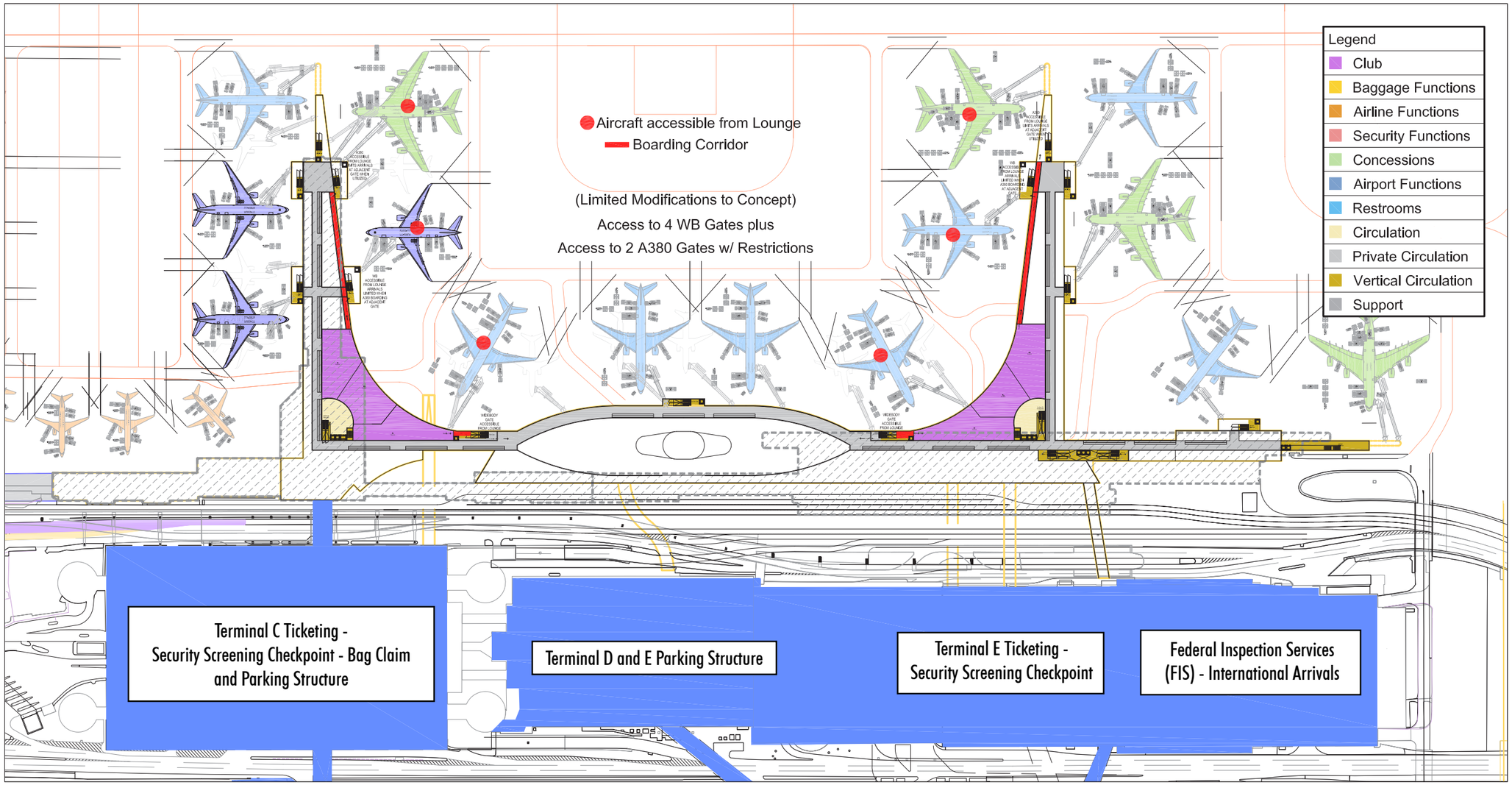
Club Boarding Concept 1 - L132 - Club Level



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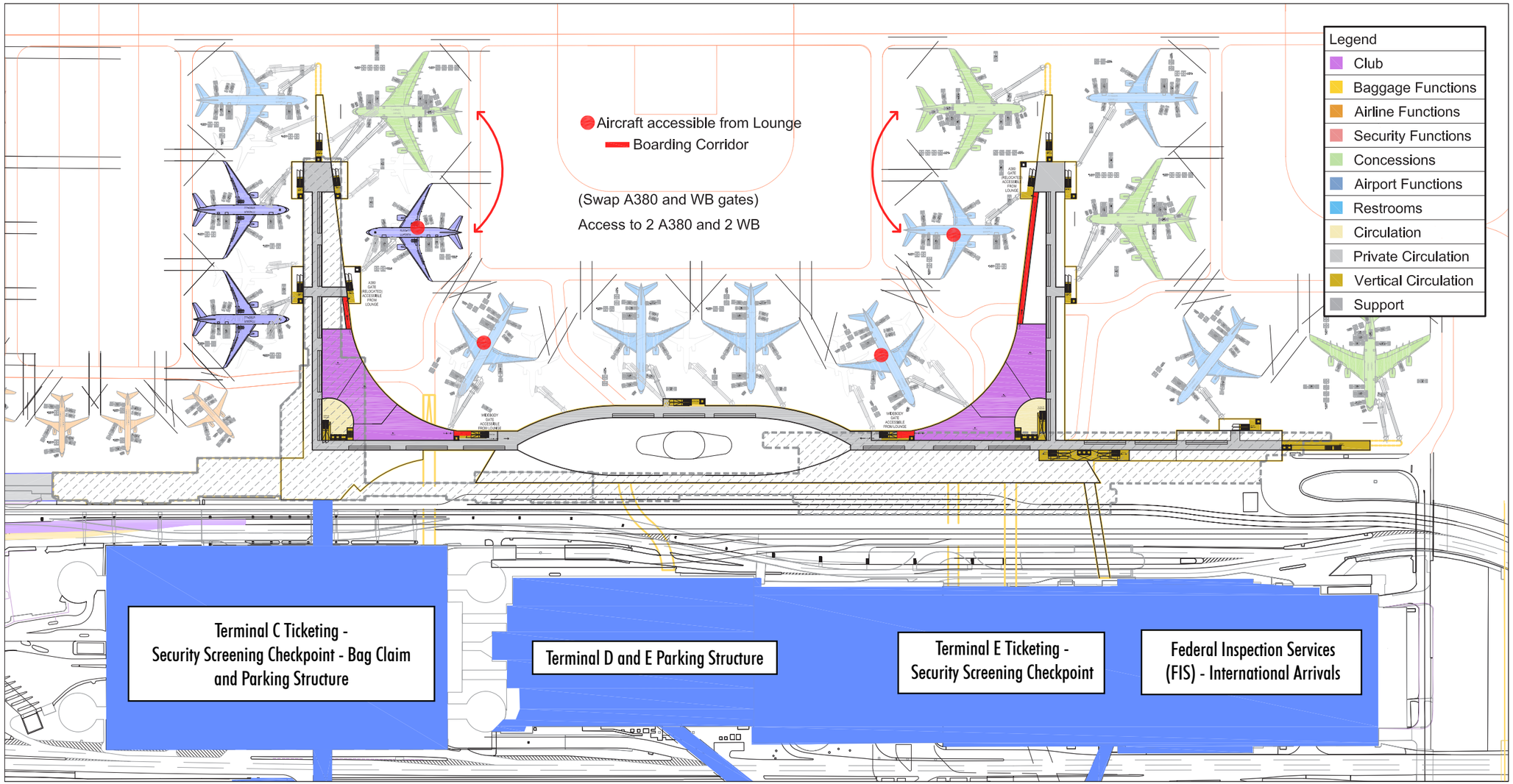
Club Boarding Concept 2 - L132 - Club Level



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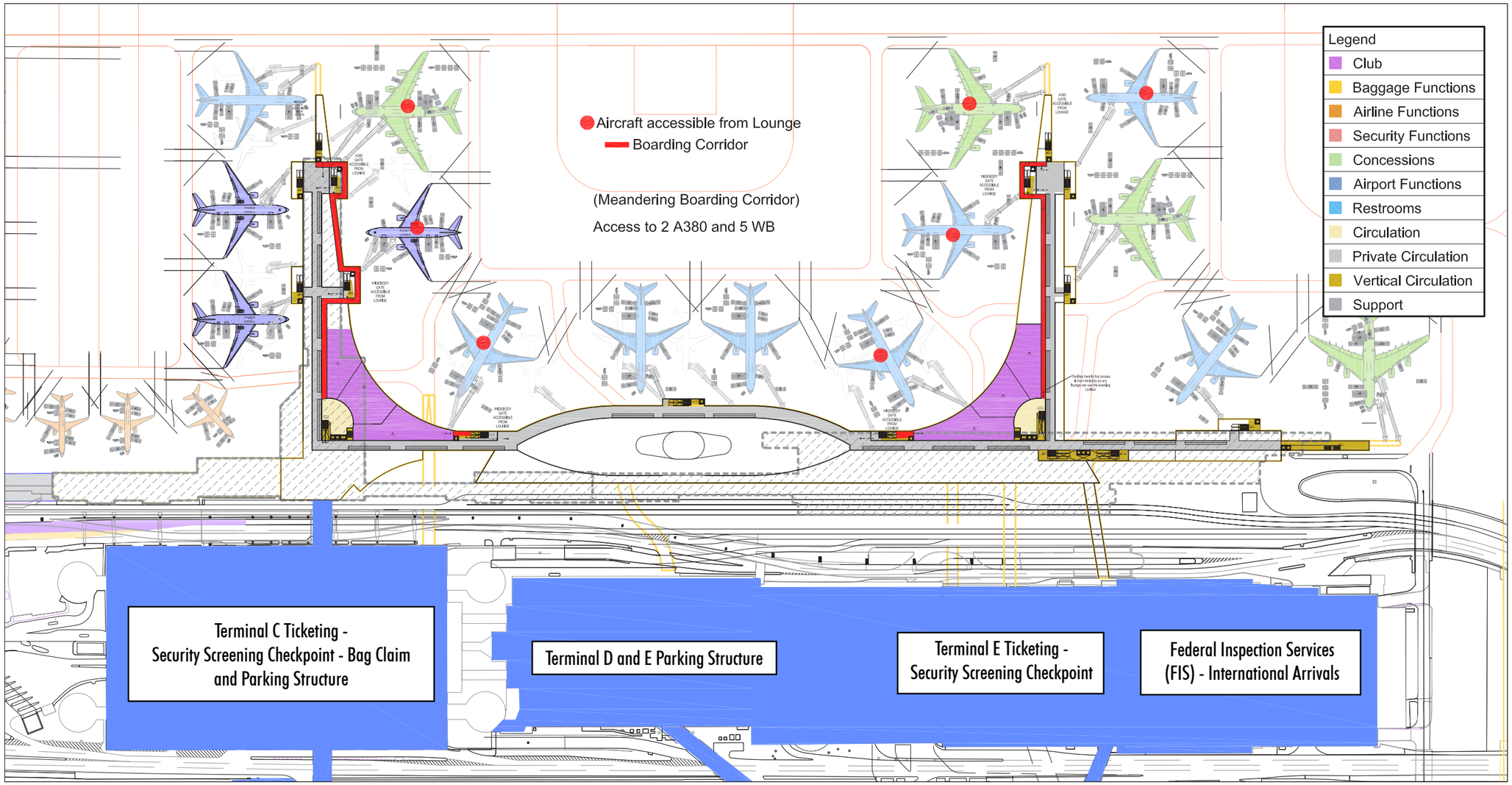
Club Boarding Concept 3 - L132 - Club Level



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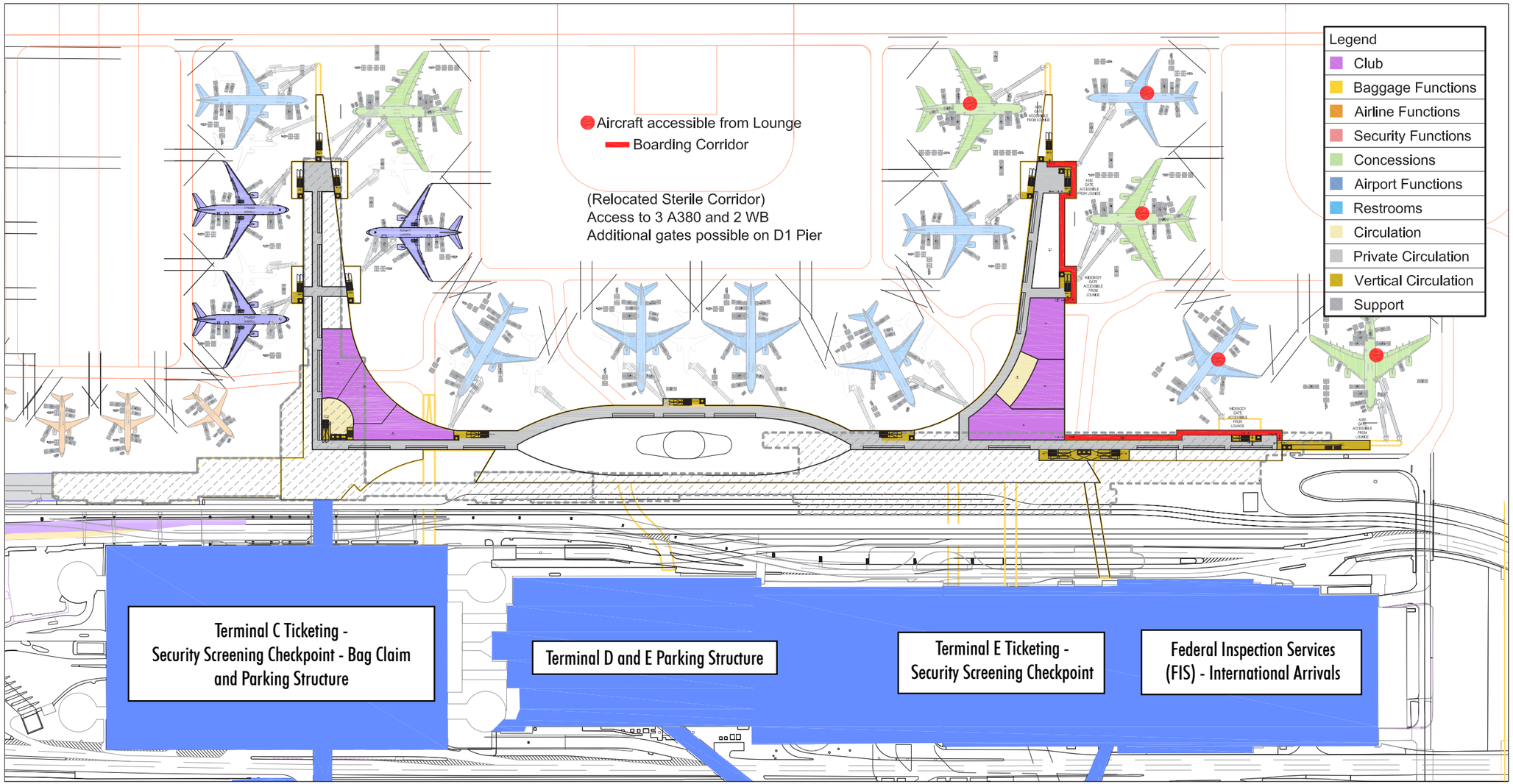
Club Boarding Concept 4 - L132 - Club Level



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5.3.6 TERMINAL BUILDING SUMMARY

A summary of the terminal building functional space allocations illustrated on the conceptual floor plans is provided in **Table 5.6**.

MLIT cross sections through the D1 pier are illustrated in **Figure 5.27** through **Figure 5.29**. Cross section of the end of the D1 pier is illustrated in **Figure 5.30**. Cross section of the central terminal is illustrated in **Figure 5.31**. **Figure 5.32** shows a cross section of the D2 pier with the central baggage inspection.

Table 5.5 Floor Plan Numbers

TERMINAL FACILITIES	SPACE REQUIREMENTS (CHAPTER 4)	TOTAL	LEVEL BY LEVEL (CHAPTER 5)				
		FLOOR PLANS (CHAPTER 5)	BAGGAGE LEVEL	TICKETING LEVEL	APRON LEVEL	DEPARTURES LEVEL	CLUB LEVEL
Airline Areas							
Total Check-in Positions (ea)	120	0	0	0	0	0	0
Total Kiosk Positions (ea)	72	0	0	0	0	0	0
Total Linear Frontage Positions (ea)	48	0	0	0	0	0	0
Check-in Lobby Area (sf)	17,160	17,160	0	17,160	0	0	0
Ticket Lobby Sales Counters (sf)	358	360	0	360	0	0	0
Airline Office and Support (sf)	20,672	20,240	0	20,240	0	0	0
Gates (ea)	15	15	0	0	0	0	0
Baggage Service Office (sf)	300	300	0	300	0	0	0
Ramp Operations/Storage Areas (sf)	7,210	7,200	0	0	7,200	0	0
Outbound Cart Positions (ea)	76	0	0	0	0	0	0
Baggage Make-up Devices (ea)	7	0	0	0	0	0	0
Outbound Baggage Make-up & Baggage Room Circulation (sf)	40,500	41,040	0	1,730	39,310	0	0
Empty Cart Storage (sf)	1,500	1,500	0	0	1,500	0	0
Inbound Piers (ea)	2	0	0	0	0	0	0
Inbound Piers (sf)	8,560	2,800	0	0	2,800	0	0
BHS Support Space(sf)	1,690	1,690	0	0	1,690	0	0
Pre-clearance Baggage Claim Area (sf)	27,000	9,000	0	9,000	0	0	0
Oversized and Non-conveyance Delivery (sf)	60	180	60	60	60	0	0
Airline Clubs (sf)	60,000	59,980	0	0	0	0	59,980
Holdrooms (ea)	15	0	0	0	0	0	0
Holdrooms D1 Pier (sf)	33,550	31,490	0	0	0	31,490	0
Holdrooms D2 Pier (sf)	29,825	29,960	0	0	0	29,960	0
Holdrooms Frontal Gates (sf)	11,650	13,410	0	0	0	13,410	0
Holdrooms East Pier (sf)	12,250	12,250	0	0	0	12,250	0
Subtotal Airlines Spaces (sf)	**271,950**	**248,560**	**60**	**48,850**	**52,560**	**87,110**	**59,980**

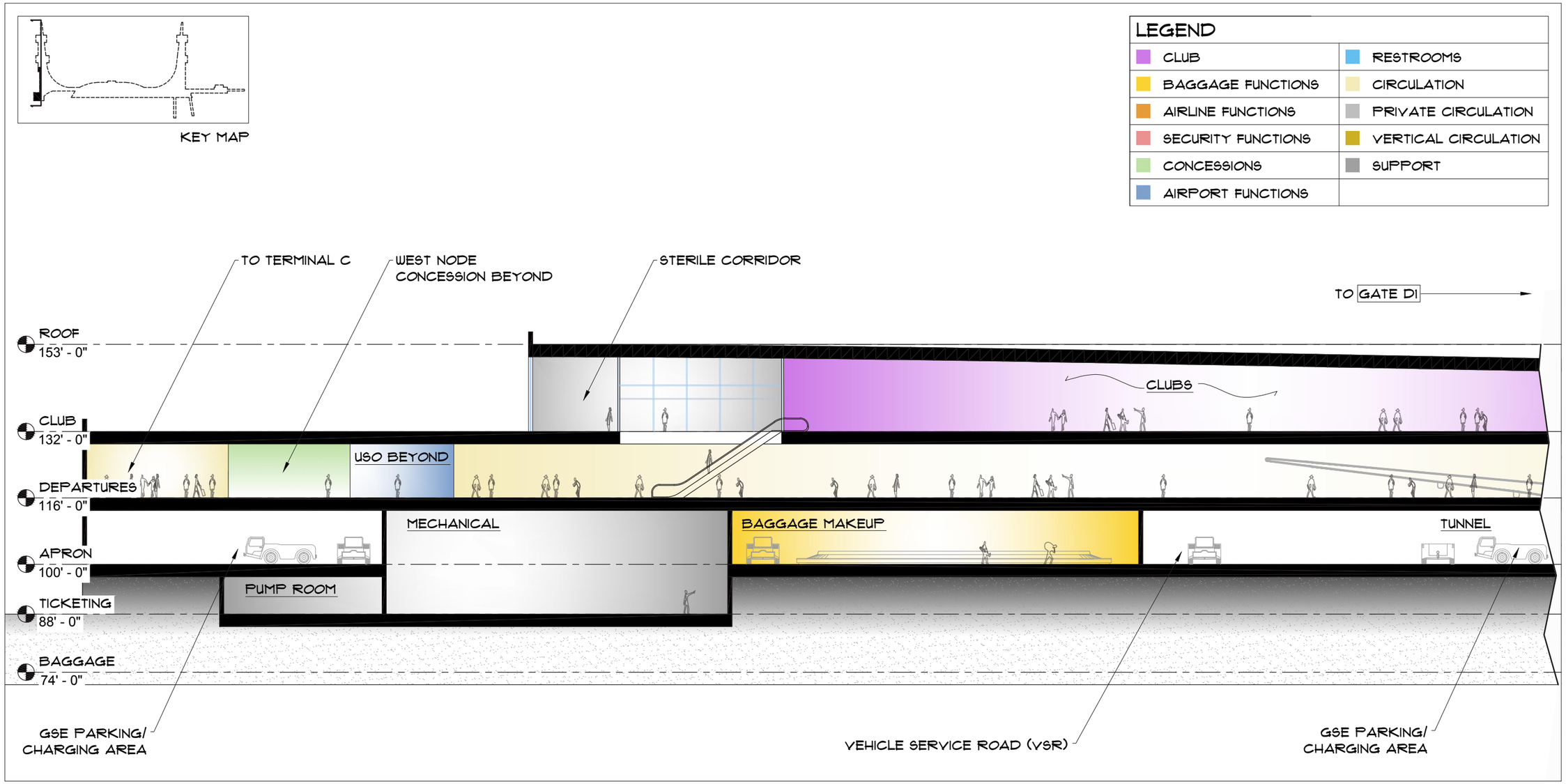
Table 5.5 Floor Plan Numbers (continued)

TERMINAL FACILITIES	SPACE REQUIREMENTS (CHAPTER 4)	TOTAL	LEVEL BY LEVEL (CHAPTER 5)				
		FLOOR PLANS (CHAPTER 5)	BAGGAGE LEVEL	TICKETING LEVEL	APRON LEVEL	DEPARTURES LEVEL	CLUB LEVEL
Transportation Security Administration (TSA)							
Passenger Security Screening Checkpoint Lanes (ea)	5	8	0	0	0	0	0
Passenger Security Screening Checkpoint (sf)	7,110	7,120	0	7,120	0	0	0
Passenger Security Screening Checkpoint Queue Area (sf)	2,700	5,480	0	5,480	0	0	0
TSA Passenger Security Screening Checkpoint Support Spaces (sf)	1,500	1,480	0	1,480	0	0	0
Baggage Screening EDS Devices (ea)	6	6	0	0	0	0	0
Baggage Screening (sf)	40,000	40,007	40,007	0	0	0	0
Baggage Screening Support Space (sf)	1,500	1,500	1,500	0	0	0	0
Subtotal TSA Spaces (sf)	**52,810**	**55,590**	**41,510**	**14,080**	**0**	**0**	**0**
Support Areas (Non-Airline)							
Commercial Program - Central Terminal (sf)	23,500	23,500	0	0	0	23,500	0
Commercial Program - D1 Pier (sf)	4,900	4,870	0	0	0	4,870	0
Commercial Program - West Node (sf)	12,600	12,600	0	0	0	12,600	0
Commercial Program - D2 Pier (sf)	3,600	3,600	0	0	0	3,600	0
Commercial Program - East Node (sf)	18,200	18,210	0	0	0	18,210	0
Commercial Program - East Pier (sf)	1,200	1,280	0	0	0	1,280	0
Commercial Program - Landside Terminal (sf)	2,800	2,800	0	2,800	0	0	0
Commercial Program - Other Services (sf)	3,500	1,180	0	1,180	0	0	0
Commercial Program Storage (sf)	11,500	11,290	0	7,030	4,260	0	0

Table 5.5 Floor Plan Numbers (continued)

TERMINAL FACILITIES	SPACE REQUIREMENTS (CHAPTER 4)	TOTAL	LEVEL BY LEVEL (CHAPTER 5)				
		FLOOR PLANS (CHAPTER 5)	BAGGAGE LEVEL	TICKETING LEVEL	APRON LEVEL	DEPARTURES LEVEL	CLUB LEVEL
Chapel (sf)	1,000	790	0	0	0	790	0
Religious Foot Wash Area - Male and Female (sf)	300	300	0	0	0	300	0
Diplomacy/Diplomatic Suite (sf)	5,000	5,000	0	0	0	5,000	0
HAS Maintenance (sf)	400	390	0	190	0	200	0
Air Marshal Confernce Rooms (sf)	300	300	0	0	0	300	0
CBP Interview Room at each International Gate Pod (sf)	1,200	660	0	0	0	660	0
Children's Play Area (sf)	600	600	0	0	0	600	0
Loading Dock (sf)	5,000	5,000	0	5,000	0	0	0
Wheelchair Storage Areas (sf)	450	420	0	420	0	0	0
Electric Cart Storage/Charging Area (sf)	100	100	0	0	100	0	0
Employee Break Room (sf)	1,400	410	0	410	0	0	0
Shared Airline Storage Closets (sf)	432	0	0	0	0	0	0
United Services Organization (USO) (sf)	1,150	1,130	0	0	0	1,130	0
Restrooms (sf)	14,800	14,710	0	2,400	0	12,310	0
Subtotal Support Areas (Non-Airline) (sf)	**113,930**	**109,140**	**0**	**19,430**	**4,360**	**85,350**	**0**
Other Currently Non-Programmed Areas							
MEP and IT Service (sf)	83,351	59,550	0	18,710	40,840	0	0
Circulation (sf)	280,762	328,690	1,790	70,100	7,800	147,250	101,750
Subtotal Other Currently Non-Programmed Areas (sf)	364,110	388,240	1,790	88,810	48,640	147,250	101,750
Total Areas (sf)	**802,800**	**801,530**	**43,360**	**171,170**	**105,560**	**319,710**	**161,730**
Other Areas Not in Building Program							
Utility Tunnel (sf)	0	30,500	30,500	0	0	0	0
Baggage Tunnel (sf)	0	13,080	13,080	0	0	0	0
United Transfer Baggage Makeup (sf)	0	12,570	0	0	12,570	0	0
Subtotal Other Currently Non-Programmed Areas (sf)	0	56,150	43,580	0	12,570	0	0
Total Areas (sf) - With All Other Non-Programmed Areas	**802,800**	**857,680**	**86,940**	**171,170**	**118,130**	**319,710**	**161,730**

MLIT Cross Section Through Pier D1 (A)



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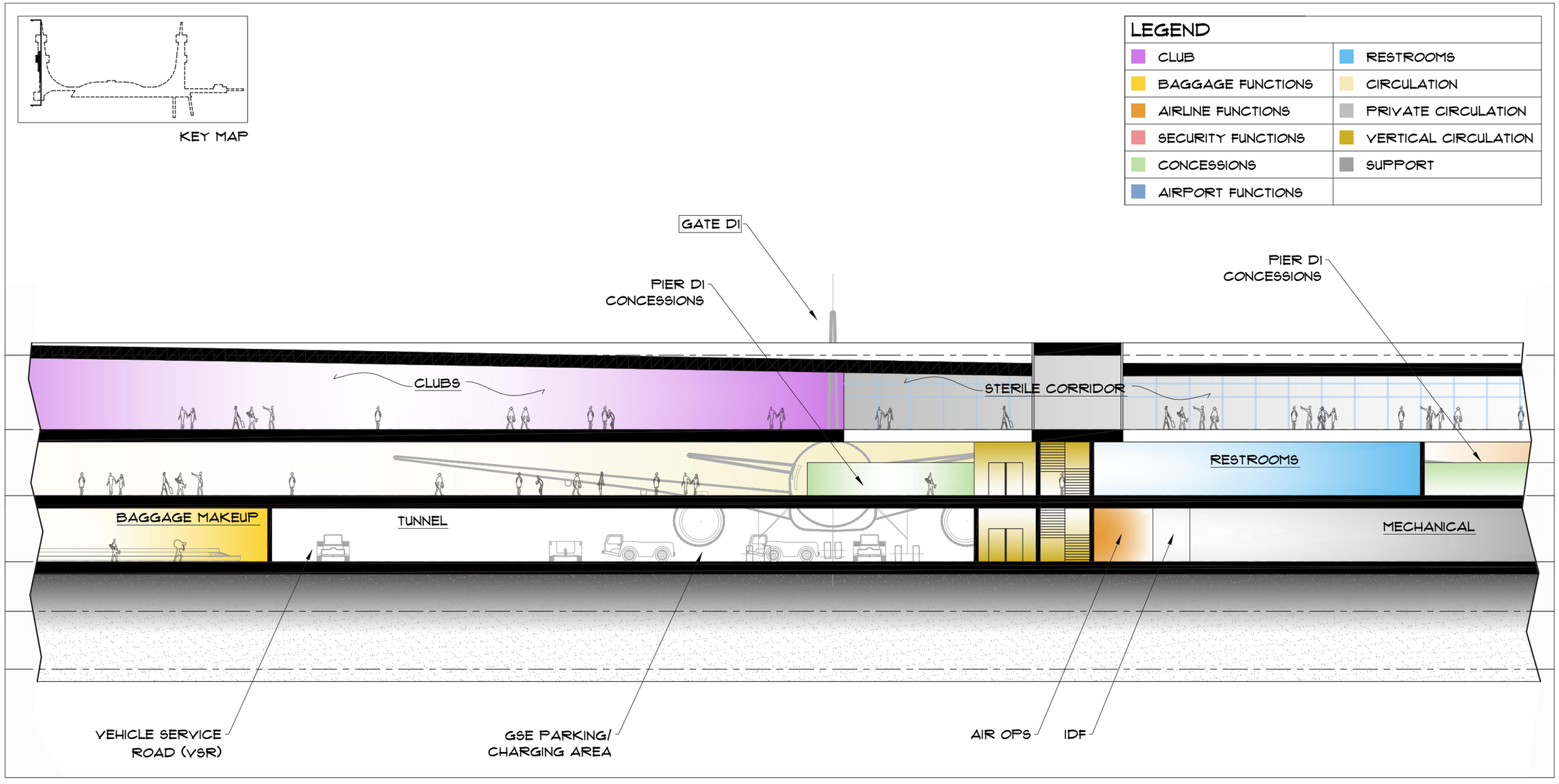
MLIT Cross Section Through Pier D1 (B)



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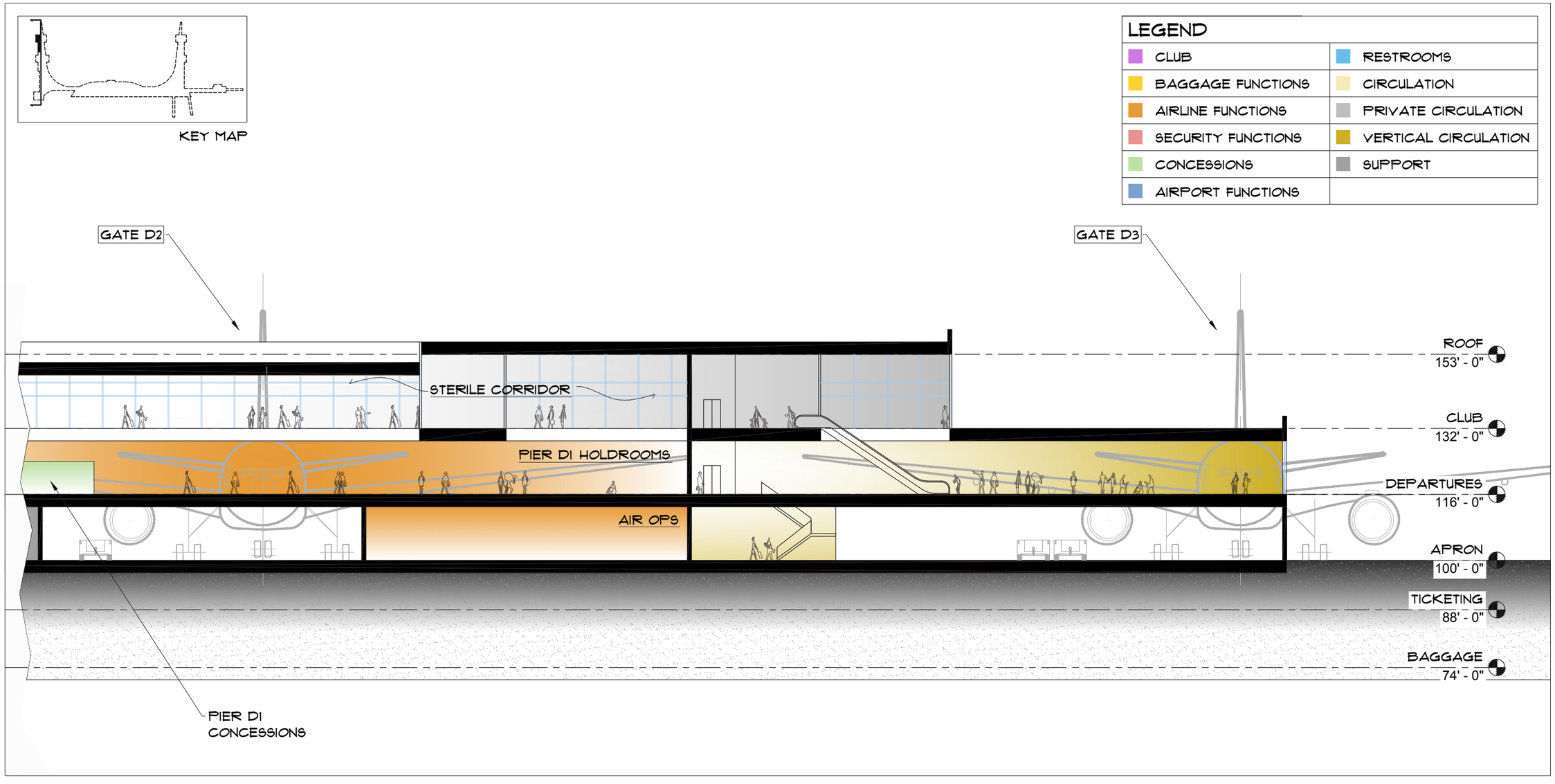

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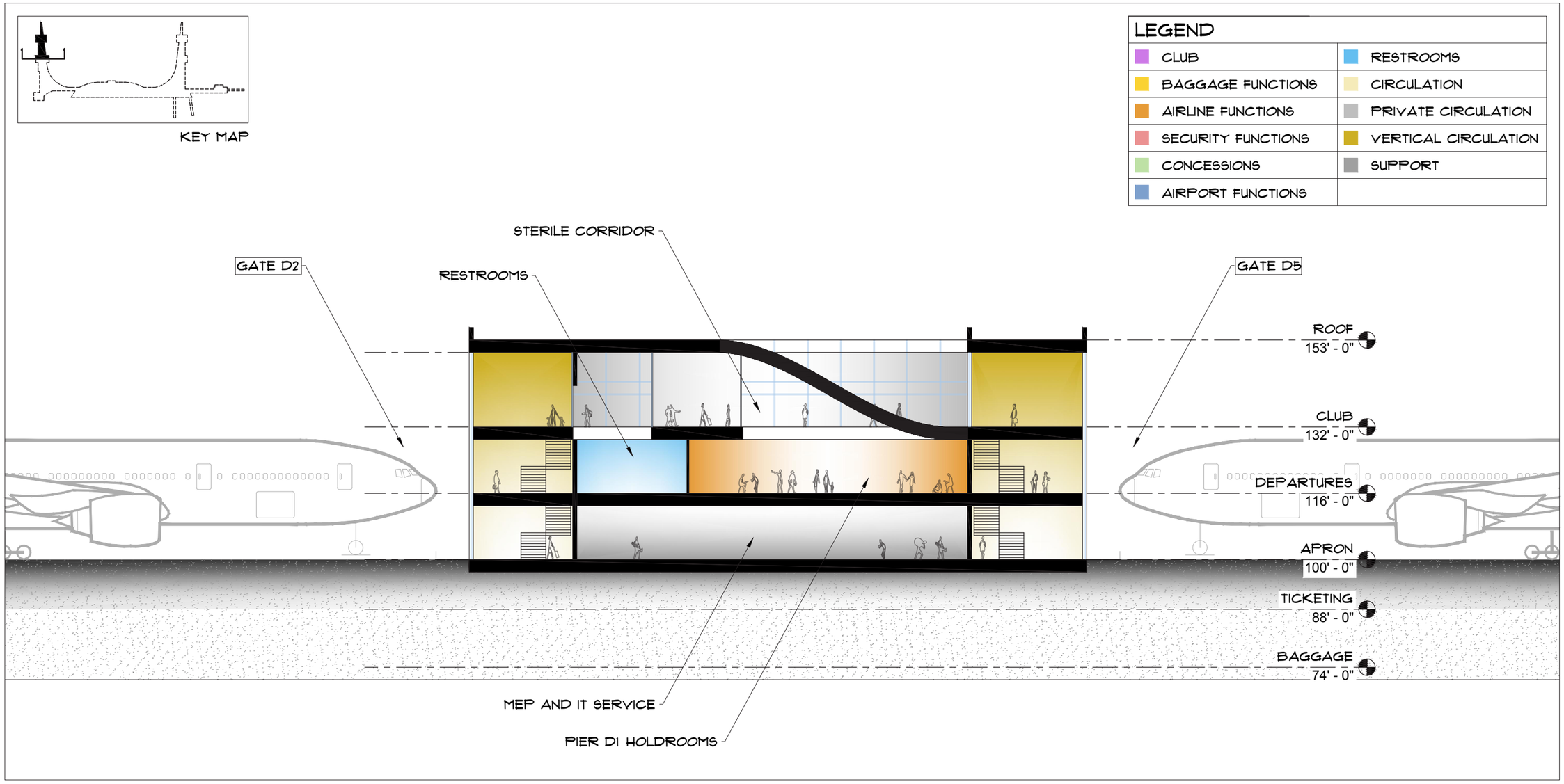

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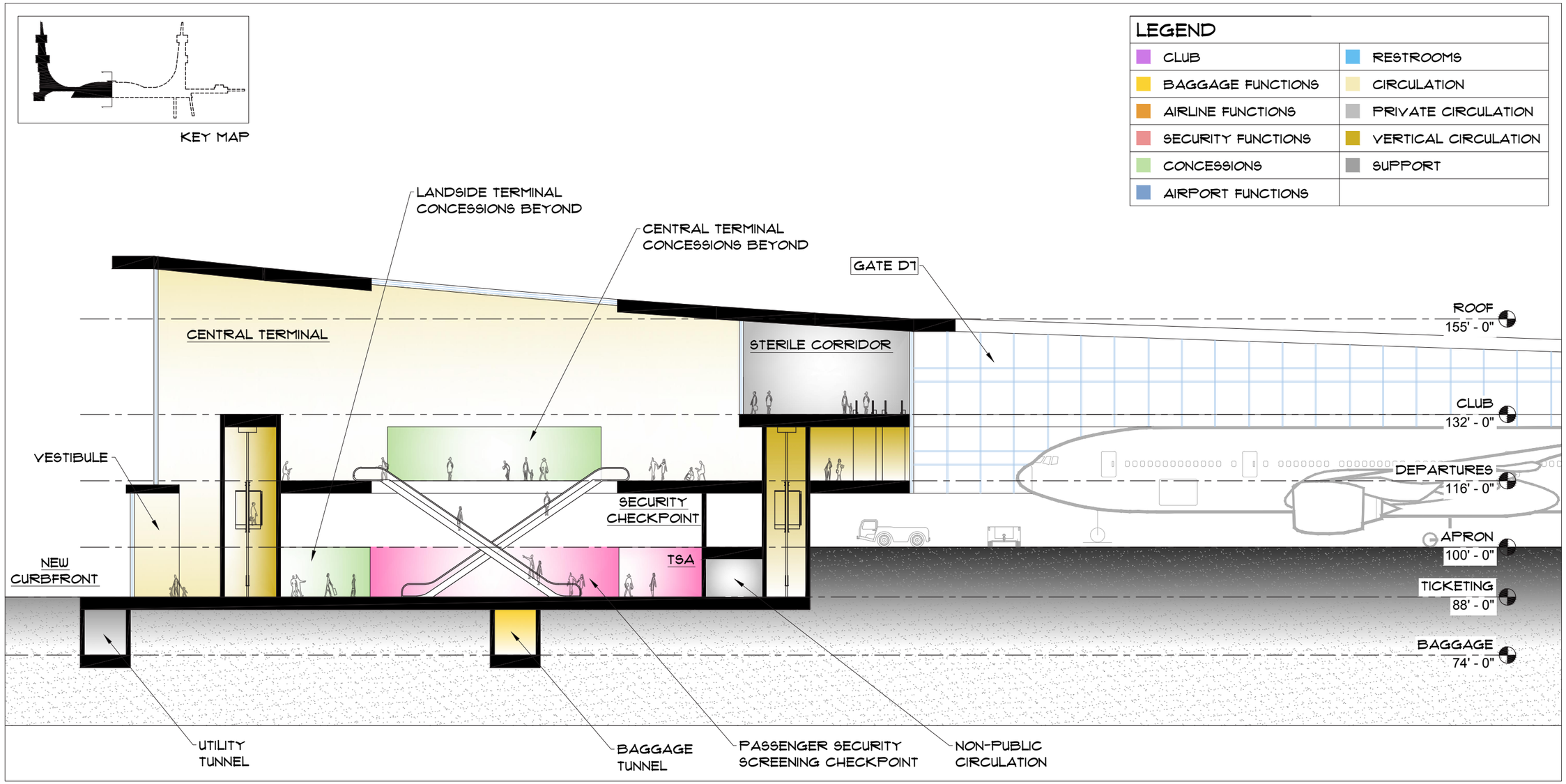
MLIT Cross Section Through Central Terminal



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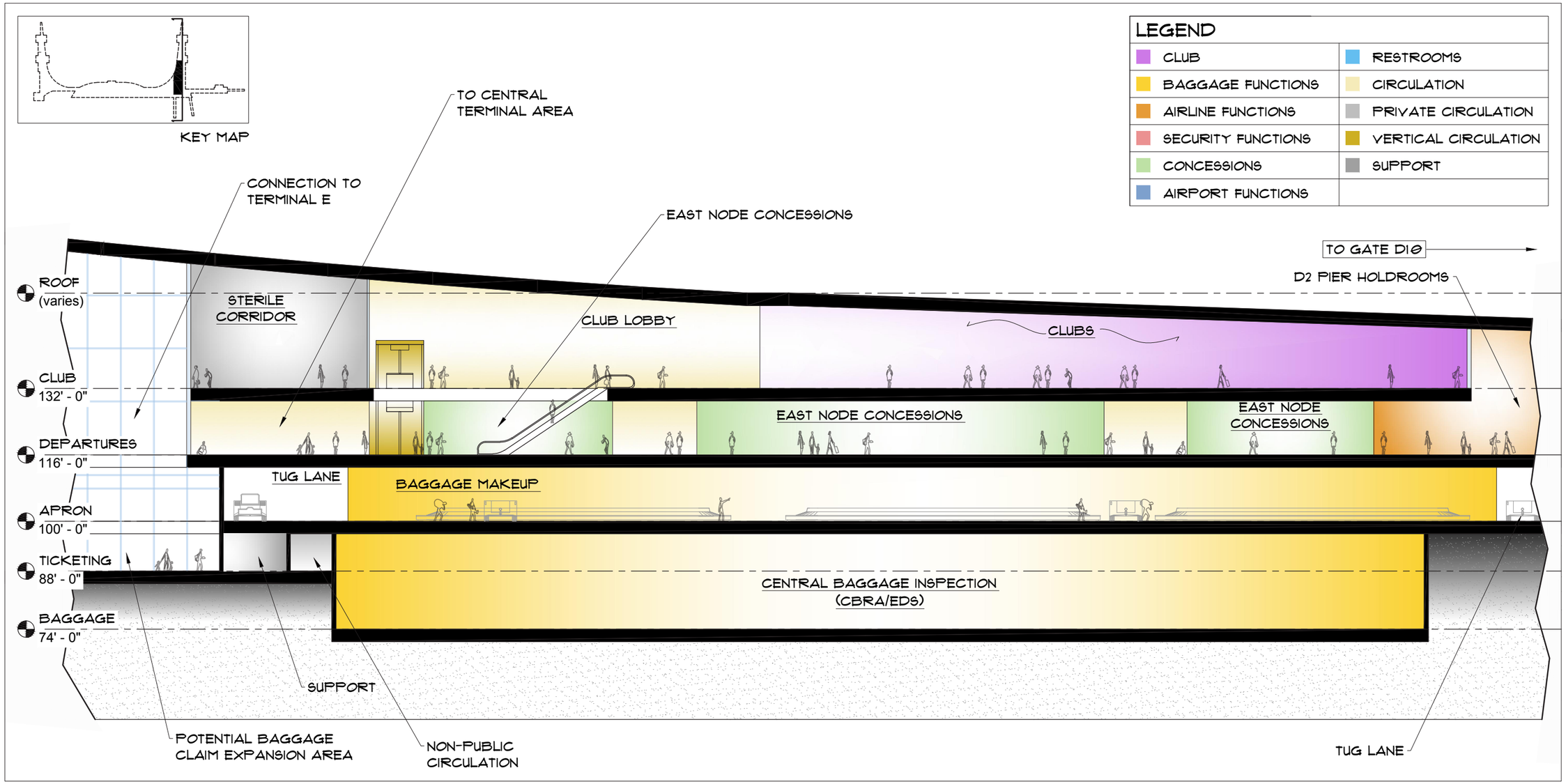
MLIT Cross Section Through Pier D2 Baggage Functions



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5.4 Terminal MEP Systems

This section presents the recommended terminal Mechanical/Electrical/Plumbing (MEP) system development for the Mickey Leland International Terminal (MLIT).

5.4.1 CHILLED WATER SYSTEM

Mickey Leland International Terminal will have an estimated total cooling system load of 3,250 tons. Approximately 6,500 gpm of chilled water flow from the Central Plant will be required to serve this cooling load. A new set of 20 inch chilled water lines will connect from the central chilled water distribution system and to a new mechanical room MRT-001. Four 2,350 gpm variable speed drive booster pumps in MRT 001 will ensure the supply of chilled water to all areas of the terminal. These pumps will have variable frequency drives to efficiently control pressure under varying loads. Chilled water piping from MRT-001 will connect to all air handling units and fan coils throughout MLIT.

An existing set of 14 inch chilled water lines from booster pumps in the Terminal C Core currently serves loads in Terminal C North. With that load being removed, the existing lines will be connected to the chilled water header from the booster pumps in MRT-001. This connection will allow partial redundancy between the chilled water from the booster pumps in the Terminal C Core and the new MLIT booster pumps in MRT 001. It will also provide operational flexibility for future system maintenance or renovation. (See **Figure 5.33** and **Figure 5.34**).

A set of 16 inch chilled water distribution lines currently delivers water to booster pumps in Terminal D. The phase of construction that includes demolition of existing Terminal D will eliminate the need for the Terminal D booster pumps. The existing 16 inch chilled water distribution lines will then be connected to the new mechanical room, MRT-001, to provide redundancy and to improve the hydraulics of the distribution system.

5.4.2 HOT WATER SYSTEM

The peak heating load of MLIT is estimated to be 18,700 MBTUH. This will require a set of 10 inch hot water lines to deliver 1,900 gpm of high temperature hot water from the Central Distribution System to the new mechanical room MRT-001. Three heat exchangers rated 9,350 MBTUH will transfer the heat to a lower temperature secondary hot water distribution system within the terminal. This secondary hot water system will have three 900 gpm variable speed drive pumps to maintain proper flow and pressure throughout the terminal. Provisions shall be made for injecting corrosion inhibitor chemicals into the secondary hot water system.

An existing set of 10 inch secondary hot water lines from heat exchangers in the Terminal C Core currently serves loads in Terminal C North. With that load being removed, the existing lines will be connected to the secondary hot water heater from the heat exchangers in MRT-001. This connection will allow partial redundancy between the secondary hot water system in the Terminal C Core and the new MLIT secondary hot water system MRT-001. It will also provide operational flexibility for future system maintenance or renovation.

A set of 8 inch distribution lines currently deliver high temperature hot water to heat exchangers in Terminal D. The phase of construction that includes demolition of existing Terminal D will eliminate the need for the Terminal D heat changers. The existing 8 inch hot water distribution lines will then be connected to new mechanical room MRT-001 to provide redundancy and to improve the hydraulics of the distribution system. (See **Figure 5.33** and **Figure 5.34**).

5.4.3 HVAC

The new building will be conditioned by air handler units located in mechanical rooms at different levels of the new terminal. Mechanical room MRT-001 located on the Ticketing Level will house chilled water booster pumps, hot water heat exchangers, secondary hot water pumps, domestic water pumps, and a domestic water surge tank. It will also house air handling units serving the west side of the Ticketing and Baggage Levels. Mechanical rooms MRT-002 and 003 on the Ticketing Level will enclose air handling units and ventilation serving the east side of Ticketing and Baggage Levels. Mechanical rooms MRA-001, 002, and, 003 will be located on the Apron Level serving the Departure and Apron Levels of D1 Pier and the west side of the Central Processor. Mechanical rooms MRA-004, 005, and 006 located on the Apron Level serve the Departure and Apron Levels of D2 and east side of the Central Processor. See **Figure 5.35**.

Mechanical rooms MRR-001 and 002 located on the roof level will serve the Club Level of the terminal (see **Figure 5.36**).

Air plenum return will be used as the design of the building allows. Ventilation units shall be installed throughout the building to provide the air changes necessary according to the quantity of persons that the new building will be designed for. The design firm will determine the final quantities, sizes, and distribution of the HVAC system.

5.4.4 DOMESTIC WATER SYSTEM

The domestic water demand for the new terminal building is estimated to be 595 gpm. The domestic water will be supplied from a combined Fire Protection (FP)/Domestic Water (DW) central storage and booster pump station, located on the west side of C Core Garage (Refer to **Section 5.4.9**, Fire Suppression). The City of Houston (COH) can't guarantee a steady residual pressure equal to 30 psi to IAH. The central storage system will be filled from new branch lines, including backflow preventers and COH water meters, connected to the existing 16 inch COH water line in North Terminal Road. Water will be pumped over to MLIT at three locations, each with a backflow preventer and HAS sub-meter, located outside of D1, the Processor and D2. (See **Figure 5.37**).

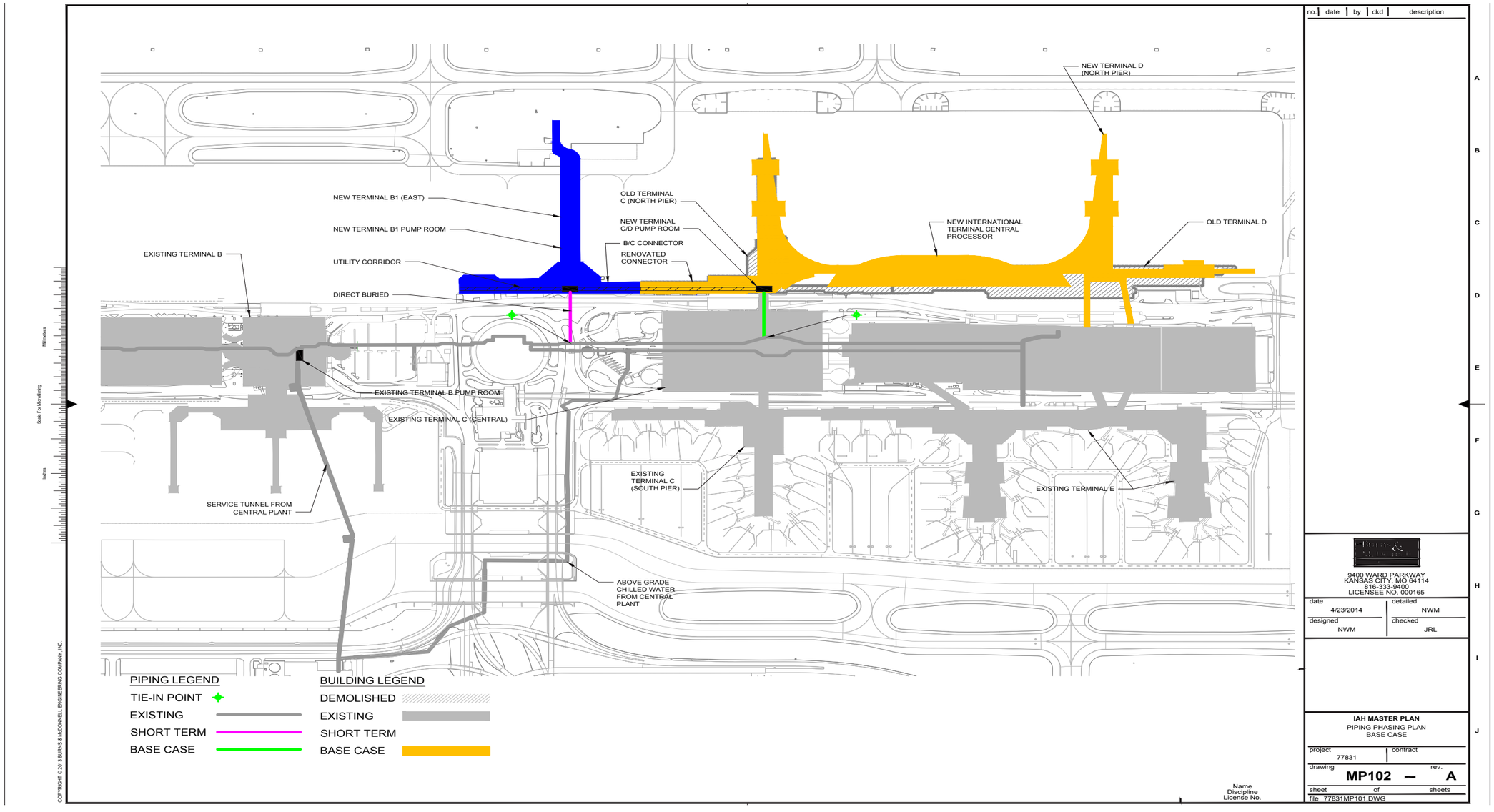
5.4.5 SANITARY WASTE AND VENT SYSTEM

The MLIT sanitary waste system will serve plumbing fixtures with a total drainage fixture unit count (DFU) of approximately 2,605 (1,203 gpm). This will require an 8 inch sanitary line on each level. In addition, it is necessary to connect approximately 18 drops between these lines at each level and the sanitary line outside the building in order to bring the discharge into the sanitary manholes around the new building. Sanitary flow direction will be reversed and discharge will be to the east to a new lift station. The direction change is to free up capacity in the west system for new Terminal B1-B3. Exterior located grease interceptor vaults will be provided on the west and the east end of the terminal. Each of these grease vaults will have a capacity of 9,000 gallons (2 each 4,500 gallon interceptors in series). Grease traps will be provided on the west and the east end of the terminal. Each of these two grease traps will have a capacity of 3,000 gallons. The recommended sanitary waste system location is illustrated in **Figure 5.51**.

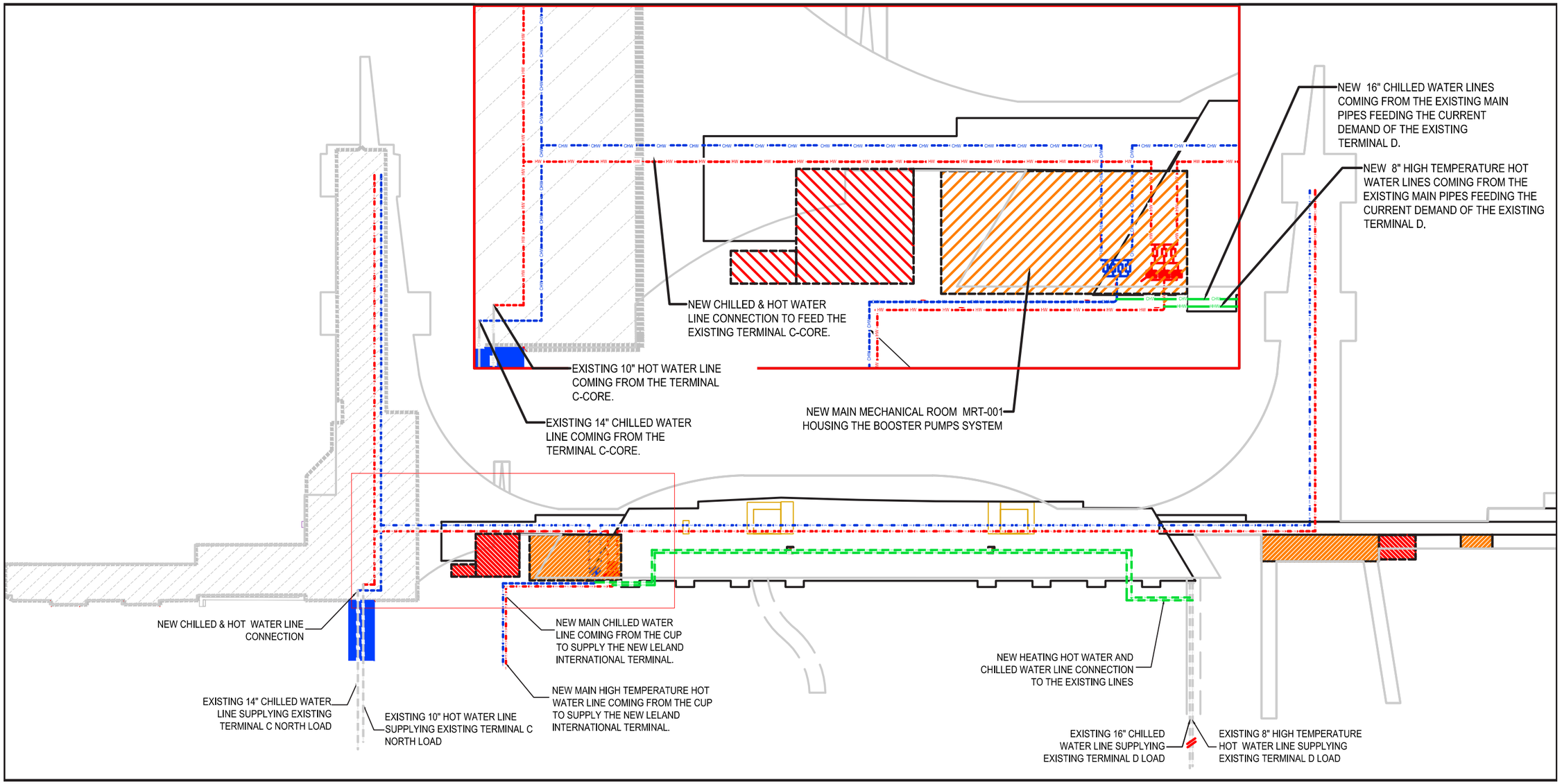
5.4.6 ELECTRICAL SYSTEM

A preliminary load calculation was performed based on the method calculation of square footage and information about the equipment that will be installed in the newest terminal building. There are three options planned regarding the power distribution of the Mickey Leland International Terminal: Option one and option two show the distribution from the substation located near the Marriott, and 12 kVA feeders would be routed to the switchgear at the room ERT-001. (See **Figure 5.38** and **Figure 5.39**).

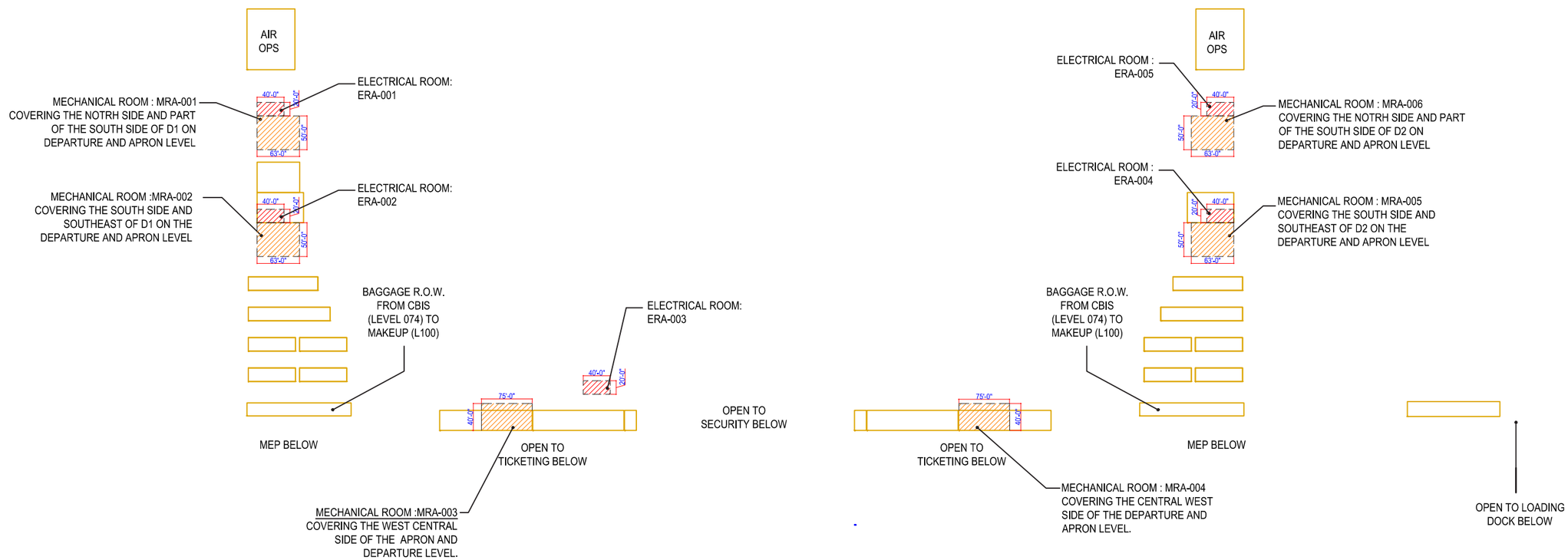
Hot Water and Chilled Water Distribution



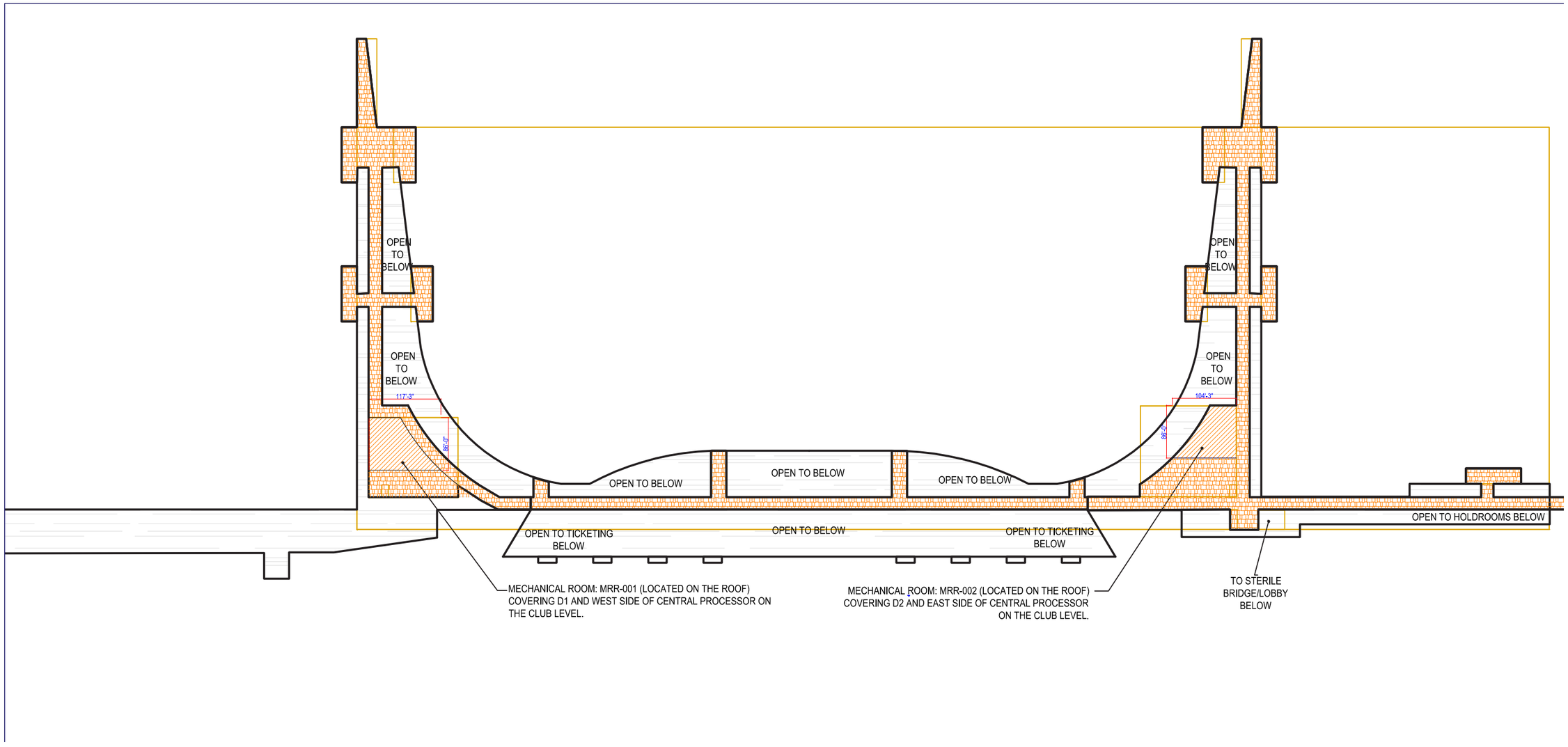
Chilled & Hot Water System L088 - Ticketing Level



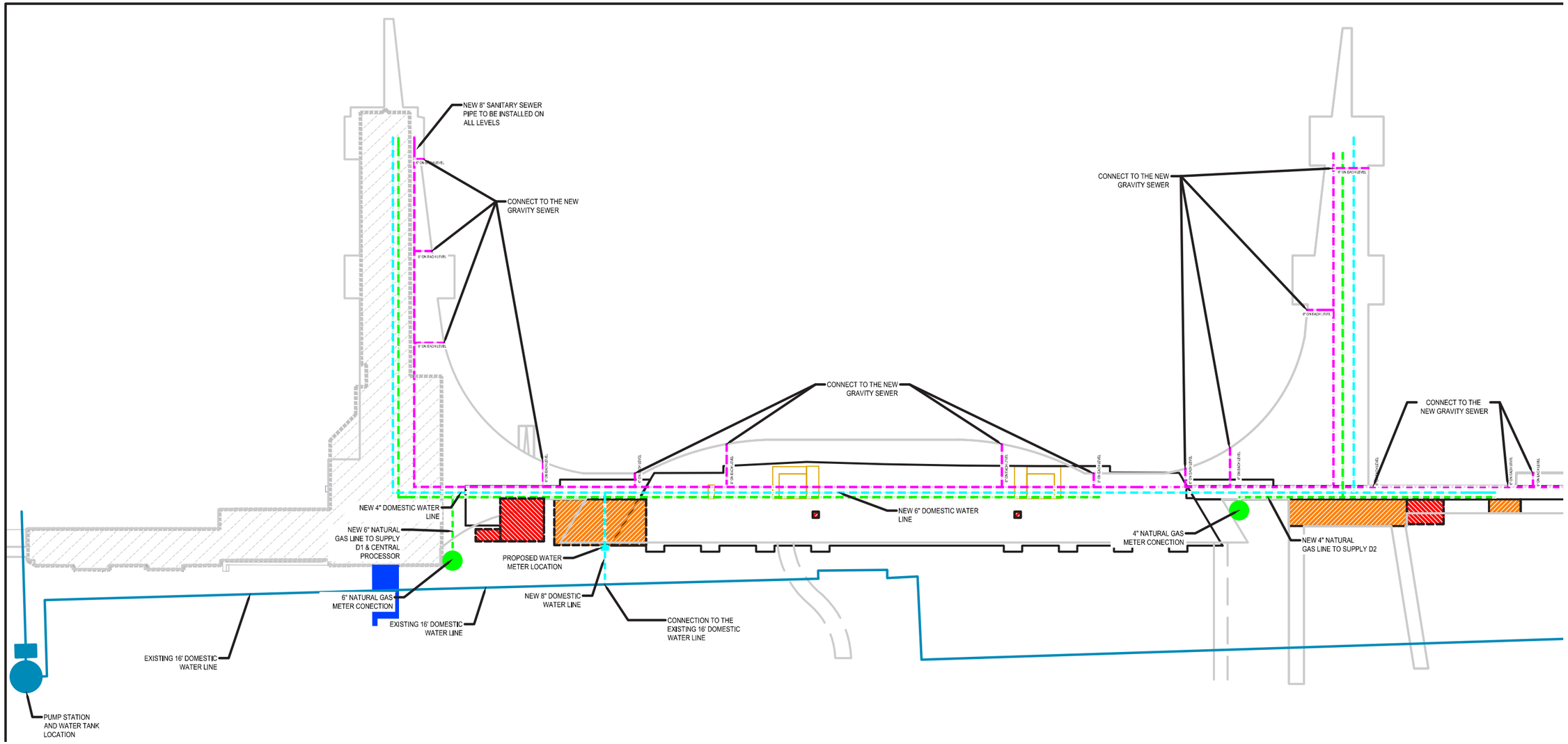
MEP-Rooms L100 - Apron Level



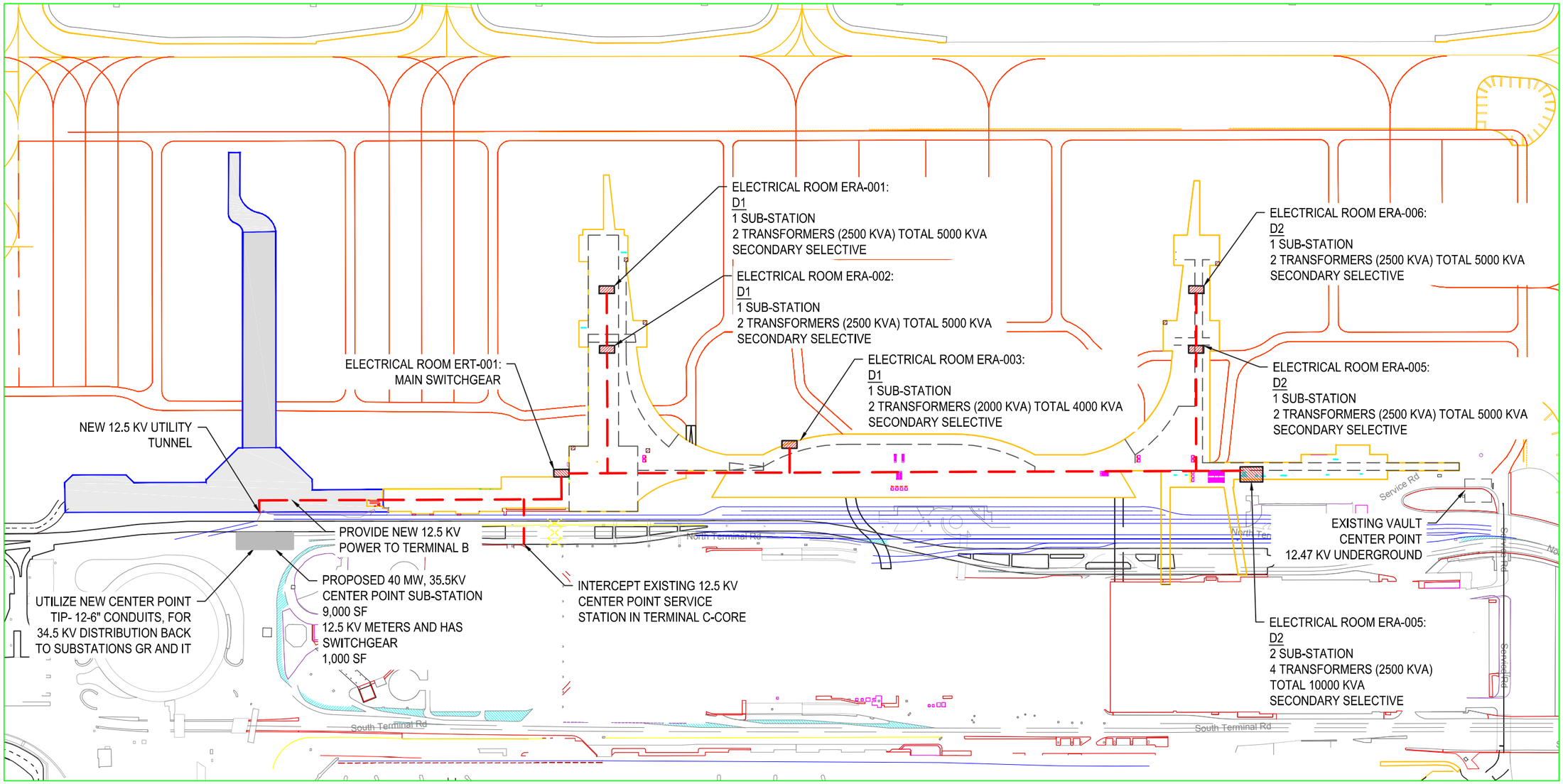
MEP-Rooms Roof



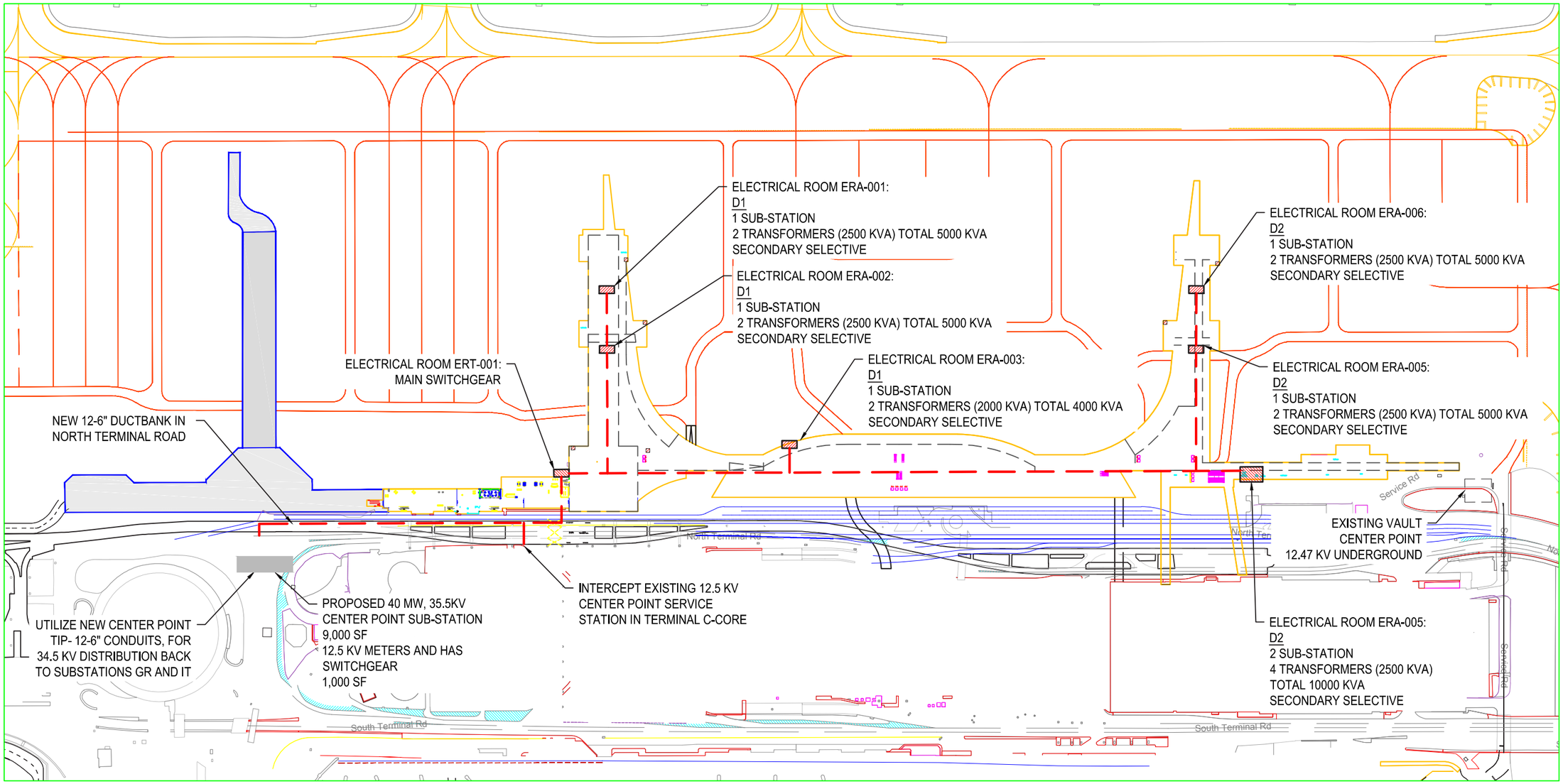
Plumbing System L088 - Ticketing Level



Power Distribution Option 1



Power Distribution Option 2



Option three shows the new CenterPoint substation located at D1 which will serve: 20 MW, 34.5 kV Substation 5,000 sf. (See **Figure 5.40** and **Figure 5.41**).

D Pier 1

An estimate of 10,000 kVA is estimated for the demanded load at MLIT which includes 3,260 kVA for the new D 1 Pier. It is recommended to place two substations along this new building, providing better load distribution. The substations will be accommodated at two electrical rooms ERA-001 and ERA-002 as shown in **Figure 5.35**. The substations will be fed by dual, redundant feeders coming from the main switchgear that will be placed in the room ERT-001. (See **Figure 5.42**) The meter and the 12.47 kV main switchgear shall be installed in room ERT-001, from where the different substations will be fed (**Figure 5.42**). CenterPoint proposed a new service 40 MW, 12.5 kV substation (9,000 sf) (**Figure 5.36**).

The location of the new electrical rooms should be evaluated for accessibility, ease of maintenance and work space requirements. The electrical rooms will include the following areas: ERA-001 (800 sf), ERA-002 (800 sf), and ERT-001 (800 sf). All the electrical rooms shall have the door swing outward from the room. Several electrical rooms will also be located in the other levels and their final size and location will be defined by the design firm.

Central Processor

A demand load equal to 2,621 kVa is estimated for the new Central Processor area. It is recommended to place a substation in this new area in order to provide a better load distribution. The room ERA-003 will house the substation (See **Figure 5.35**). This room will require the following area: ERA-003 (800 sf). The electrical room should have the door swing outward from the room. Several electrical rooms will also be located in the other levels and their final size and location will be defined by the design firm.

D Pier 2

A demand load equal to 3,025 kVa is estimated for the new D2 Pier. It is recommended to place two substations along the future D2 Pier to provide a better load distribution in the new building. The substations will be located in the electrical rooms ERA-004 and ERA-005 as shown in the **Figure 5.35**. They will be fed by dual, redundant feeders coming from the main switchgear located in Room ERT-001. (See **Figure 5.36**).

The Electrical Room ERT-004 will house two substations that will be fed by dual, redundant feeders coming from the main switchgear located in room ERT-001. (See **Figure 5.35**) The location of the new electrical rooms should be evaluated for accessibility, ease of maintenance, and work space requirements. The electrical rooms will require the following areas: ERA-004 (800 sf), ERA-005 (800 sf), and ERT-004 (2,400 sf). All the electrical rooms should have the door swing outward from the room. Several electrical rooms will be located in the other levels as well, and their final size and location will be defined during the design.

For additional information see **Figure 5.43**, **Figure 5.44,** and **Figure 5.45**.

5.4.6.1 Grounding System

There is a need to develop a new grounding system to cover the newest terminal building. This new grounding system shall be connected to the existing grounding loop. The final sizing shall be completed during the final design phase. In addition, ground bus assemblies should be installed in all new electrical, radio antenna, and data rooms. It is recommended that ground bus assemblies be added to the existing electrical systems.

The ground bus assemblies should then be connected to one another. At a minimum of four points, the ground bus assemblies should then be connected to the ground loop in the ground. The contractor should test the entire system to ensure compliance with NEC.

5.4.7 INFORMATION TECHNOLOGY

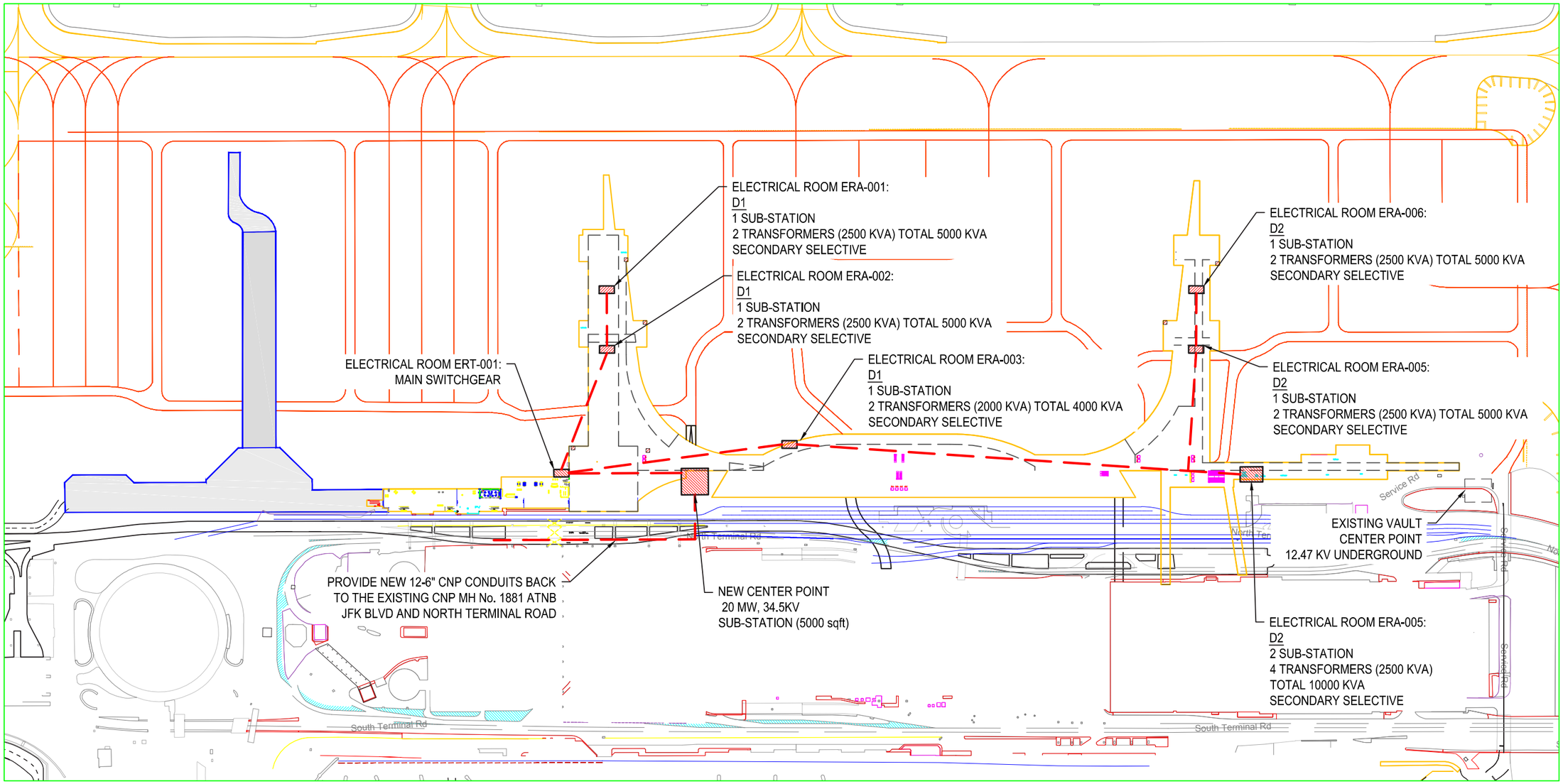
The Existing Terminal C MDF located in the Terminal C Core will have fiber optic (FO) and copper service feeds to the Terminal C North BDF disconnected once construction has begun on Terminal C North. All other systems in the Terminal C MDF, that feed Terminal C South as well as the Terminal C Core, will be protected in place. The Terminal C North BDF will be decommissioned once construction on Terminal C North has begun.

The existing PBX system in the existing Terminal D MDF will be relocated to the new MDF as the airport-wide telephone system transitions to Voice Over Internet Protocol (VOIP). In addition, the airport FO going through the existing MDF will be relocated to the new Mickey Leland International Terminal D, Pier D1 MDF.

There will be one new MDF room for both piers D1 and D2, and will be located at the base of the Mickey Leland International Terminal D1 Pier. Extensive reroutes will have to be made in order to facilitate cut-overs to this location. The new MDF will house all the core layer networking equipment and be a central connection point for all telephone and cable TV connections, including fiber optic converters, Cisco type routers and switches, centralized telephone and fire alarm interface for the PA system, central building management control center, energy management system, wireless network, radio communications, data communications, head units for eVIDS, as well as ACS and CCTV. With a basic level of service required for the baseline operation of the systems required for the new terminal, the MDF room should be no less than 1,000 sf, and be located at the first point of entrance into the terminal for all communications systems. In addition, to support the cut-over of the existing PBX system, an additional 500 sf should be provided. The MDF room will provide a central hub for communication distribution to 17 smaller telecommunications rooms or Intermediate Distribution Frame (IDFs) located throughout the terminal. The MDF room shall have all systems backed up with an Eaton Powerware UPS system to maintain system power during brownouts or during generator start-up. It is recommended that a centralized UPS system be provided in, or adjacent to, the main electrical room and MDF in order to provide flexibility for future expansion or service redistribution during construction. The UPS configuration should be similar to that in Terminal C Core, with three UPS systems in parallel, for redundancy and ease of maintenance. Any combination of two UPS systems in parallel shall be capable of sustaining the entire load.

The 27 smaller, 250 sf IDFs will house routers for connections to local airline GIDS; connections to airline and passenger WIFI routers; local eVIDS systems; amplifiers, noise sensors and network switches for local PA systems; ACAMS security panels for local doors; CCTV network hubs for signal consolidation and local viewing, if required by individual airlines; local fire alarm sub-panels provisions for connectivity to TSA's Hi-SOC WAN; and BAS. In addition to the IDFs smaller telecommunications closets located at each gate pod will also be provided, with single mode fiber optic and copper backbones back to the MDF. These closets will be limited to Passenger Boarding Bridge (PBB) support, monitoring systems, and phones. All other systems including ACS, VDGS, CCTV, and PA shall be routed back to the nearest IDF room. This is to ensure that when the gate is being utilized for boarding an aircraft, critical systems will still be accessible without disrupting passenger traffic. Each IDF shall be connected to the centralized UPS system for emergency power. All fiber optic and copper backbones shall be installed in Cable Trays on the Apron Levels from the MDF to all IDFs and Telecommunication Closets at the gates. When fiber or copper is placed in cable tray, exposed to the elements or, in any way impacted by the environment it shall be installed in conduit.

Power Distribution Option 3



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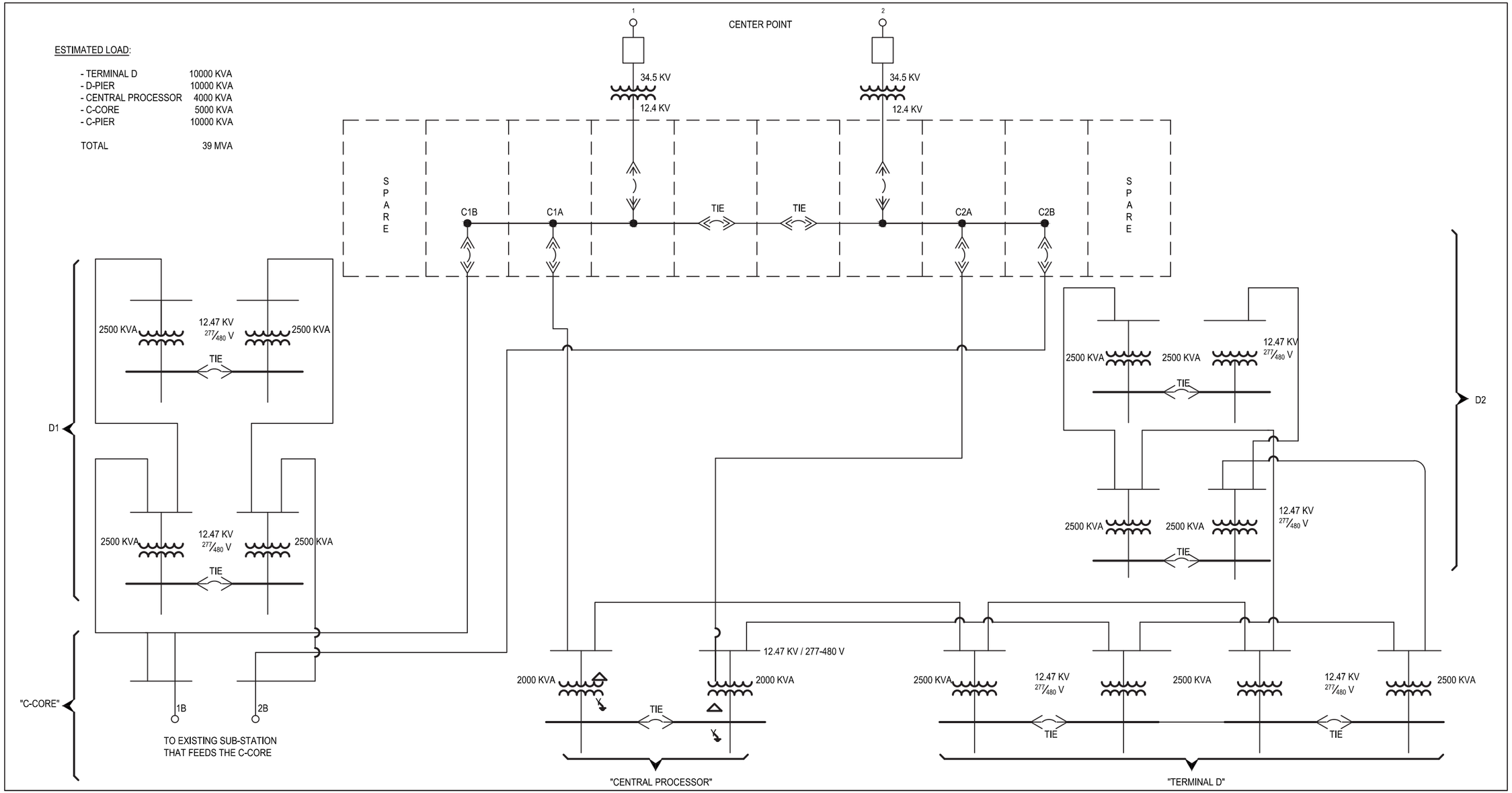
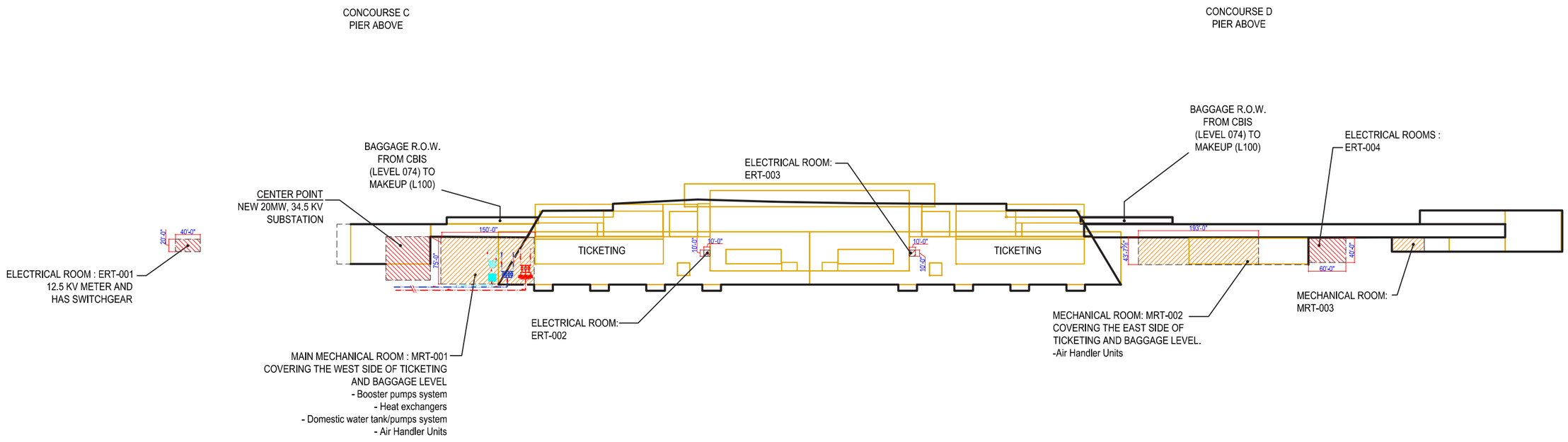
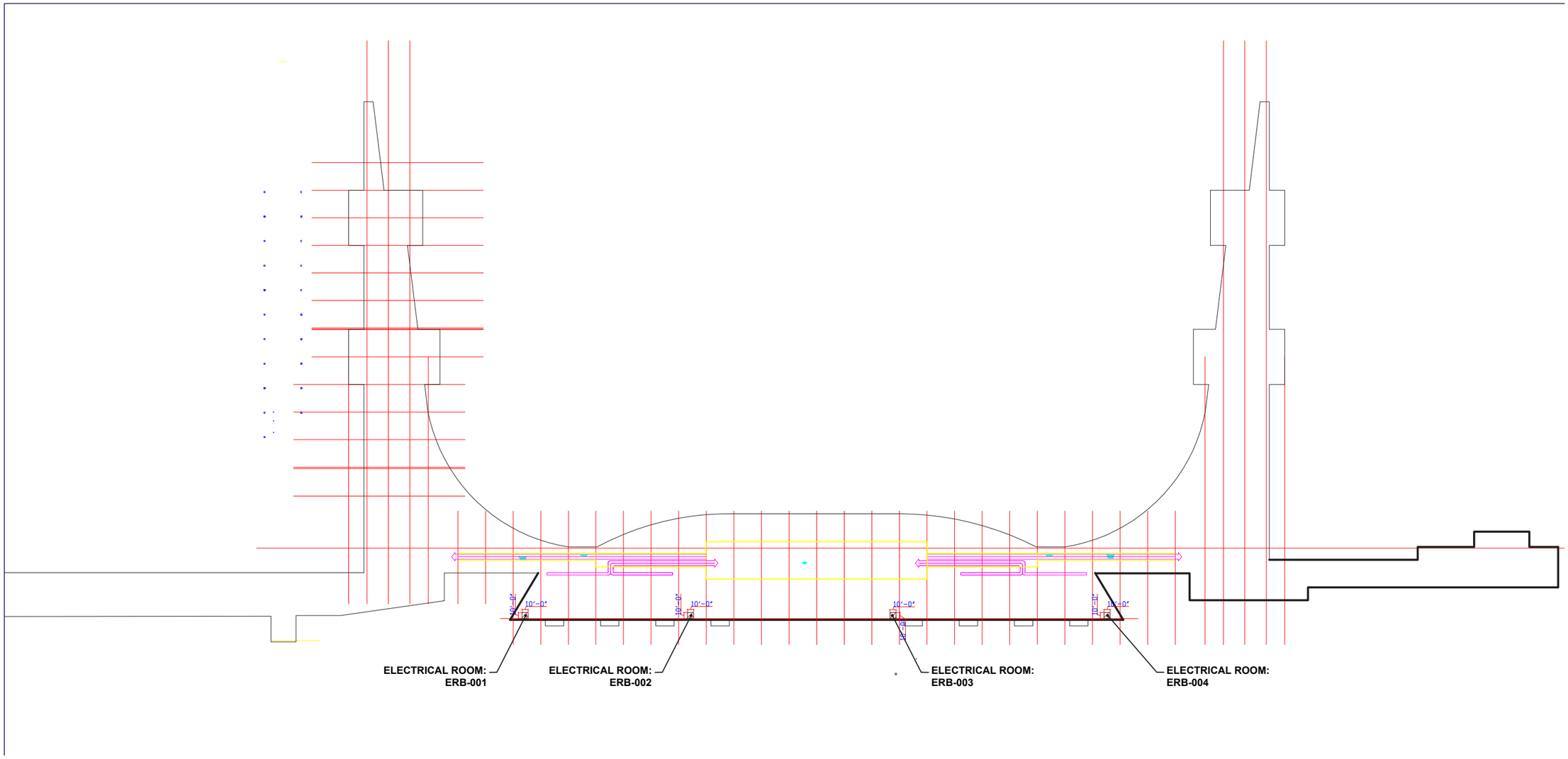
Power Distribution Option 3



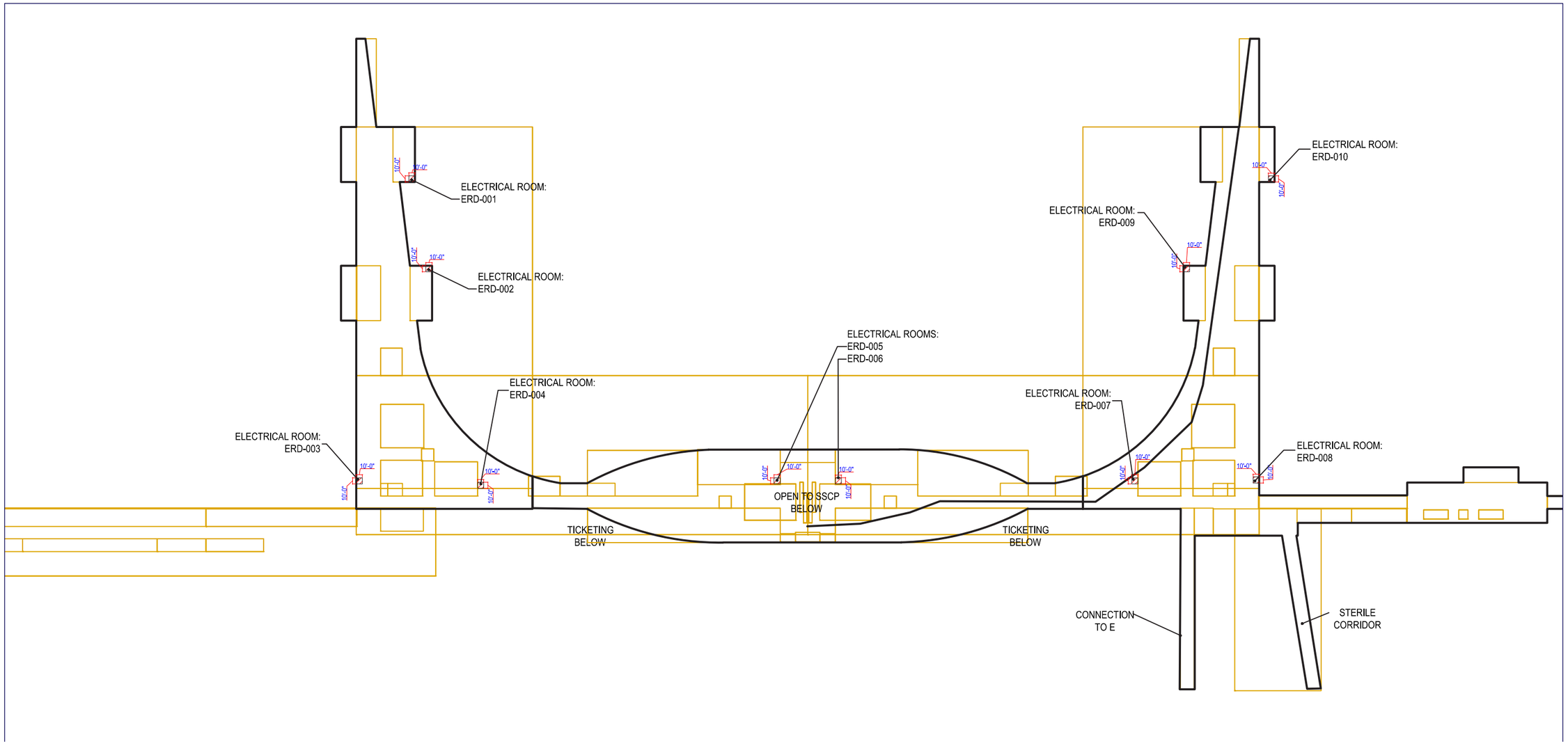
MEP-Rooms L088 - Ticketing Level



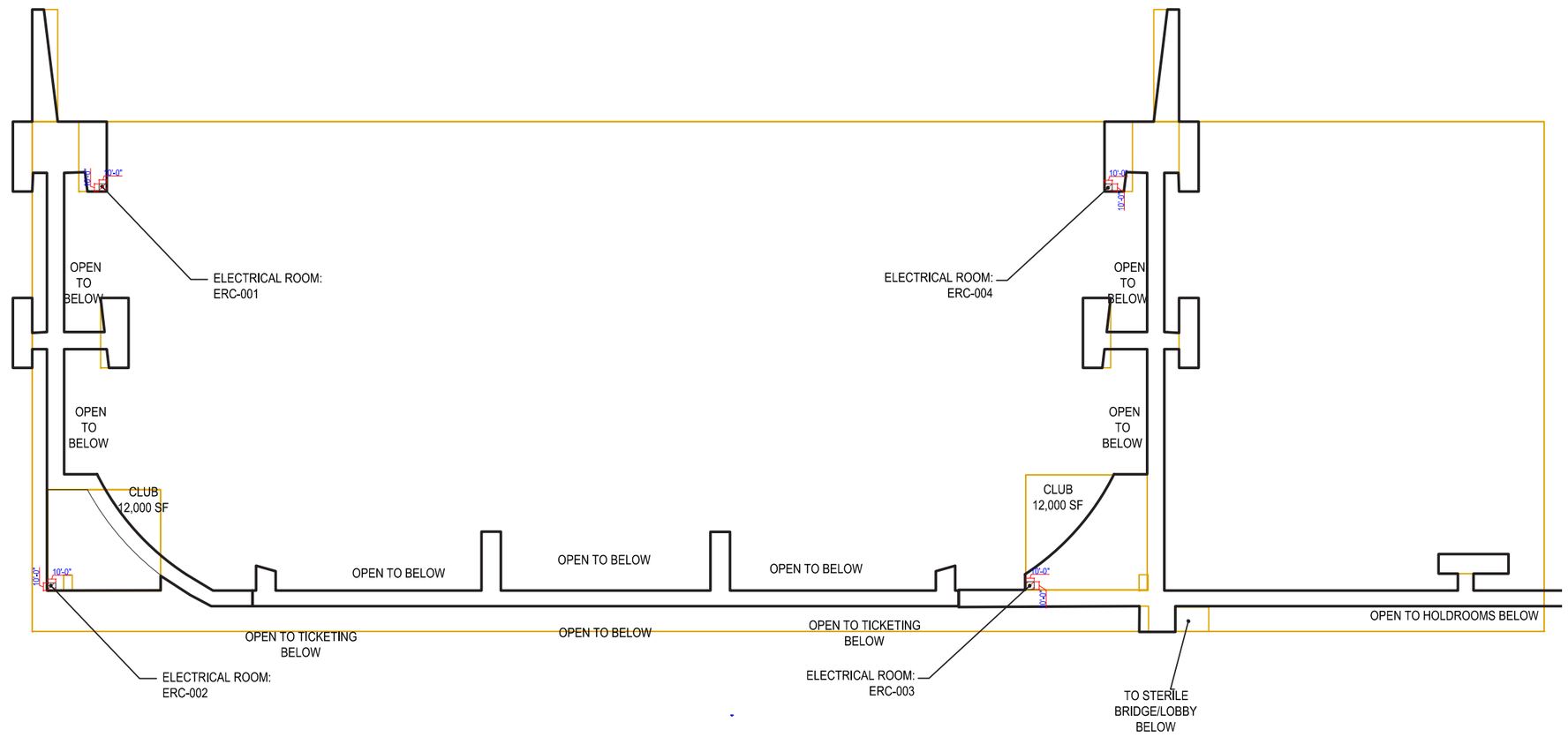
MEP-Rooms L074 - Baggage Level



MEP-Rooms L116 - Departure Level



MEP-Rooms L132 - Club Level



In addition, each Telecommunications Closet, IDF, and the MDF will have a dedicated UPS backed up air-conditioning unit, capable of operating independently of the terminal cooling system, to allow for whole room cooling during extended blackouts, or CUP failures.

The existing Terminal D has a rooftop penthouse with radio equipment for airline communication and tracking equipment. This equipment will need to be relocated into a new 250 sf penthouse located on the roof of MLIT Pier D1, as close to the end of the pier as architecturally possible. Radio antennas will have to be mounted around the edge of the penthouse with line of sight to the apron.

The existing Terminal D Public Announcement System (PA) consists of an IED system that is in the process of being upgraded. The new PA system shall match the new upgraded system, and consist of all necessary components for a complete and operational system, including amplifiers, IP microphones at all gates, noise detectors and zone specific directional tower speakers.

The existing EVIDS system is InFax, and has been recently upgraded. The new EVIDS system shall be similar to the existing system, and meet all architectural design requirements.

All gate and check-in counters shall utilize CUTE systems. See architectural design requirements for additional information regarding location and system infrastructure.

IAH currently uses passenger tracking systems in order to show wait times at TSA checkpoints. The technology detects the presence of a gadget via its embedded Wi-Fi and Bluetooth signals, and tracks these passengers as they move through security. This technology will be duplicated and provided within not only the TSA checkpoints but also allow the airport to analyze passengers' movements more closely and collect data on how people use retail and restaurant options as well as in the Customs Corridor, at the airports direction. Tracking technology, similar to what is currently being used by IAH, shall be used to track restroom patrons in order to notify maintenance and cleaning staff when the restroom needs to be cleaned.

5.4.7.1 General LAN Requirements

All LAN equipment, unless otherwise specified, shall be manufactured by Cisco Systems. Substitutions for specified Cisco Systems components are NOT permitted. The LAN configuration shall be a hierarchical star utilizing centralized core switches that star out to individual edge level devices located throughout the premises in designated areas. Single Mode fiber optic cable shall provide the connectivity between all devices. Each edge level device services the HAS communications equipment (administrative LAN workstations, building management stations, etc.) via UTP Copper Cabling. All LAN equipment shall provide Internet Protocol (IP) switching across all types of network technologies and topologies, including Ethernet, Fast Ethernet and Gigabit Ethernet. The LAN architecture shall be based on 10 Gbps between the two core networking switches located in the MDF and the edge level networking equipment located in the TR. In addition, the edge level equipment shall be dual homed to the separate core devices where applicable. Each active device shall be accessible from a network, console, or auxiliary RS-232 port. A configuration specialist shall be able to enter supervisory mode and change default configurations as appropriate for required operation of special system components. Each active device shall be capable of generating Simple Network Management Protocol (SNMP) or SNMP3 alarms. The device shall be respondent to RMON inquiries from an expert level network management inquirer. All network equipment shall be compliant to physical and operational parameters. The equipment shall be capable of responding to SNMP, SNMP3, and/or RMON network management program calls from the Network Management System. Network equipment shall provide multimedia and multicast support through use of Protocol Independent Multicast (PIM), Internet Group Management Protocol (IGMP). Network equipment shall support full-duplex connectivity on links (10 Base-TX, 100 Base-TX, 1,000 Base-TX, 100 Base-F/TX, and 1,000 Base-FX).

All network equipment shall be Virtual Local Area Network (VLAN) compatible based on both port and MAC addresses. VLAN assignments shall be configurable from a centralized administrative console. Network equipment shall not require reconfiguration of end-station network interface cards or network interface card drivers to accommodate intra-VLAN and inter-VLAN traffic. Network equipment shall support automated VLAN creation and administration capabilities. Network equipment shall support port mirroring. This shall be done by sending frames directly from a specified port to another switch port or from an external network analyzer.

Network equipment for use in the main MDF and TRs shall belong to one family of product. The equipment must allow for common sparing of all Interface Processor Modules and all Supervisor Modules. Network equipment shall support Terminal Access Controller Access Control System (TACACS), in order to provide secure port filtering. The equipment must enable individual ports to allow access only to certain workstations. All active LAN devices shall include all software as required for interconnectivity. All active devices shall have fully functional network management options installed. The wired system shall perform as designed providing a minimum of 10/100/1,000 Mbps to each end user device and one Gbps from edge switch to core switch on the backbone. The 802.11ac wireless access devices shall be provided in order to allow full terminal access to the wireless network. The designer shall coordinate with Airport Security, IT and CBP in order to determine where to limit coverage.

The new MLIT Pier D1 MDF core switch will need to be tied back to the admin redundant core switches, therefore a new 10 GB link from the MDF to each admin core switch will be required.

5.4.7.2 Access Control System (ACS)

Provide a complete ACS including iCLASS Elite Contactless smart card readers, or equivalent, with keypad where required. Card readers shall be "single-package" type, combining controller, electronics, and antenna in one package. Connect card readers to intelligent field panels (IFPs). The intelligent field panels shall be connected to the security host, by means of a TCP/IP network. It shall respond to commands from the host. Each IFP shall connect into the TCP/IP network through an Ethernet HUB. The IFP shall forward to the host information regarding access, status, and alarms, which the IFP has gathered from the readers and sensor devices that the IFP controls. The IFP shall meet or exceed the following functional requirements and each IFP shall be identifiable from the central host by means of a unique IP address.

All IT and communications installations shall be in accordance with the latest version of HAS/PDC/Design Division specifications; Section 270553, Identification and Labeling of Communication Infrastructure; Section 270526, Telecommunications Grounding and Bonding; Section 270528, Interior Communication Pathways; Section 271100. Communications Cabinets and Equipment Rooms; Section 271300, Backbone and Riser Media Infrastructure; Section 271500, Horizontal Media Infrastructure; Section 272100, Data Communication Network Equipment; Section 272200, PC, Laptop, and Servers Equipment; Section 275113, Audio Communication System; Section 281300, Access Control; Section 270543, Exterior Communication Pathways; Section 274100, Electronic Visual Information Display System; Section 272133, Airport WIFI; Section 270420, Distributed Antenna System; Section 270450, Television Distribution System.

5.4.8 NATURAL GAS

The preferred plan for natural gas service to the MLIT will be from the existing CenterPoint gas main located in North Terminal Road. CenterPoint owns and operates the plastic natural gas main. It enters the airport running north on JFK boulevard, runs east on South Terminal Road then north to North Terminal Road at the east side of Terminal D. It starts out at four inches on the east side of Terminal D and reduces down to a two inch line as it runs west. Terminal C has a single gas meter. Line pressure is between 30 and 40 psig. CenterPoint owns the meter and reduces line pressure down to 5 psig, 2 psig or 4 ounce building pressures to serve building demands.

CenterPoint provides a branch line to Terminal C, off the 2 inch main. The line enters the western portion of the building on the landside, west of the receiving dock. Refer to **Figure 5.46** for the natural gas plan. CenterPoint will replace the existing meter with a new unit and provide standard building pressure as required.

The MLIT gas demand is estimated to equal 45,000 CFH. Per the Utilities Master Plan, Appendix A-1, the natural gas demand is based primarily on concessions. CenterPoint Energy (CNP) maintains the existing 2 inch main in North Terminal Road and meters and pressure reducing stations. CNP line pressure ranges between 30 to 40 psig. Gas pressure is adequate to meet the MLIT estimated natural gas demands for MLIT.

5.4.9 FIRE SUPPRESSION

The new MLIT will require modifications to the fire protection system in order to meet the 2012 International Fire Code (IFC). City water pressure has been recorded below 30 psig. Plans by the city to increase the pressure are five or more years away with no guarantee at this date. The preferred plan is to install two aboveground water storage tanks, each equally sized at 500,000 gallons, with a booster pump station and a new combined fire/domestic water loop to serve Mickey Leland International Terminal and Terminal B. Separate fire system and domestic water branch lines will feed the terminal off the new combination loop. (See **Figure 5.47**). Fire branch lines will have reduced pressure double check assemblies and the domestic water lines will have meters. The storage tanks will be supplied from the city water mains and include isolation valves, supply pumps, reduced pressure double check assemblies and city water meters.

Per the 2012 IFC, the MLIT construction type and size requires a flow rate equal to 1,500 gpm for 4 hours (1,500 gpm x 60 min/hr. x 4 hr. = 360,000 gallons). Allow a minimum of 600,000 gallons for DW storage. Including a 10% unusable water tank factor, due to minimum water level for pump NPSH requirements and a maximum fill level, total tank capacity will need to be 400,000 gallons (FP) plus 600,000 gallons (DW) equals 1 million gallons or two tanks at 500,000 gallons each.

No hydrant static or residual pressure and flow test data was available from The City Fire Prevention Chief Inspector or the IAH ARFF Fire Station Chiefs. Verbal information provided by HAS is that the city water pressure fluctuates and has been recorded at 33 psig. Use FM-200 or another safe fire gas suppression system versus Halon for fire protection in grease hoods and IT areas.

5.4.10 FIRE ALARM SYSTEM

A new fully addressable fire alarm system will need to be incorporated into the new terminal. This system will have to be tied back into a main fire alarm control panel room, in accordance with the local fire department, within the terminal as well as back to the main emergency response center at the ARFF and/or police offices. These new systems will have to be capable of interfacing with the existing Honeywell Notifier fire alarm systems within the existing terminals, as well as other existing ancillary buildings. Additional migrating hardware and or software may be required in order to fully integrate the different systems.

5.4.11 BUILDING AUTOMATION SYSTEM (BAS)

The building automation system at IAH uses Allerton local controllers throughout the terminals that are networked to a central control system. Until recently the central control system consisted of a server running Allerton Envision software. The system is monitored and controlled by operators at the Central Plant. In the last two years the system has been undergoing a transition to a separate server running Tridium Niagra software which has more advance capabilities than the Envision system. The Tridium Niagra system utilizes the same Allerton field controllers as the Allerton Envision system. The Central Plant, Terminal A, and Terminal C have already been switched to the Tridium Niagra system. The building automation for the new Mickey Leland International Terminal shall include Allerton field controllers connected to the new Tridium Niagra system to conform to the development plan for building automation. The Building Automation System (BAS) is to be open architecture and a fully integrated system including control and monitoring of HVAC, lighting/day lighting control, electrical distribution (sub metering), domestic water distribution (sub metering), pressures, temperature and flow rates for HVAC chilled and heating water systems, lift stations, and integrated with master BAS located at the Central Utilities Plant (CUP). BAS controls and monitoring capability to be provided remotely, in Building Operations, and provide real-time energy management control and monitoring capability.

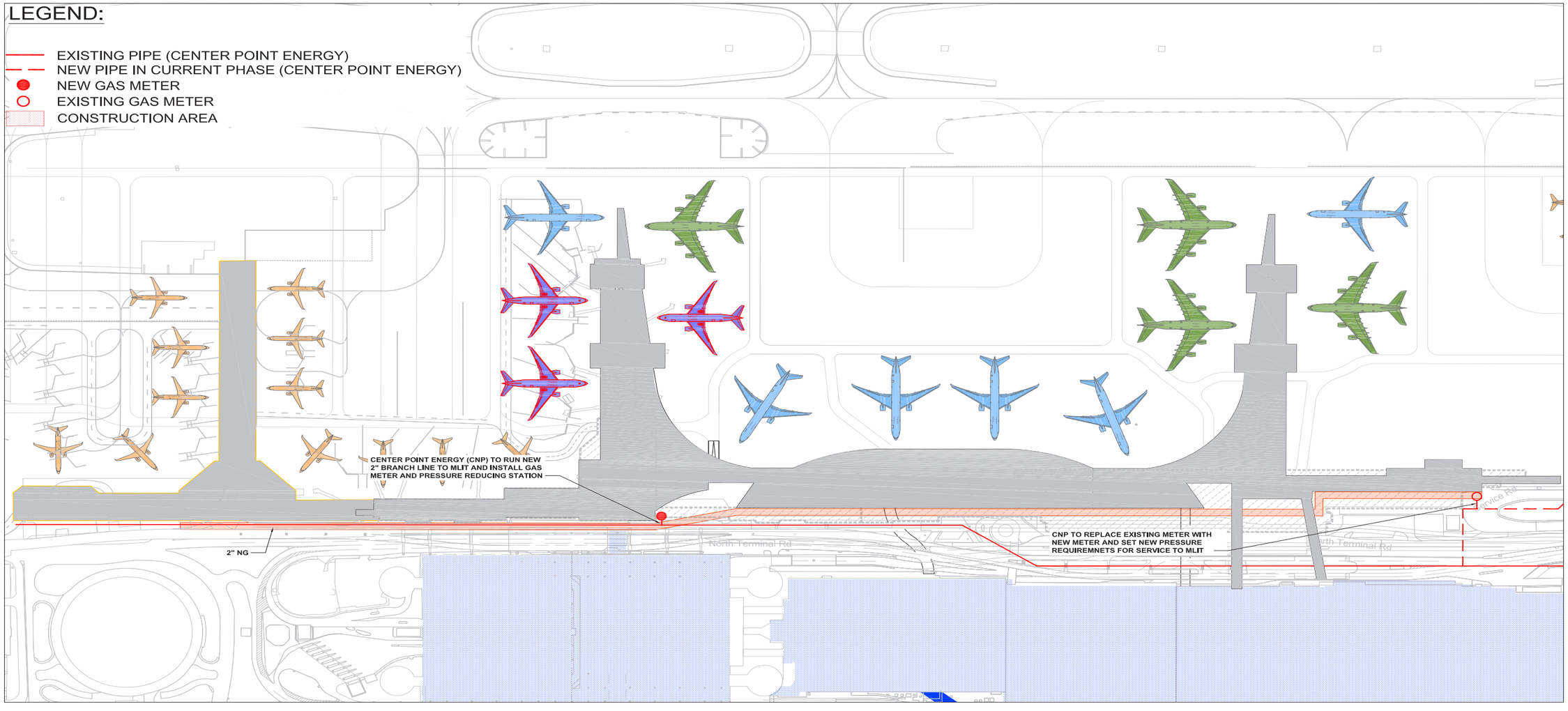
Terminal E is an exception in that it uses a Johnson Controls building automation system.

Detailed points for monitoring and control will be determined by the design engineer. The following are typical points that should be included and connected to the building automation system:

- Space, temperature, and humidity sensors
- Building pressurization at selected locations throughout each terminal
- CO2 sensors in return air ducts
- Discharge air temperature on any air terminal boxes using reheat
- Supply and return temperature for chilled water and hot water at each mechanical room or separate air handling unit
- Supply and return pressure (or differential pressure) at each mechanical room
- Return and supply air temperature at each air handling unit
- Run status for all air handling units, fan coil units, and compressors
- Tank high/low level alarms for domestic water tank
- Lighting sensors and controls to maximize energy savings from day lighting
- Monitoring of pre-cooling air systems at each gate
- Monitoring of UPS systems
- Monitoring of people movers and elevators

Fire and security systems are separate from the building automation system. However, general alarms from fire and security shall be linked to the building automation system to notify the building operations personnel that a situation exists. Emergency power will be provided by maintaining two independent electrical services from CenterPoint instead of using onsite emergency generators. All switchgear and unit substations between the point of service and all panels serving life safety loads shall be monitored and alarmed if a failure occurs in either power source.

Proposed Natural Gas Preferred



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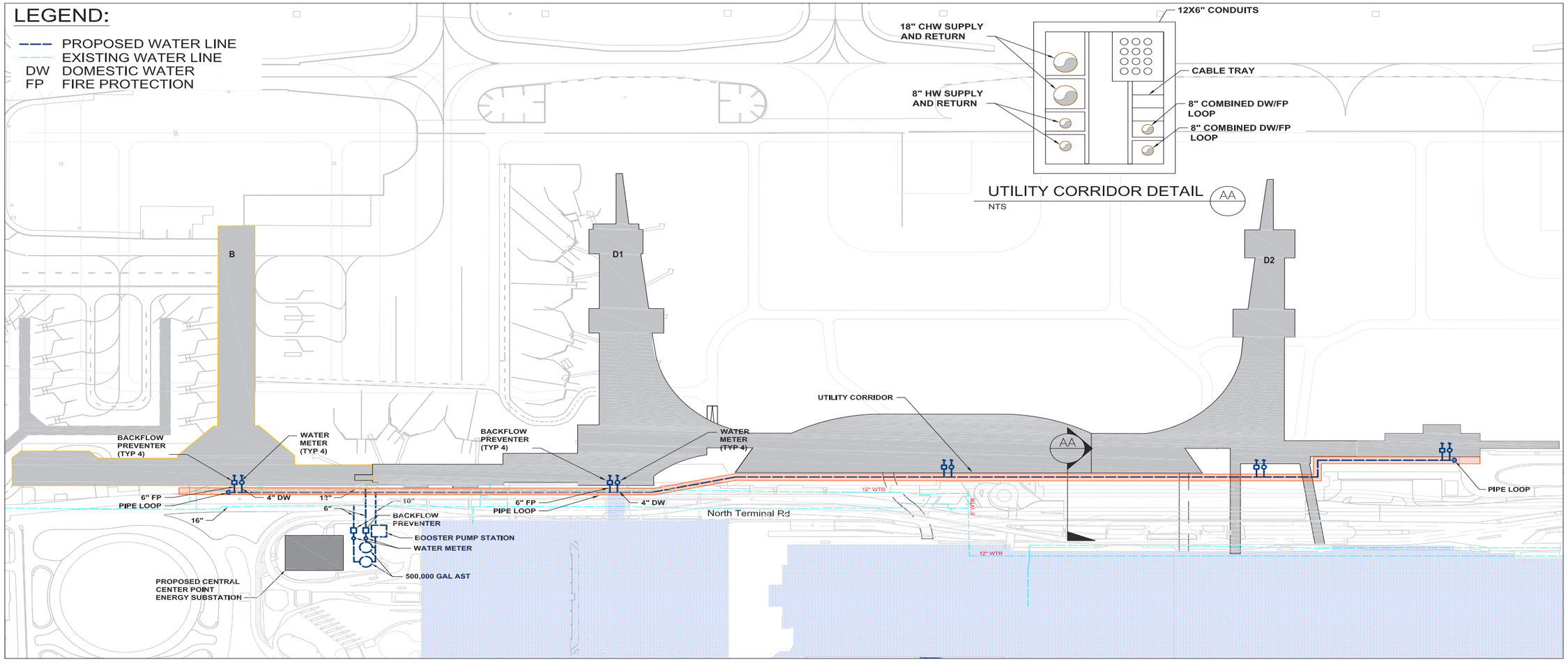
Proposed Fire Protection Preferred



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5.5 Site Utilities

This section presents the recommended site utility development for the Mickey Leland International Terminal (MLIT).

5.5.1 SITE POWER

CenterPoint Energy owns and maintains the primary electrical power system at Bush Intercontinental Airport. IAH is served by four substations:

1. Greens Road, located west of JFK Boulevard on Greens Road.
2. Intercontinental, located north of the fuel farm on Aldine Westfield Road.
3. Treaschwig, located 2.5 miles north of the airport at the intersection of Eagle Crossing and Treaschwig Road.
4. Westfield, located 2 miles NW of the airport near the intersection of Bammel Road and Imperial Valley Drive.

After entering the airport, overhead lines are routed underground in duct banks. These typically consist of 12, six inch PVC conduits encased in concrete, with manholes at 400 ft intervals.

Greens Road and Intercontinental substations supply the majority of airport loads. Major loads include the terminal hotel complex, central utility plant, control tower, ARFF Stations and airfield lighting vaults. The 35 kV feeds from Treaschwig, Intercontinental and Westfield supply power to the north side of the airport. Loads include airfield lighting, air cargo, and an ARFF station. Independent, dual feeds from the substations provide redundancy for all critical airport loads. Current substation loads are 48 MW at 12 kV and 2.00 MW at 35 kV. The largest airport demand loads as of August, 6 2013, are show below.

Central Utility Plant	11.8 MW
Federal Inspection Service	2.5 MW
Hotel	1.5 MW
Terminal A Vault & South Concourse	3.0 MW
Terminal B Vault & South Concourse	5.2 MW
Terminal C South, Vault & Parking Garage	5.3 MW
Terminal D Vault	2.0 MW
Terminal E	8.0 MW
Total:	39.3 MW

The Central Utility Plant (CUP) and Terminal/Hotel complex load is 39.3 MW and comprises 79% of the total airport load. The 12 kV feed to the CUP can support an expanded plant load of 5,000 tons of cooling equipment but this will max out the infrastructure. Other infrastructure configured predominately for 12 kV distribution is adequate for current loads. However, as per CenterPoint, in order to supply new loads, the infrastructure will need to be upgraded to accommodate dual 35 kV feeds throughout the airport. As part of this effort, HAS has established a Tenant Improvement Project that calls for the expansion of the existing CenterPoint infrastructure with a new twelve, 6 inch duct bank. This duct bank will help accommodate the new infrastructure required to support the new Mickey Leland International Terminal.

In order to support the estimated 20,000 kVA of additional connected load located in the MLIT as well as support the new Terminal B load, a new 12.5 kV, 14,000 sf substation is proposed. The new substation will receive 12.5 kV power from both Greens Road and Intercontinental substations, in a 9,000 sf dedicated CenterPoint transformer and switchgear room. Both Greens Road and Intercontinental substations have adequate capacity to carry current and future loads. Directly adjacent to this will be a 3,000 sf HAS operated meter and switchgear room for 12.5 kV distribution to airport loads. An additional 2,000 sf will be provided for security fencing, access, and parking. This new 14,000 sf substation will be capable of supplying a minimum of 40,000 kVA and be located just west of the Terminal C processor/parking structure. Refer to **Figure 5.48**. This new substation will provide 12.5 kV power to the following connected loads:

New Terminal B	10.0 MW
Existing Terminal C Core/C South	5.3 MW (Demand Load, See Above)
New MLIT Terminal D2	10.0 MW
New MLIT Terminal D1	10.0 MW
Total:	35.3 MW

In addition to providing power to the above listed loads, requirements shall be made to provide no less than six feeders to three additional loads, including a future D3 Pier.

In order to facilitate the distribution of the 12.5 kV feeders, a new utility tunnel will be constructed directly in front of Terminal B and continue East to Pier D2. Provisions for 12.5 kV power will be provided in the Utility Tunnel in front of Terminal B, however, the connected electrical loads and distribution will be designed by others. The existing Terminal C Core 12.5 kV CenterPoint transformer and switchgear room will be acquisitioned and remodeled for a new HAS operated 12.5 kV transformation room. The phasing for this effort is described in **Section 7.0**. A new 12.5 kV, double ended switchgear will be added to the main electrical room in the MLIT. To support this new switchgear, 4 new 15 kV, 12 MVA feeders will need to be provided from the new CenterPoint substation. The new 15 kV, 12 MVA feeders will be run in the utility tunnel. Each feeder will be capable of handling the full load of one of the new piers. Each feeder will be a redundant feeder from separate switchgear within the new substation, and feed separately from substations IT and GR.

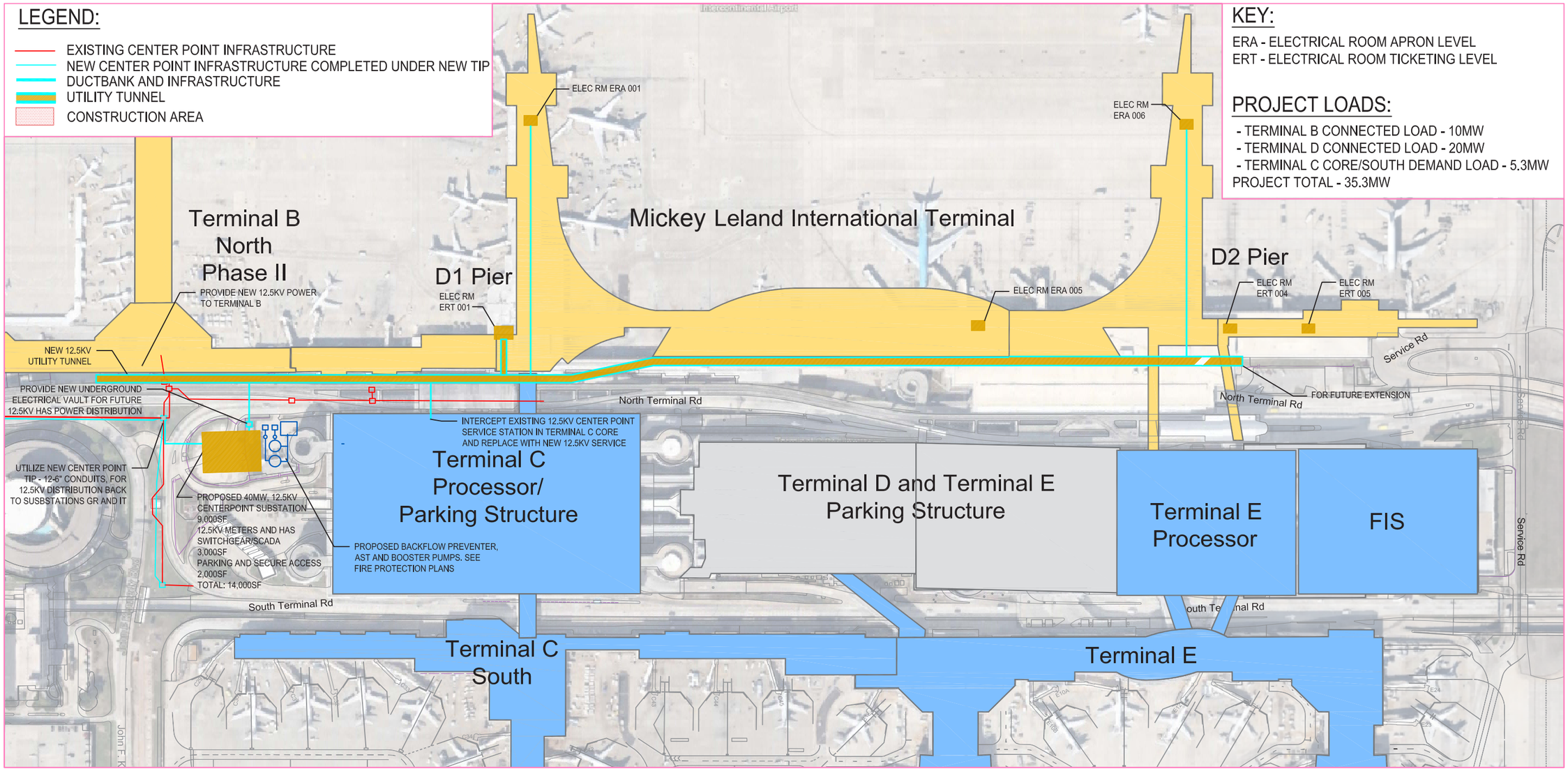
5.5.2 SITE COMMUNICATION/IT

Existing fiber optic cables from the existing Terminal D MDF go to the Terminal C MDF, through the existing C Connector. These cables will have to be intercepted and rerouted outside the limits of phase 1 work. See **Chapter 7**, for additional phasing information. The final build out of the new Mickey Leland International Terminal will have this existing fiber optic connection to the Terminal C MDF, routed underground, in the utility tunnel, just outside the new terminal on the landside. Fiber optic cables and copper communication lines will be run within cable trays mounted within the utility tunnel. All fiber optic routes will be terminated back in the new Mickey Leland International Terminal MDF room, located at the base of the new Pier D1. See **Figure 5.49**.

The new MDF will house all new termination points for the existing airport fiber optic backbone. These connections will have to be made, in a systematic coordinated way, such that no critical systems are allowed to be down longer than one hour, and only during off-peak hours as dictated by HAS. All fiber optic cables that go through the existing Basement Level FIS connector will have to be rerouted through the new MDF. This will require that all terminations in the existing Terminal D MDF be relocated to the new Mickey Leland International Terminal fiber optic node, and all fiber optic cables routed through the existing Terminal D MDF will have to be cut, re-routed, and spliced into the new MDF. The designer will be responsible for coordinating each system to be cut-over, ensuring that all critical systems have been accounted for prior to any cuts being made.

The existing "Brown Shack" location, in the North East corner of the CTA, adjacent to a secure access point, has above ground splices and termination blocks. This above ground infrastructure is no longer needed and,

Preferred Alternative 12.5 KV Distribution



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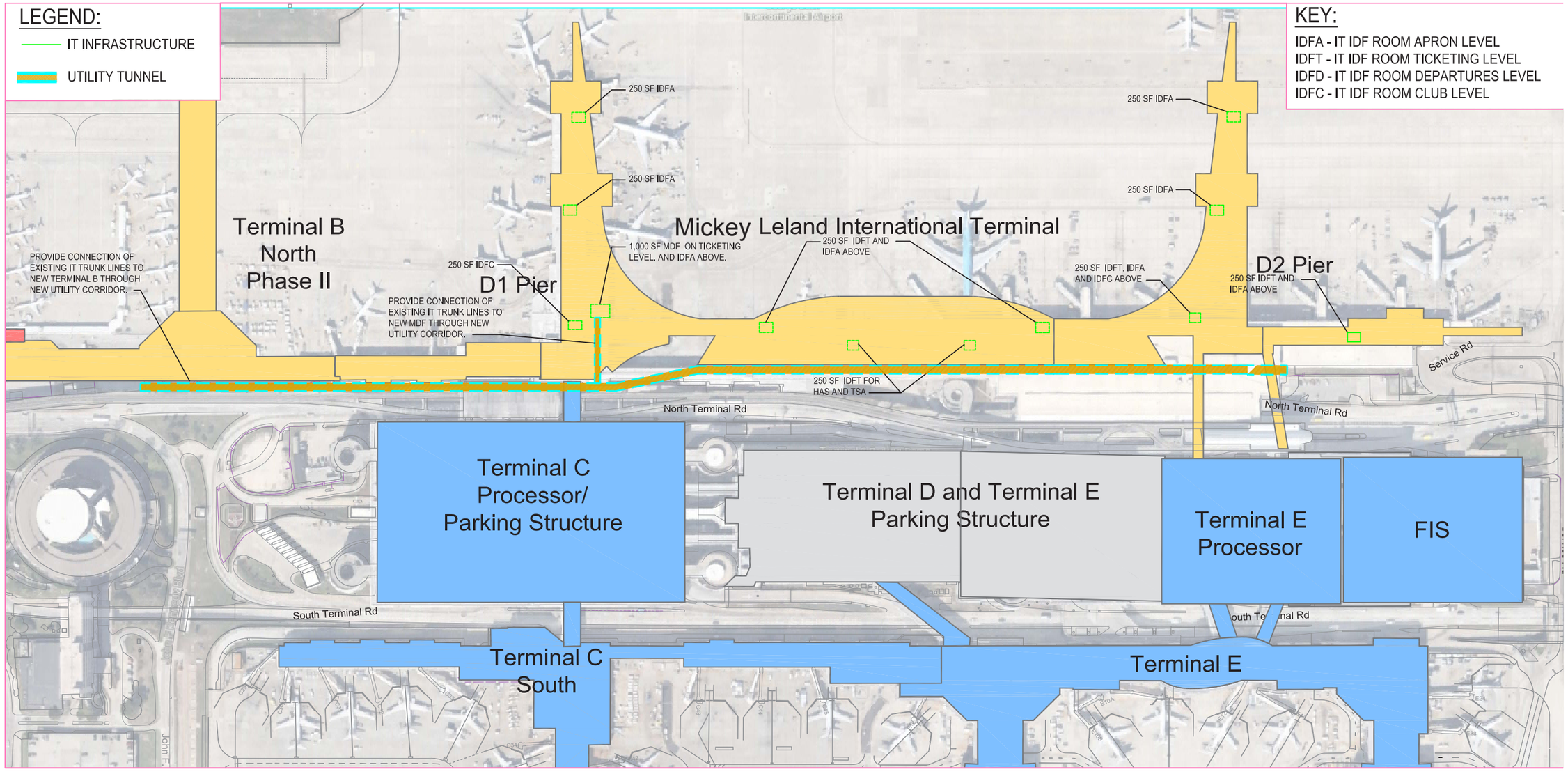
Preferred Alternative 34.5KV/12.5KV Distribution

Fig 5.48

Preferred Alternative IT Distribution



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as part of the scope of this project, will be rerouted underground. A new adjacent manhole shall be provided in order to intercept the existing conduit, and provide a splice location for the existing fiber optic cable and copper communication lines. These lines will be pulled from the new manhole at the "Brown Shack" location all the way back to the new MDF in the MLIT, and terminated in such a manner as to ensure continuity to the previously served systems.

All exterior communications installations shall be in accordance with HAS/PDC/Design Division Specifications; Section 270543, Exterior Communication Pathway; Section 2705533 Identification and Labeling of Communication Infrastructure;

The existing UA IT infrastructure supporting gates C24 through C26 will remain and be undisturbed as this infrastructure will connect the new Terminal B North facility to the existing Terminal C ticketing processor. In the event the reconstruction of Terminal C North affects this infrastructure, MLIT will replace per UA IT specifications.

5.5.3 WATER SYSTEM

The existing 16 inch looped water line is adequate to provide the rebuild of Terminals B, D1, and D2 fire protection and domestic water demand. However, booster pumps will be required to distribute domestic and fire protection water throughout the terminals and to all the different water services. Refer to **Section 5.4.9**, Fire Suppression, for discussion on a combined FP/DW central storage and booster pump system.

The principal elements of the recommended water distribution complex are composed of the following:

- Two, 500,000 gallons tanks, each served by a 6 inch line which are cross connected and tied into the existing City of Houston water lines, one 16 inch and one 12 inch line.
- Two ea 500,000 Gallon Tanks at C-Garage Site
    - Tanks sized for B1, B2, B3, A & MLIT, B Core & C Core
- One ea 1,500 gpm pump
- One ea future space for a 1,500 gpm pump
- Two ea 500 gpm pumps
- Two ea 500 gpm tank fill pumps
- Two ea future spaces for 500 gpm pumps
- Pump House
- Electrical
- Earthwork
- Controls
- Backflow preventer and water meter on each 6 inch line servicing tanks.
- Double 8 inch line installed inside the utility corridor and looped to each other. Terminal service lines will be tapped into this loop.
- Each terminal will be served by a 4 inch domestic waterline and a 6 inch fire protection water line.
- Gate valve, backflow preventer on all fire protection service lines.
- Water meter and gate valve on each domestic water service line.

The recommended domestic water and fire water site utility layouts are illustrated in **Figure 5.50**.

5.5.4 SANITARY SEWER SYSTEM

Design of new sanitary sewer system for the new Terminals D1 and D2 shall consider the following four principal lessons learned from the existing conditions:

- Simplified Network: Existing sanitary sewer network is a complex and hard to maintain system resulting from several modifications through past decades.
- Non-Ferrous Pipes: Existing sanitary sewer lines are cast iron. HAS Project 638 investigations from 2010 show that the existing CI lines are all heavily deteriorated.
- Depth: Existing collector line is higher than the terminal basement. New system shall be deep enough to safely cover all levels of the new terminals.
- Flow Direction: The existing 12 inch sanitary sewer line currently serving Terminals C and B and flowing west is at near capacity. Provide relief to this line by diverting flow of new terminal loads to the east

The estimated peak demands, based on peak hour loads, are:

- Terminal D1: 270 gpm
- B/D Connector: 95 gpm
- Central Processor: 290 gpm
- Terminal D2: 270 gpm
- United Airlines facilities and other loads from east of terminal D2: 65 gpm
- Total Load: 990 gpm

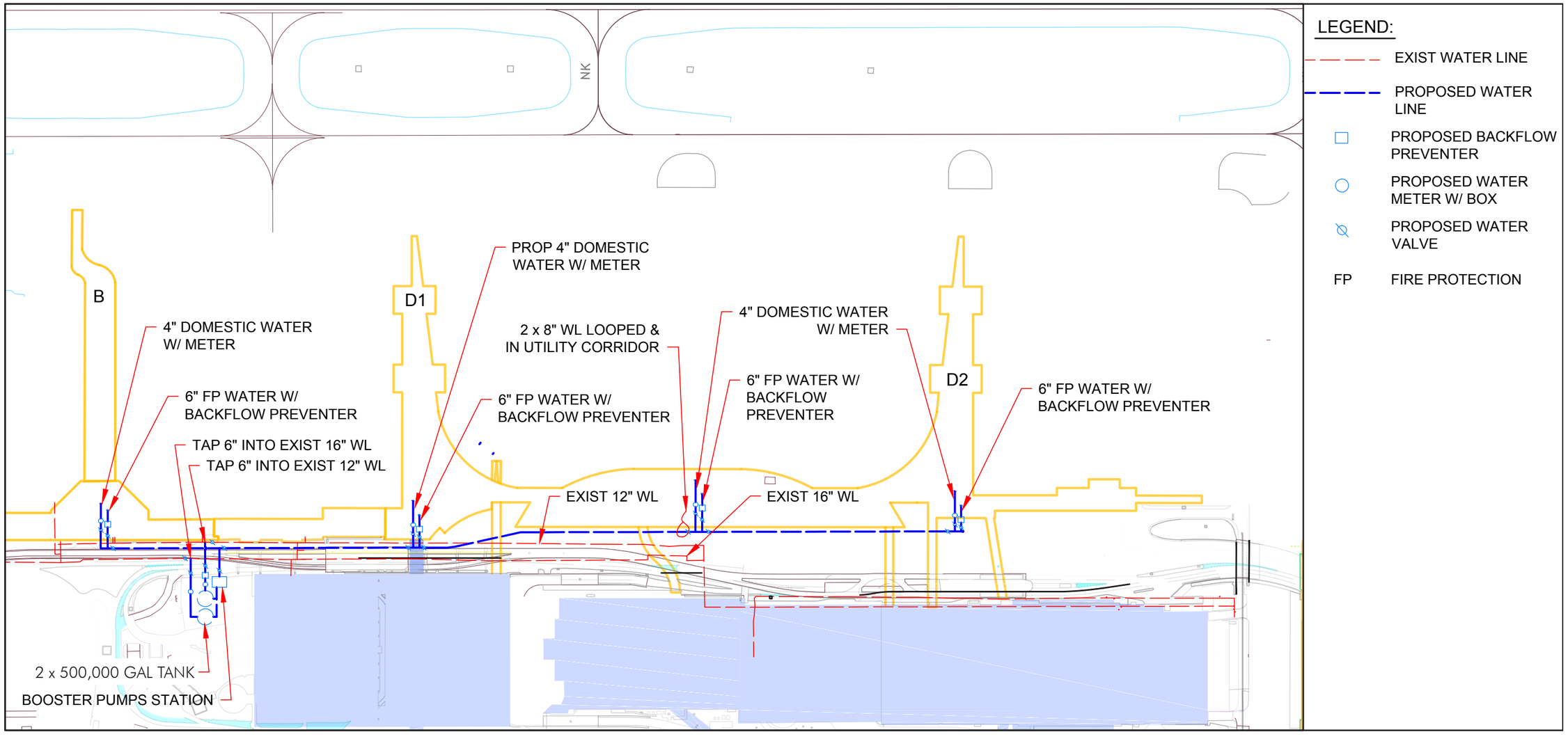
Exterior located grease interceptor vaults will be provided on the west and the east end of the terminal. Each of these grease vaults will have a capacity of 9,000 gallons (two each 4,500 gallon interceptors in series). The recommended sanitary waste system location is illustrated in **Figure 5.37** and **Figure 5.51**.

With respect to the recommendations made in the last paragraph, the proposed sanitary sewer system scenarios should include:

- Removal of both lift stations at gate D4 and Terminal D West.
- Removal of the existing Terminal C North gravity lines. They are heavily corroded with substandard slope.
- An 8 inch non-ferrous gravity line for Terminal D1 and the B/D Connector; the line needs to change to 10 inches after interception of approximately half of the central processor load and flow up to east of Terminal D2.
- An 8 inch non-ferrous gravity line for Terminal D2.
- A 12 inch line from east of Terminal D2 to the new lift station.
- All gravity lines shall be sloped to meet or exceed The City of Houston standards.
- Construction of a new lift station with firm capacity of 990 gpm, per City of Houston Standards, Submersible Lift Stations, at southeast of the new Terminal D2.
- Construct a new force main from the new lift station to The City of Houston Lift Station Number 3.

The proposed sanitary sewer alternatives are illustrated in **Figure 5.51**.

MLIT Proposed Waterline



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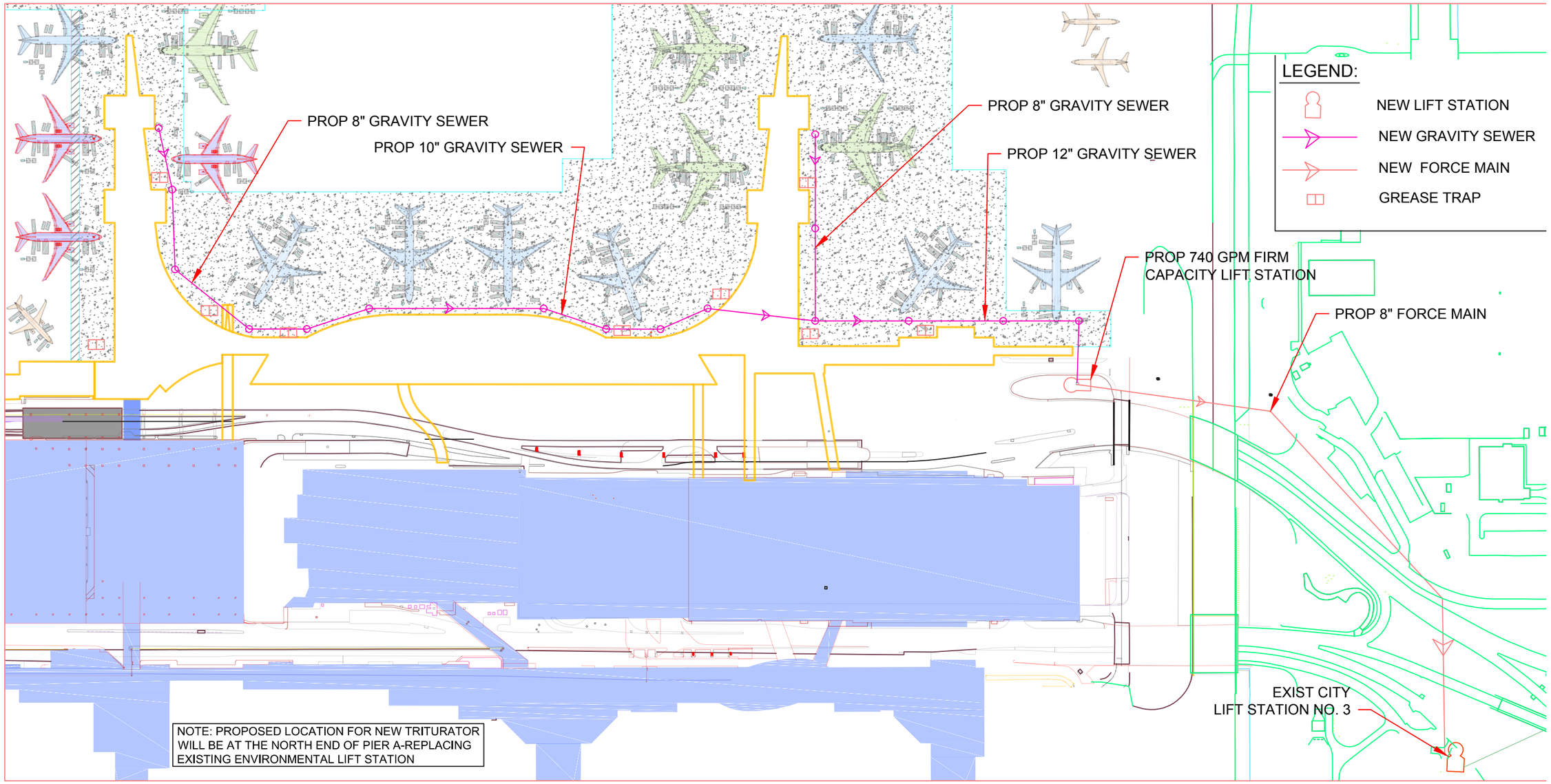
MLIT Proposed Sewer Line



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5.5.5 APRON GRADING AND DRAINAGE

The proposed expansion of Terminal C North and Terminal D with the construction of the new central processor and concourses will require a significant amount of the existing apron pavement to be removed and reconstructed in order to meet current design standards. Construction of the existing apron pavement was originally completed in 1990 prior to the commissioning of Terminal D. The existing apron in the Terminal D area drains via sheet flow to the north, away from the Terminal, where it is collected in an existing trench drain equipped with environmental bypass that is located approximately 590 ft to the north of the building face. The existing apron at the Terminal C North area drains to the west, east, and north toward a similar network of trench drains equipped with environmental bypass.
To assess the amount of existing pavement that will need to be replaced, due to the construction of the new Terminals, the design team reviewed available as-built records and the most recent "Pavement Condition Assessment Report". In addition, the existing apron grading and drainage systems were reviewed for conformance to meeting current FAA Design Standards as well as National Fire Protection Association (NFPA) Codes.

The most recent pavement condition survey performed on the Terminal C North and Terminal D apron pavement was completed in 2008 and the results of that assessment indicated that the existing apron pavement was generally in very good condition. The Pavement Condition Index (PCI) results for the apron ranged from a "good condition" rating of 67 to an "excellent condition" rating of 92. It should be noted that the HAS is in the process of completing a new PCI survey, analysis, and report that is scheduled to be ready by mid-year 2015.

Apron grading and drainage is governed by FAA and NFPA Design Criteria. FAA Advisory Circular 150/5300-13 "Airport Design" states that apron grades for an aircraft approach category C and D apron pavement cannot have a slope in excess of one percent. In addition, the apron pavement grades are required to drain away from the terminal building especially in aircraft fueling areas.

NFPA Code 415 "Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways" requires that the minimum apron grade shall be 1%, the apron pavement needs to drain away from the building, and no drainage or collection structures can be located within 50 ft of the building face. The 50 ft collection structure criteria is in place to assure that there won't be any surface runoff collection points within 50 ft of any building face in the event of a fuel spill.

Currently the existing Terminal C North and Terminal D Apron satisfies both the FAA's and the NFPA's design requirements. However, construction of the new concourses will impact the existing grading patterns, and drainage collection points on the apron, that in turn will require modifications to the existing apron pavement.

In order to meet apron grading criteria, approximately 800 ft of the existing trench drain that runs parallel to the existing Terminal D building face, and a segment of the Terminal C North trench drains, will need to be removed due to the construction of the new terminal concourses. A new set of trench drains will be required to collect stormwater runoff on both the east and west sides of the new concourses. New storm sewer connection points will be required to tie the trench drains into the existing storm sewers that are located on the north side of the apron.

The overall grading pattern, adjacent to the new concourse's building face, will need to change from the existing northerly direction of flow pattern to one that drains away from the new concourse in both an east and west direction of flow. A conceptual grading plan is shown in **Figure 5.52**. As shown in this figure, rotating the apron grading plan by 90 degrees Fahrenheit will require a significant amount of pavement to be reconstructed.

The proposed apron grading and drainage improvements in the area of Terminals C North and Terminal D are illustrated in **Figures 5.53** and **Figure 5.54**.

5.5.6 HYDRANT FUELING

Per a Terminal C airside site visit with Allied Aviation on April 30, 2012, the Fuel Farm has plenty of capacity to serve the airport and the distribution system is adequate to meet peak demand for all airport terminal and hardstand gates. Total fuel system storage equals 11.9 million gallons and the average daily fuel consumption ranges between 1.6 and 1.8 million gallons per day (MGD). The Fuel Farm has 16 hydrant pumps rated at 1,000 gpm/each and 16 respective filter separators rated at 1,250 gpm/each for a total peak flow rate equal to 16,000 gpm. Peak daily demand was 4,500 gpm.
Terminal C has 13 gates (C14 – C26) with passenger boarding bridges (PBB). Estimated current Terminal C demand is 3,005 gpm (three wide-body, ten narrow-body aircraft). Projected Terminal D1 demand is 2,425 gpm (one A380, five wide-body, and two narrow-body aircraft). Net peak fuel flow is anticipated to decrease based on the fewer number of larger aircraft. The existing system will also accommodate peak fueling for an A380 Group VI aircraft, which may fuel from two hydrant pits at 800 gpm per pit (or a total of 1,600 gpm).

Current peak fuel flow projections were based on the following:

- Three wide-body aircraft: (67% diversity) x (3 aircraft) x (500 gpm/aircraft) = 1,005 gpm
- Ten narrow-body aircraft: (50% diversity) x (10 aircraft) x (400 gpm/aircraft) = 2,000 gpm
- Zero ADG VI aircraft: (25% diversity) x (0 aircraft) x (1,400 gpm/aircraft) = 0 gpm
- Subtotal = 3,005 gpm

New Mickey Leland International Terminal (D1) peak fuel flow projections were based on the following:

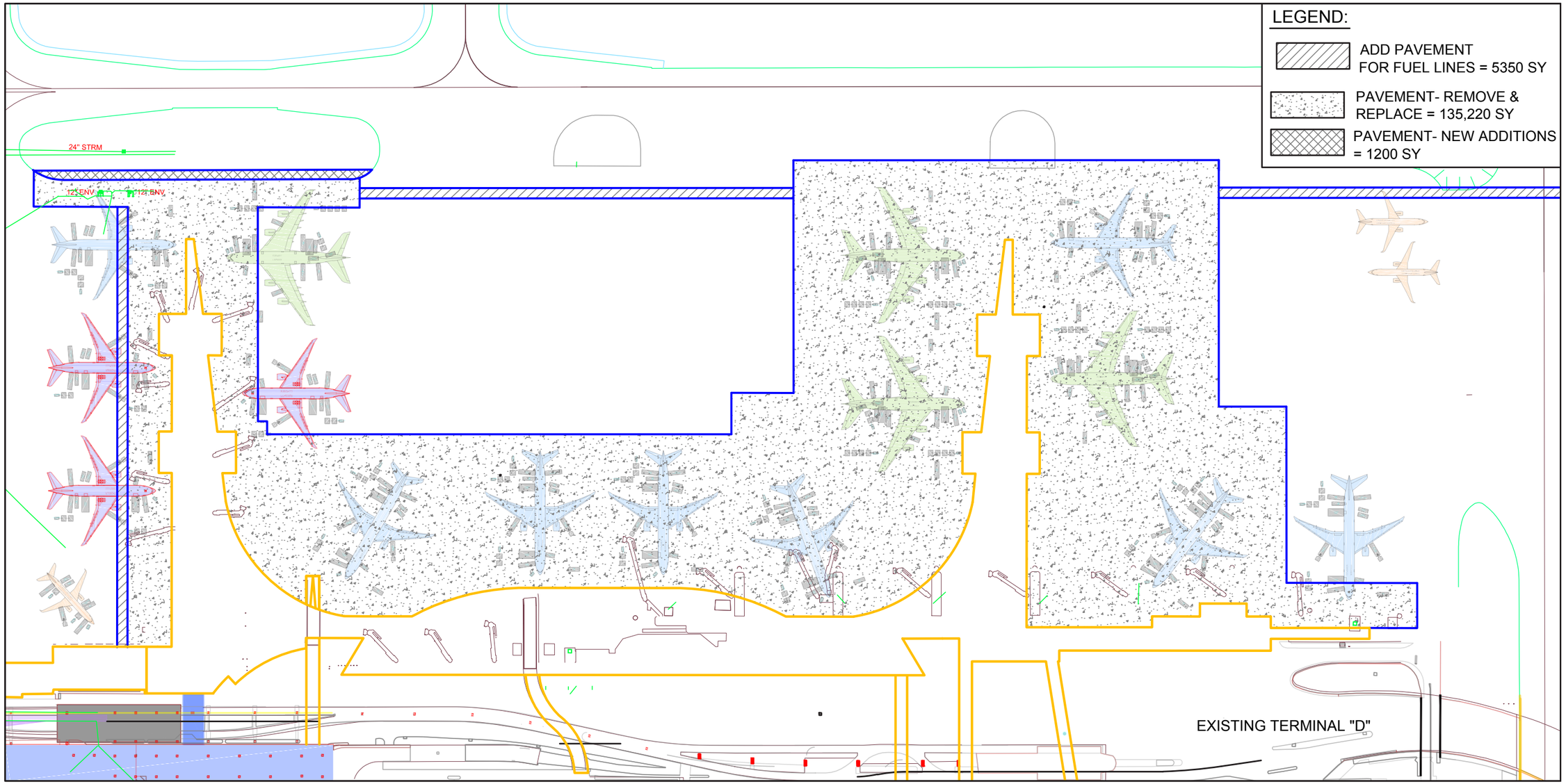
- Five wide-body aircraft: (67% diversity) x (5 aircraft) x (500 gpm/aircraft) = 1,675 gpm
- Two narrow-body aircraft: (50% diversity) x (2 aircraft) x (400 gpm/aircraft) = 400 gpm
- One ADG VI aircraft: (25% diversity) x (1 aircraft) x (1,400 gpm/aircraft) = 350 gpm
- Subtotal = 2,425 gpm

Refer to **Section 5.2.1**, Aircraft Fueling System, for the preferred plan regarding the hydrant system. Terminal building changes and aircraft parking arrangement changes will impact the fuel main lines, hydrant, and hardstand fueling systems. The preferred plan replaces the entire hydrant distribution system serving the MLIT.

This work will involve multiple phases of aviation fuel shutdowns. In addition to the new hydrant pits, a separate Emergency Fuel Shutoff (EFSO) system is needed. The new EFSO system will be designed to avoid shutting down both the hydrant and hardstand fuel pits simultaneously when an EFSO button is activated. The preferred alternative includes separating the hydrant and hardstand systems with motor operated valves (MOV). When an EFSO button is pushed, the respective MOV would be energized and closed, isolating one system from the other in the event of a fuel emergency. This will require independent MOV isolation between the hydrant and hardstand fuel pits. The EFSO communication I/O system will be replaced and indicate MOV valve position, EFSO condition, and remote or local alarm back to the Fuel Farm control system.

The cathodic protection system will need to be replaced to service the new fuel mains and hydrant/hardstand distribution systems. Preferred corrosion protection system for the fuel system is impressed current with anode beds.

MLIT Rebuild Proposed Apron Grading



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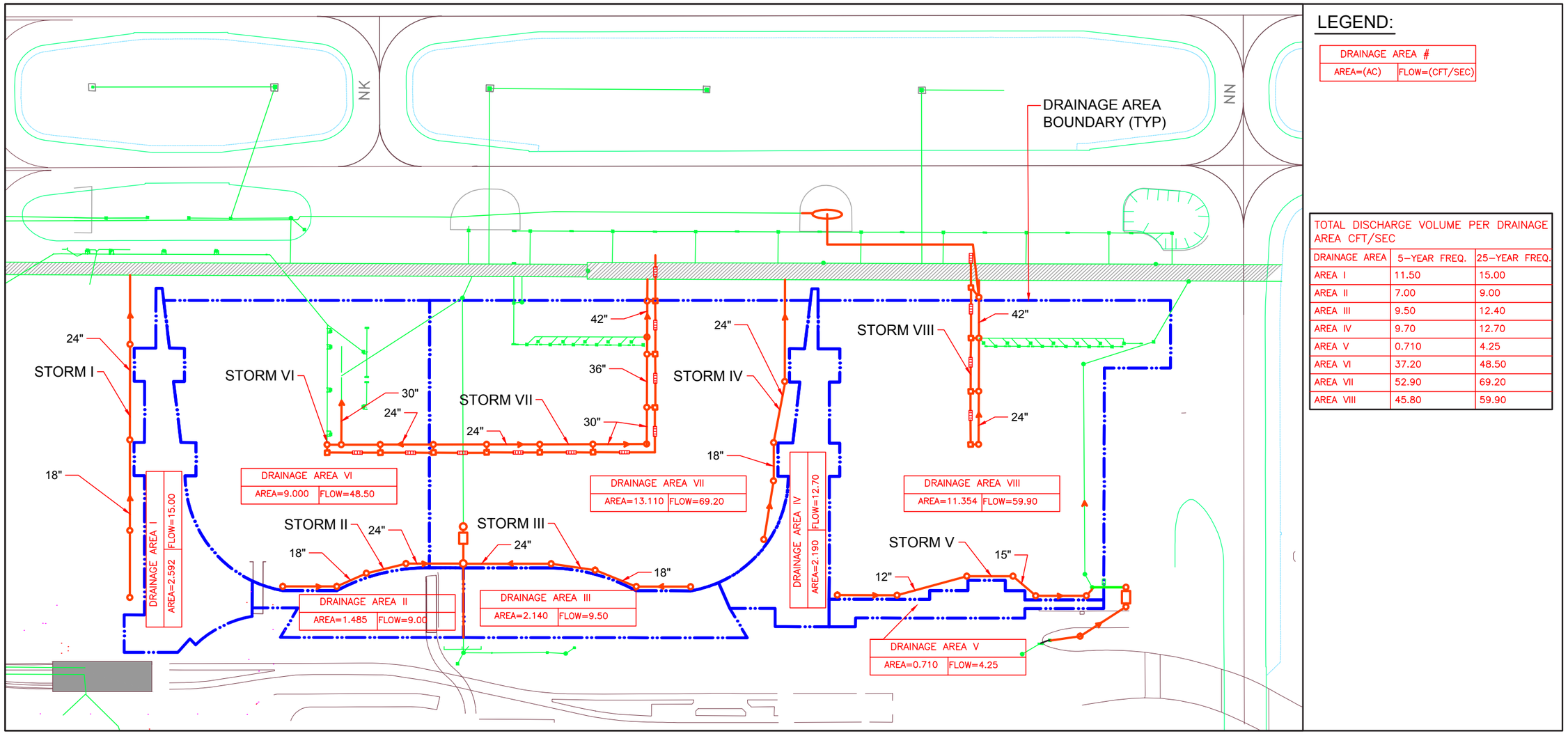
MLIT Drainage Area Map

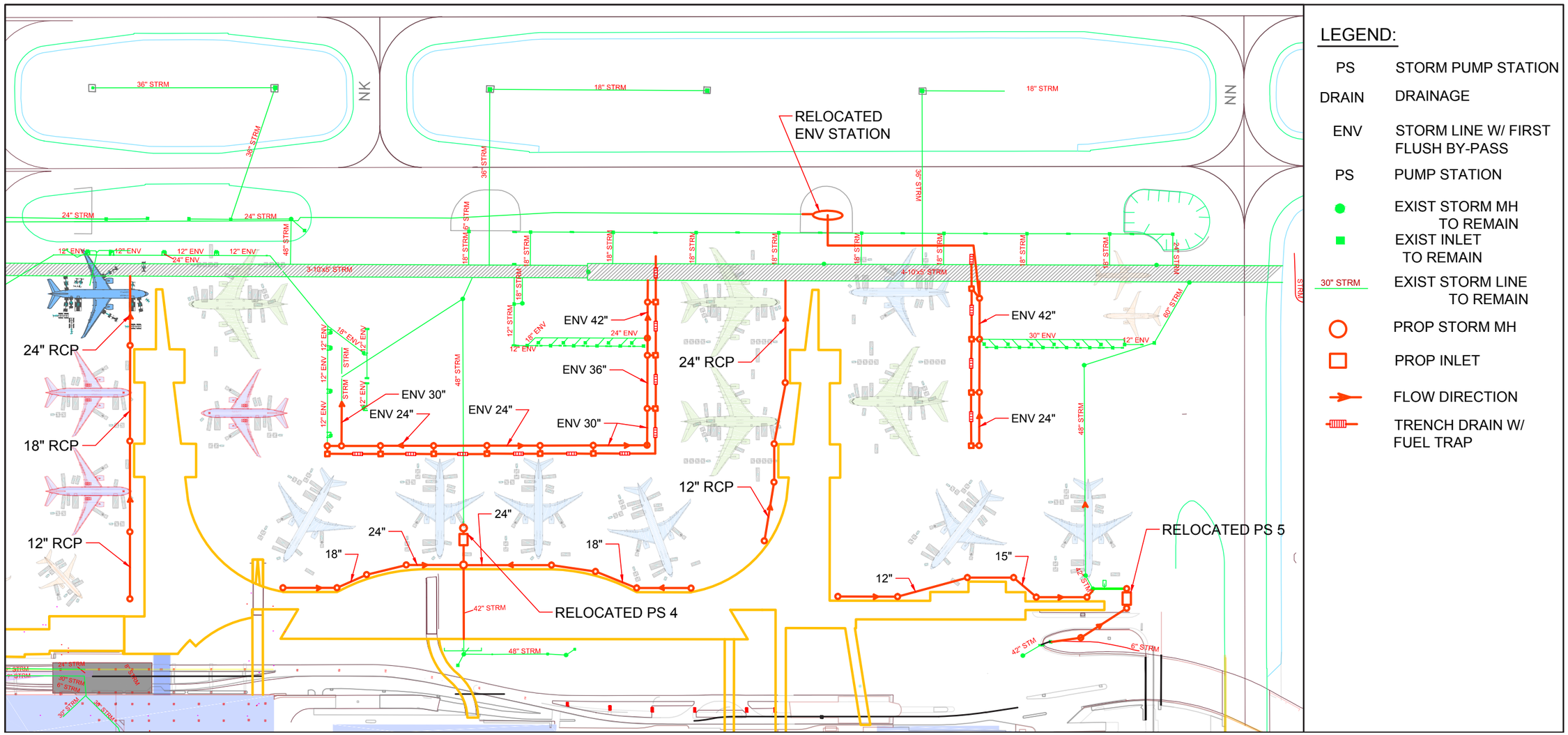


TOTAL DISCHARGE VOLUME PER DRAINAGE AREA CFT/SEC

DRAINAGE AREA	5-YEAR FREQ.	25-YEAR FREQ.
AREA I	11.50	15.00
AREA II	7.00	9.00
AREA III	9.50	12.40
AREA IV	9.70	12.70
AREA V	0.710	4.25
AREA VI	37.20	48.50
AREA VII	52.90	69.20
AREA VIII	45.80	59.90

0' 100' 250'

MLIT Proposed Storm Drainage



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5.5.7 UTILITY INFRASTRUCTURE (TENANTS)

The level and extent of utilities infrastructure needed to support concessions activities, will include HVAC, plumbing, fire sprinklers, electrical power, lighting, controls, and information technology systems connections. HVAC to consist of heating and cooling, ventilation, and grease duct systems. Plumbing to include exterior grease interceptor vaults, stainless steel plumbing between the food concessions and the grease vaults, and ductile iron sanitary pipe between the grease vault discharge points and the sanitary line connections. Electrical power to be brought to local panels. IT to be brought to each space. Submeters to be included for electrical, gas, and water services.

Concession tenants to build out each respective space, within the walls of the space, at time of space turnover. Tenants to provide their own equipment including sinks, garbage disposers, dishwashers, kitchen exhaust hoods, and hot water heating units.

5.6 Landside

This section presents the recommended landside improvements for the Mickey Leland International Terminal (MLIT). Development considerations were coordinated with landside needs identified in the LeighFisher analysis conducted for the Master Plan.

5.6.1 ROADWAYS

The current terminal curbside roadway has three 10 ft wide lanes serving private vehicles and two 10 ft wide lanes serving commercial vehicles. Per requirements provided by LeighFisher, four lanes are required adjacent to the new Terminal D to serve both private and commercial vehicle curbside activity and a separate commercial curb is not required for the programmed activity levels. The roadway adjacent to the new Terminal D is proposed to have four lanes and provide a minimum width of 11 ft per lane to allow more space for vehicles to maneuver offering a higher level of service and more comfortable vehicle operating conditions along the roadway. Travel lanes could also be 12 ft wide with a 10 ft drop-off lane adjacent to the terminal.

The Above People Mover (APM) guideway and supporting columns follow the North Terminal Roadway bringing the APM closer to the Terminal C Concourse on the north side of the roadway past the Terminal D/E Garage. This constricts the space available to merge lanes from the new Terminal D Roadway and tie it into the North Terminal Roadway. **Figure 5.55** illustrates proposed landside improvements including an option to merge the Terminal D Roadway into a single lane merging with the North Terminal Roadway north of Terminal C. This will require the lane to weave between APM columns but allows for an added lane that would continue to Terminals A/B, allowing vehicles to have time to merge onto the terminal exit around the end of Terminal C, similar to the existing configuration.

Alternately, the lanes exiting from Terminal D could continue to Terminals A/B before exiting as shown on **Figure 5.56**. This would allow two lanes to exit the new Terminal D curbside and avoid weaving between APM columns, but would require all traffic from Terminal D to exit through the Terminal A and B complex. This option has been retained for consideration in the current planning.

The new location of Terminal D leaves approximately 70 ft between the Terminal D entrance roadway and the Terminal E upper level ramp at the entrance to the terminal complex. This would allow space for a roadway bypassing Terminal E and tying directly into Terminal C from the entrance as shown in **Figure 5.57**. This concept should be vetted further, but space should be protected to allow for this bypass in the future.

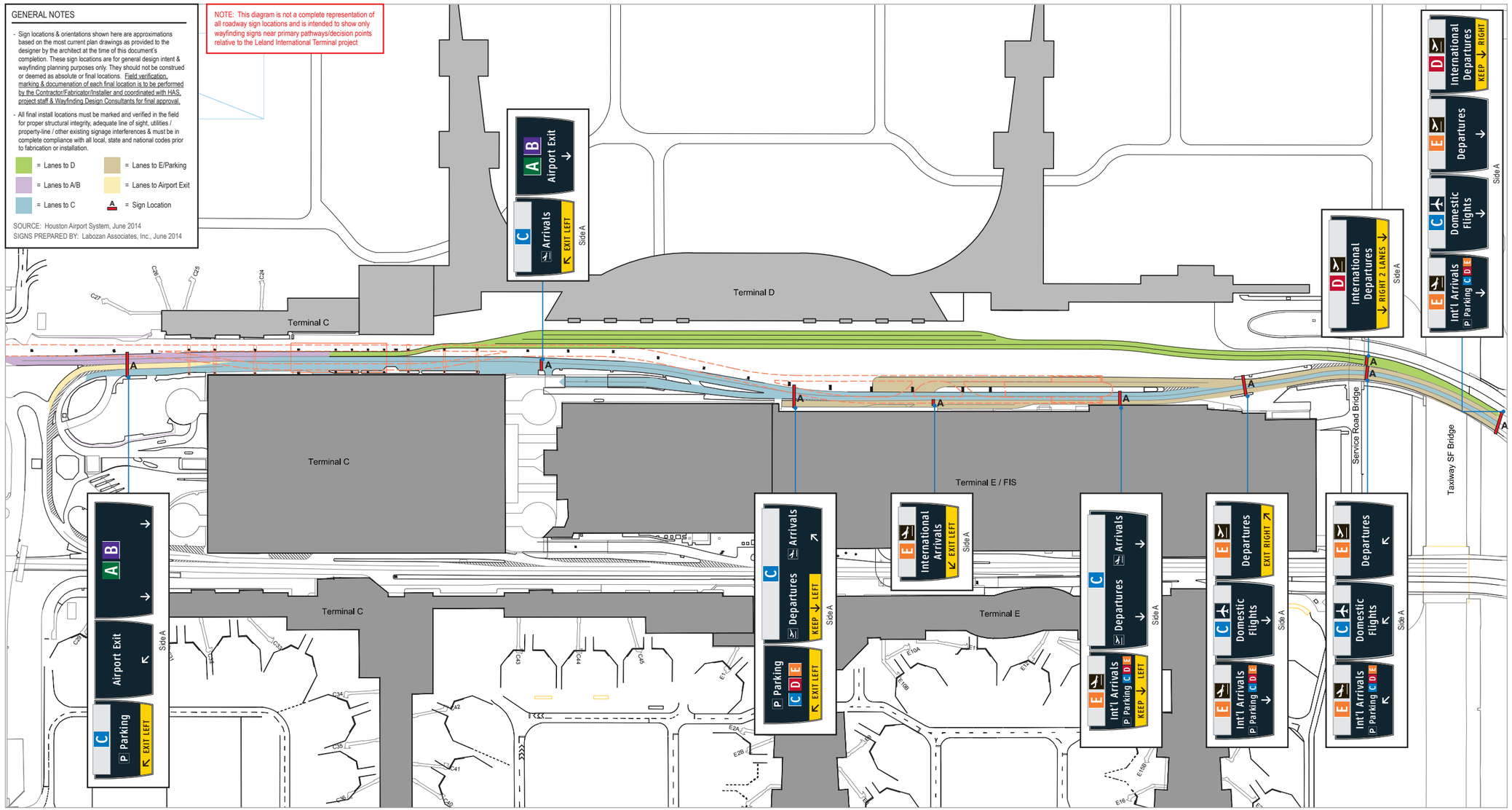
5.6.2 CURB

The new location of Terminal D north of its existing location will allow for additional curb depth along the face of the building. The curb depth would increase from 15 ft to 25 ft from the face of the terminal and 20 ft from the vestibules. This will provide additional area for passengers to unload at and allow better circulation of passengers, baggage, and carts along the curb. As shown on **Figure 5.55** and **Figure 5.56**, the curb is 1,060 ft long and serves private and commercial vehicles unloading along the face of the building.

5.6.3 PARKING

The new Terminal D will result in the loss of the two existing employee parking lots located on the east and west end of the Ticketing Level. It is recommended to provide close-in parking areas for terminal building employees and vendors in the final design. The existing helix that provides access to the Terminal D and Terminal E parking structure would also be eliminated in the proposed terminal development. Vehicles wishing to park at Terminal D will need to use the left hand entrance to Terminals E and C and it is recommended that vehicle roadway signage be updated to direct all parking to the left side of the entrance roadway.

Roadway Alternative 1



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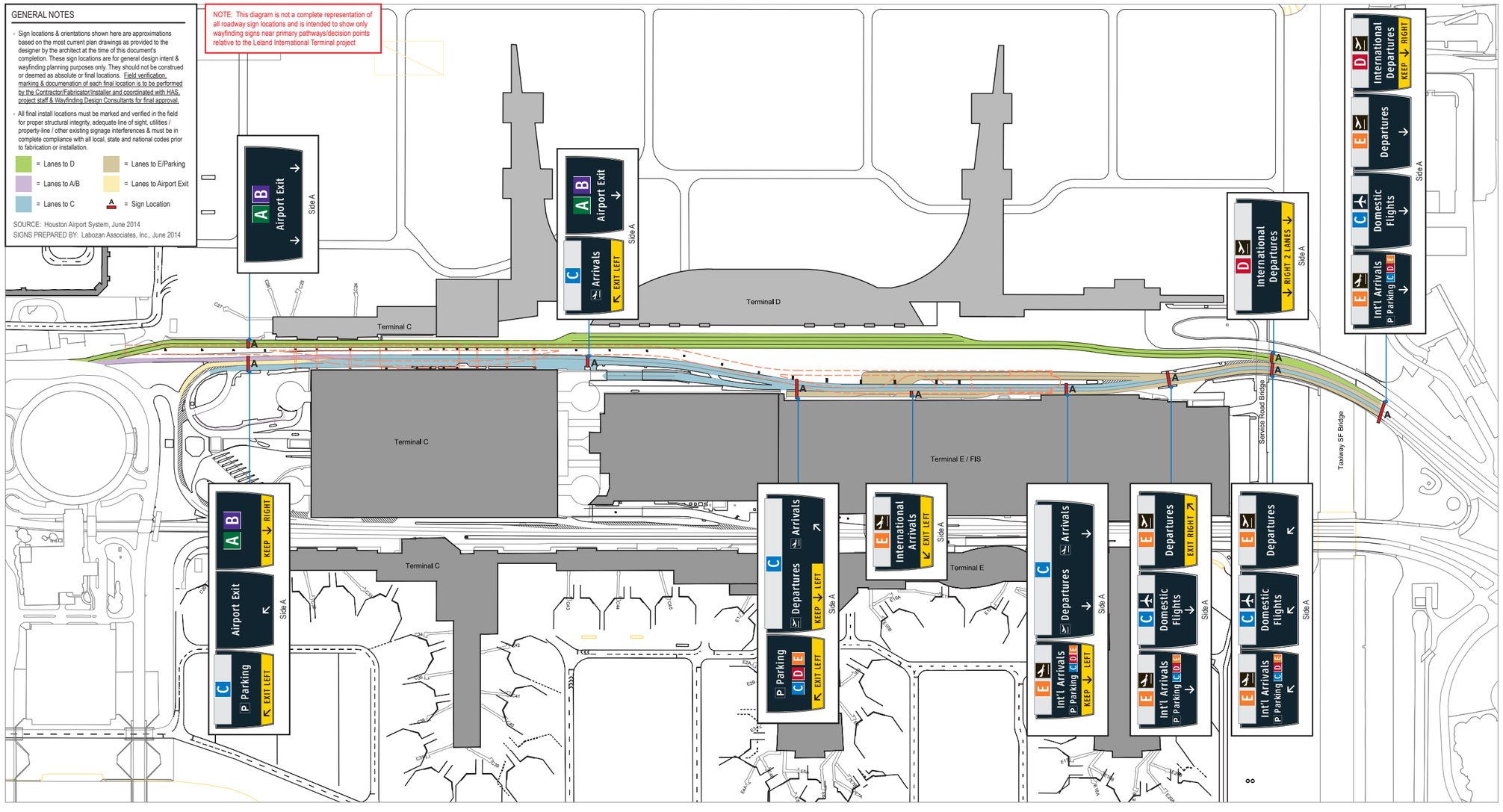
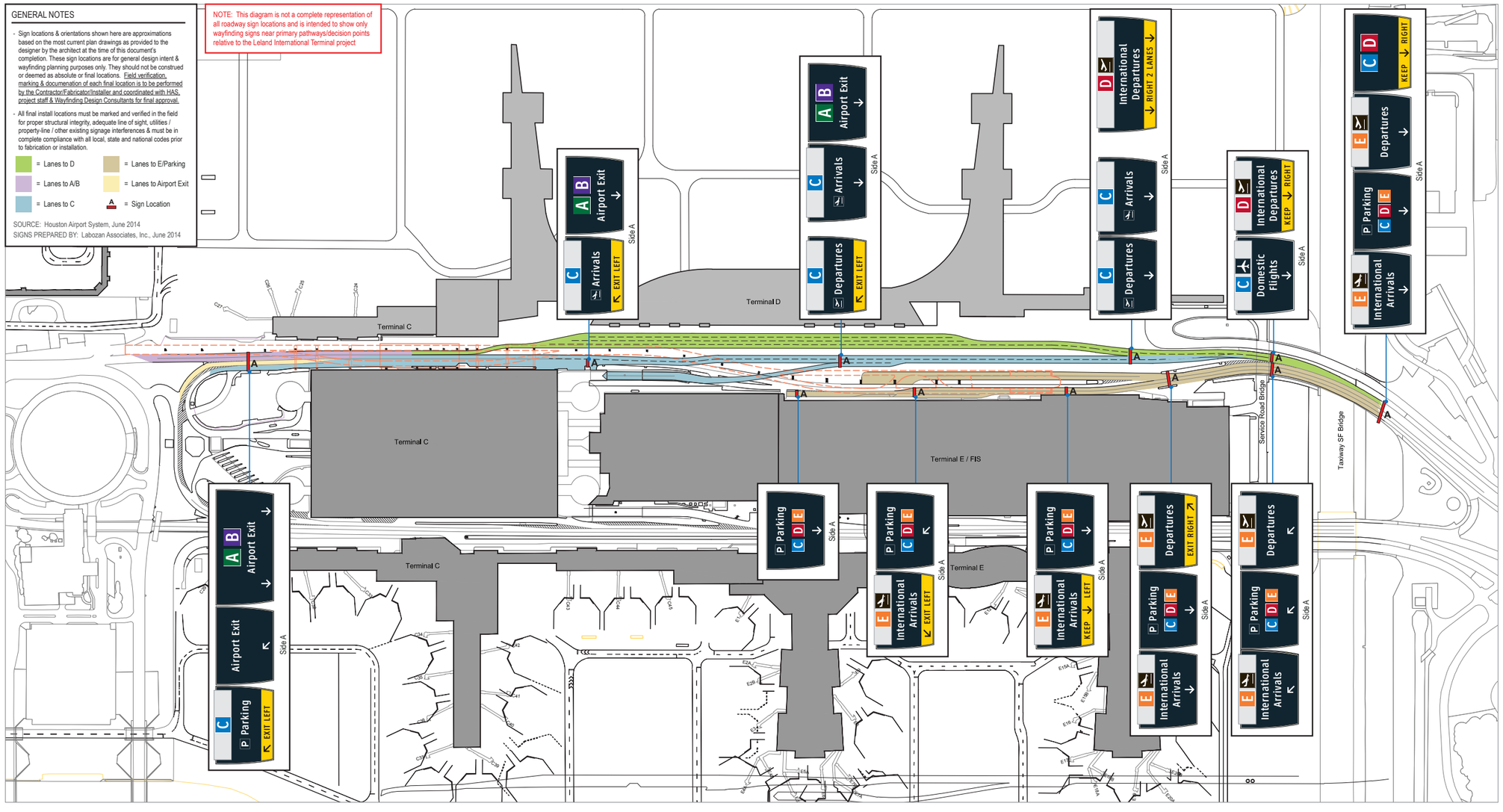
Roadway Alternative 2



Roadway Alternative 1A (Terminal E Bypass)



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Chapter 6

Program
Concept
Design
Criteria

6.0 Program Concept Design Criteria

This chapter summarizes the design criteria that the selected design firm should take into consideration as the program moves forward through design and construction. Sections of this chapter address the architectural vision for the terminal, governing codes and standards that need to be met during design, incorporation of the City's Art Program into the final design, wayfinding for the new terminal, and suggestions regarding Best Practices and Sustainability.

HAS identified seven areas that the design firm needs to keep in mind while completing the final design of the MLIT:

- Function
- Aesthetics
- Intuitiveness
- Affordability
- Future Expansion Capability
- Competitive Class Facility
- Maintainability

6.1 Architectural

6.1.1 LEVEL OF FINISH

Chapter 5 identified the different functional areas that need to be incorporated into the final design of the terminal. HAS has developed a Design Manual that outlines requirements for finishes of the various functional areas within the terminal. Coordination between the design firm and HAS will need to take place in developing final finish specifications and selection of all other furnishings and equipment.

6.1.2 ARCHITECTURAL CONCEPT

This section offers the design firm preliminary architectural renderings used in advanced planning to layout the MLIT. It was important to develop three-dimensional (3-D) renderings to identify how functional areas inside and outside the terminal building would operate. It was also important to develop the 3-D renderings due to the complexity of rebuilding the terminal in its existing location in several phases while continuing to operate flights out of the facility. A description of the construction phasing thought process is included in Chapter 7.

Figures 6.1 through **Figure 6.12**, show the preliminary architectural vision for the ticket lobby, departure concourse along the pier, the concession core, the diplomatic room and an airline club.

Interior View of Ticketing Hall

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent. Ticketing Hall shall be common use.

Central Processor - Ticketing

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent. Ticketing Hall shall be common use.

Interior View of Security

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Interior View of Pier

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Concourse - Blended Holdroom

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Interior View of Concessions

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Interior View of Airline Club

NOTE: Shell only; interiors provided by airline.

Interior View of Diplomacy/Diplomatic Suite

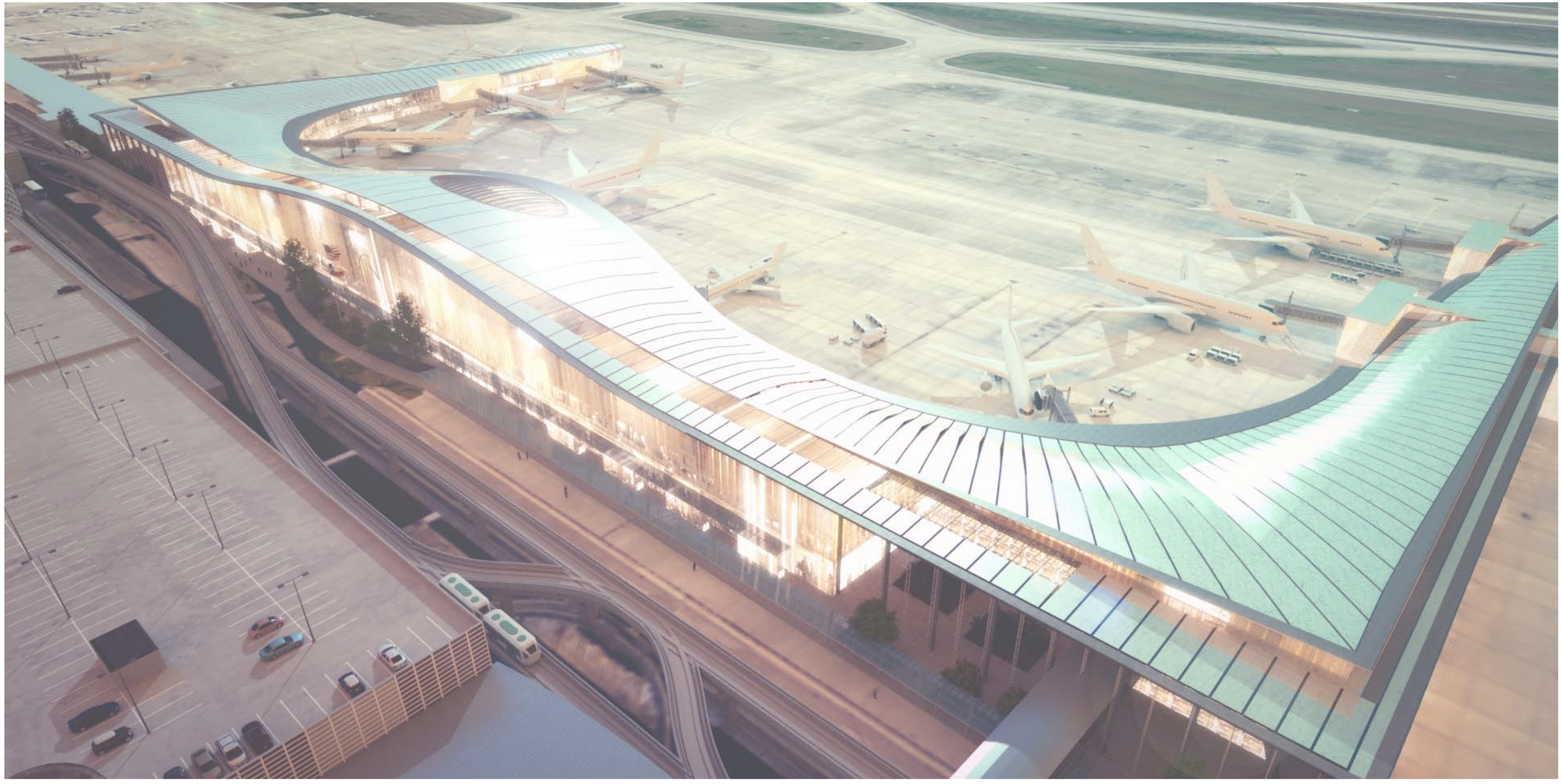
Interior View of Airline Club

NOTE: Shell only; interiors provided by airline.

Exterior Landside

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Exterior - Landside



NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

Exterior - Airside

NOTE: Architectural interpretation for visualization purposes only; does not necessarily reflect owner's design intent.

6.2 Governing Codes and Standards

The reconstruction of MLIT will require that the new structure adhere to all current codes and standards applicable to this type of building. The sources of the applicable codes and standards are spread among several national, state, and local jurisdictions with each having some involvement in the design and construction of the MLIT, even if the structure is being reconstructed or just reconditioned. While all applicable codes, guidelines, standards, and governing authorities may not be listed in this subsection, it is the responsibility of the design architect/engineer to address all applicable codes, standards, and guidelines set forth by governing authorities with jurisdiction over the project. Industry standards were not listed individually, but information can be accessed through the following industry websites.

- Airports Council International-North America: www.aci-na.org
- American Association of Airport Executives: www.aaae.org
- Airport Consultants Council: www.acconline.org
- Transportation Research Board - Airport Cooperative Research Program: www.trb.org/ACRP

Following is a list of governing authorities, and applicable codes and standards.

- Federal Aviation Administration
- The City of Houston
- Harris County Flood Control District
- Texas Commission on Environmental Quality
- Texas Department of Licensing and Regulations, Architectural Barriers
- U.S. Environmental Protection Agency
- U.S. Green Building Council
- American Society of Heating, Refrigerating and Air Conditioning Engineers
- Transportation Security Administration Checkpoint Design Guidelines (CDG), Revision 5.1, May 7, 2014

Governing Codes, City of Houston
- Building Code, 2006 International Building Code with City of Houston Amendments
- Fire Code, 2006 International Fire Code with City of Houston Amendments
- Mechanical Code, 2006 Uniform Mechanical Code with City of Houston Amendments
- Plumbing Code, 2006 Uniform Plumbing Code with City of Houston Amendments
- Electrical Code, 2011 National Electrical Code with City of Houston Amendments
- Energy Code, 2009 International Energy Conservation Code with City of Houston Amendments

Governing Codes, State of Texas
- Architectural Barriers Act, Article 9102, Texas Civil Statutes, effective 4/1/94
- 2010 Standards of Accessible Design, effective 3/15/12

Standards and Guidelines, Federal Aviation Administration
- Advisory Circular 150/5300-13A, Airport Design, dated 9/28/12
- Advisory Circular 150/5220-21C, Aircraft Boarding Equipment, dated 6/29/12
- Advisory Circular 150/5340-1K, Standards for Airport Markings, dated 11/17/10
- Advisory Circular 150/5320-15A, Management of Airport Industrial Waste, dated 9/8/08
- Advisory Circular 150/5360-13, Planning and Design Guidelines for Airport Terminals, dated 4/22/88
- Advisory Circular 150/5230-4B, Aircraft Fuel Storage, Handling, Training, and Dispensing on Airports, dated 9/28/12
- Title 14, Code of Federal Regulations, Part 139, Airport Certification, dated 6/9/04
- Title 14, Code of Federal Regulations, Part 77, Objects Affecting Navigable Airspace, dated 8/15/07
- FAA Order 1050.1E, Environmental Impacts: Policies and Procedures, as amended
- FAA Order 5050.4, National Environmental Policy Act (NEPA) Implementing Instructions for Airport Projects, as amended
- Airport Cooperative Research Program (ACRP) Report 25: Airport Passenger Terminal Planning and Design

Standards and Guidelines, Department of Homeland Security
- Recommended Security Guidelines for Airport Planning, Design and Construction, Revised May 2014
- Airport Technical Design Standards Passenger Processing Facilities, August 2006

Standards and Guidelines, Houston Airport System
- CAD/Geospatial Data Standards (www.fly2houston.com/TIP)
- IT Standards (www.fly2houston.com/TIP)
- IAH Surveyors Handbook (www.fly2houston.com/TIP)
- General Design Standards
- Signage Standards Manual will be provided by HAS - PDC
- HAS Electrical Standards
- TSA Planning Guidelines and Design Standards to Checked Baggage Inspection Systems (PGDS 4.1 or most current)

Standards and Guidelines, American Association of State Highway and Transportation Officials
- A Policy on Geometric Design of Highways and Streets

U.S. Green Building Council
- LEED for Multiple Buildings and On-Campus Building Applications Guide, LEED NC Fundamental and Enhanced Commissioning

National Fire Protection Association
- NFPA 10, Standard for Portable Fire Extinguishers, 2007 Edition (or Latest Edition)
- NFPA 13, Standard for the Installation of Sprinkler Systems, 2007 Edition (or Latest Edition)
- NFPA 14, Standard for the Installation of Standpipes and Hose Systems, 2007 Edition (or Latest Edition)
- NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection, 2007 Edition (or Latest Edition)
- NFPA 30, Flammable and Combustible Liquids Code, 2008 Edition (or Latest Edition)
- NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, 2006 Edition (or Latest Edition)
- NFPA 70, National Electrical Code, 2008 Edition (or Latest Edition)
- NFPA 72, National Fire Alarm and Signaling Code, 2007 Edition (or Latest Edition)
- NFPA 80, Standard for Fire Doors and Other Opening Protectives, 2007 Edition (or Latest Edition)
- NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems, 2002 Edition (or Latest Edition)
- NFPA 90B, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 2006 Edition (or Latest Edition)
- NFPA 92A, Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences, 2006 Edition (or Latest Edition)
- NFPA 101, Life Safety Code, 2006 Edition (or Latest Edition)
- NFPA 110, Standard for Emergency and Standby Power Systems, 2005 Edition (or Latest Edition)
- NFPA 407, Standard for Aircraft Fuel Servicing, 2007 Edition (or Latest Edition)

- NFPA 415, Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways, 2008 Edition (or Latest Edition)
- NFPA 780, Standard for the Installation of Lightning Protection Systems, 2008 Edition (or Latest Edition)
- NFPA 900, Building Energy Code, 2007 Edition (or Latest Edition)

U.S. Department of Homeland Security, U.S. Customs and Border Protection, Federal Inspection Services

- Air/Ports-of-Entry Technical Requirements (ATR), published by the Immigration and Naturalization Service (INS), February 2002
- Holdroom Design Standards, September 20, 2000
- Airport Technical Design Standards, Passenger Processing Facilities, dated August 2006 or the latest approved version
- Things to Look for in the Design of Inspection Facilities at Airports, Seaports, and Ferryports, published by the INS in February 1999
- Federal Inspection Services' Airport Facility Guidelines, June 2012
- Airport Border Integrity Antiterrorism Program Overview, published by the INS in 1999

Other Applicable Guidelines and Standards

- Americans with Disabilities Act, 28 CFR Part 35, Final Rule, published July 26, 1991
- Title VI of the Civil Rights Act of 1964 (42 USC 2000(d) et seq.)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA) Standard 90.1, Energy Standard for Low Rise Residential Buildings, 2007 Edition with Change 1 in 2010
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE) Standard 62.1 and 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Commercial/Residential Buildings
- U.S. Green Building Council, Leadership in Energy and Environmental Design for New Construction and Major Renovations (LEED-NC) v2.2
- Texas Health and Safety Code, Chapter 382, (Texas Clean Air Act)
- Resource Conservation and Recovery Act of 1976 (Solid Waste Disposal Act) and amendments
- Federal Emergency Management Agency, National Flood Insurance Act of 1968/The Flood Disaster Protection Act 1973
- Texas Administrative Code, Title 30, Part 1 Texas Commission on Environmental Quality, Chapter 334, "Underground and Aboveground Storage Tanks" American Institute of Steel Construction, Specifications for the Design, Fabrication, and Erection of Structural Steel
- Health & Safety Code, "Elevators and Escalators"
- Airports Council International, ACI 318-02, Requirements for Reinforced Concrete
- Texas Department of Insurance, First Tier Coastal Counties Wind Load Criteria

Standards

- Houston Airport Standards
- All applicable FAA regulations
- HAS Tenant Improvement Manual, Latest Edition
- Bush Intercontinental Airport/Houston, Surveyors Handbook, (Latest Edition)
- HAS Terminal Design Guidelines
- HAS Restroom Design Guidelines
- Design team shall coordinate with HAS Landscaping Coordinator

American Society of Mechanical Engineers

- ASME A17.1, Safety Code for Elevators and Escalators
- ASME A17.2, Inspector's Manual for Elevator and Escalators

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

- ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, 2010
- ASHRAE Standard 62.1, 2007
- ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, 2007
- ASHRAE Standard 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

National Electrical Manufacturers Association

- All applicable standards

Underwriters Laboratories

- UL Labeling Requirements
- UL 1008, Transfer Switch Equipment
- UL 1449, Surge Protective Devices, 3rd Edition
- UL 1558, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

American Association of State Highway and Transportation Officials

- Standard Specifications for Highway Bridges
- A Policy on Geometric Design of Highways and Streets
- LEED for Multiple Buildings and On-Campus Building Applications Guide

The Governing Standards for the Design of Hydrant Fuel Systems

- American National Standards Institute B31.3, Process Piping
- National Fire Protection Association 415, Standard on Airport Terminal Buildings, Fueling Ramps
- National Fire Protection Association 407, Standard for Aircraft Fuel Servicing

6.3 Art Program

As a part of the MLIT Program the integration of art and cultural spaces must be planned alongside other functional areas of the terminal complex. Currently, Houston's two commercial airports (George Bush Intercontinental and William P. Hobby) have varying art works on display or integrated into the architecture or landscape. As Houston's George Bush Intercontinental Airport is a part of the Houston Airport System, a City of Houston Agency, it is subject to the 1999 Civic Art Ordinance stating that 1.75% of construction monies in city run projects should be allocated to art beautification (this does not apply to runways, taxiways and ramps).

HAS has an Art Curator that works in close collaboration with an independent non-profit organization that promotes the integration of civic art in the cityscape of Houston. This organization, the Houston Arts Alliance, is a key stakeholder in determining the vision and the standards to be used when addressing art integration in the terminal space. The art that HAS and the Arts Alliance has commissioned is largely from emerging artists in the Houston area. A part of their mission is also to foster the creative community in Houston and give it exposure throughout the airport system. In other cases, artists came to Houston and setup their workshops locally in order to build the commissioned piece close to its' exhibition point.

The HAS Art Department and the Houston Arts Alliance have two different types of works that they would like to see integrated into the terminal complex.

Consideration should be given to the use of art as intuitive wayfinding during design. HAS has concerns over locating art on the concourse level if it impedes passenger circulation. Consideration should be given to the use of art to establish a "sense of place".

6.3.1 INTEGRATED/PERMANENT ART

Integrated/permanent art works are generally of a large nature and are installed as part of the architecture or landscape, with a view of being permanent and lasting the life of the architecture.

The Houston Airport System in concert with the Houston Arts Alliance will work with the design architect to determine suitable locations for these large permanent installations as well as requirements for their design.

These locations are centrally located at a place of gathering or a high traffic node. Typically these locations have double height spaces with significant natural light sources and sufficient artificial light when natural lighting is not adequate.

Art works of this magnitude are often voluminous and have either a large footprint, if they are freestanding, or require solid anchor points from the ceiling if they are hanged. In the case that they are suspended from the ceiling, the anchor points must be designed to handle the weight which often ranges in the 1,000 lbs per anchor point range. This requires that HAS, the Arts Alliance, the commissioned artist, and the architect work in concert to ensure that the location chosen is a location that enhances the passenger experience, and is suitable from a structural perspective to support the art piece.

Provisions should be made to ensure that the piece is also easily accessible for cleaning and maintenance purposes, and can be easily removed should the piece be chosen for replacement at a later time.

Examples of integrated/permanent art are shown in **Figure 6.13** and **Figure 6.14**.

Figure 6.13 – Example of Permanent Piece by Paul Vilinski

Figure 6.14 – Example of Permanent Piece by Ed Wilson

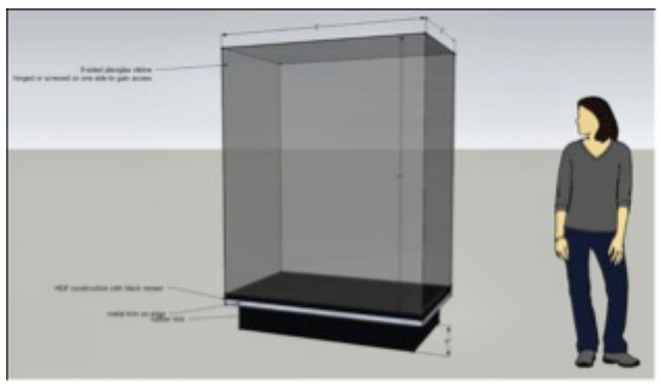
6.3.2 PORTABLE/ROTATING ART

The HAS is actively building a collection of art works that is considered portable, meaning the pieces are movable and can be displayed in a gallery type setting or displayed in a protective casing in public areas. These pieces consist generally of flatwork (photography, paintings, etc.) and small 3D objects (sculptures or worked pieces of a moderate size).

Different ideas to present these works to the public are under investigation, including a gallery space or display cases in public areas with high passenger flow.

The airport plans to use a standard freestanding display case that could be installed in different areas of the terminal and relocated at will. This display case (see **Figure 6.15**) would be suited for common-size flatworks and small to medium sized objects. These cases would need electrical power for internal lighting. Secured power sockets should be built flush into the floor in locations that would be identified as potential locations for these portable displays. These displays would be acquired separately by HAS.

Firgure 6.15 – Example of a display case

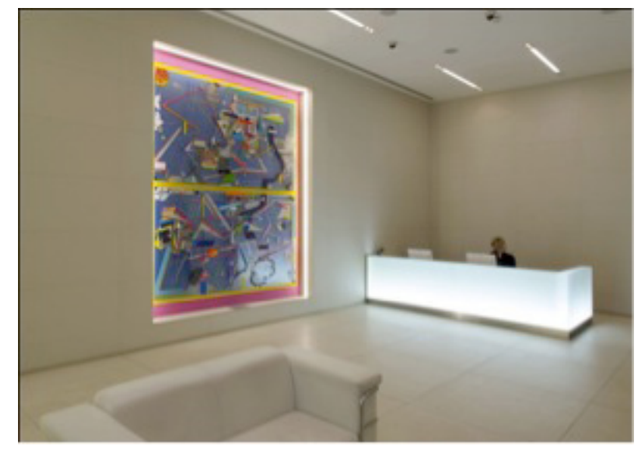


Certain vertical surfaces in the terminal would be ideal locations for the integration of permanent cases built into the walls where flat art work could be displayed (see **Figure 6.16** and **Figure 6.17**). The wall would have a glass enclosure, ideally 3 ft off the floor and 4 ft wide, with the display section between one and two feet deep. Larger versions could be built to handle larger flat art works. These built-in cases should provide adequate lighting that protects the vulnerability of certain pieces. The lighting should follow a straight forward formula that avoids large cans and halogen lights. Light Emitting Diodes (LEDs) with a CRI accuracy of a true 3,000 K are preferred. Lamps can be dimmed to around five percent of their light output without creating a difference in color temperature. Alternatively, T8 strips can be considered. Additionally, if natural light is present, the glass should filter out ultraviolet rays to protect the works as well as be removable to access the art and for cleaning. The value of certain pieces can be quite high so the glass encasing should be made as secure as possible.

Consultation between the architect, HAS and the Arts Alliance should occur to ensure optimal locations for the integrated works as well as to create the maximum positive impact on the passenger experience.

Figure 6.16 – Preferred flatwork display casing

Figure 6.17 – Larger integrated flatwork display

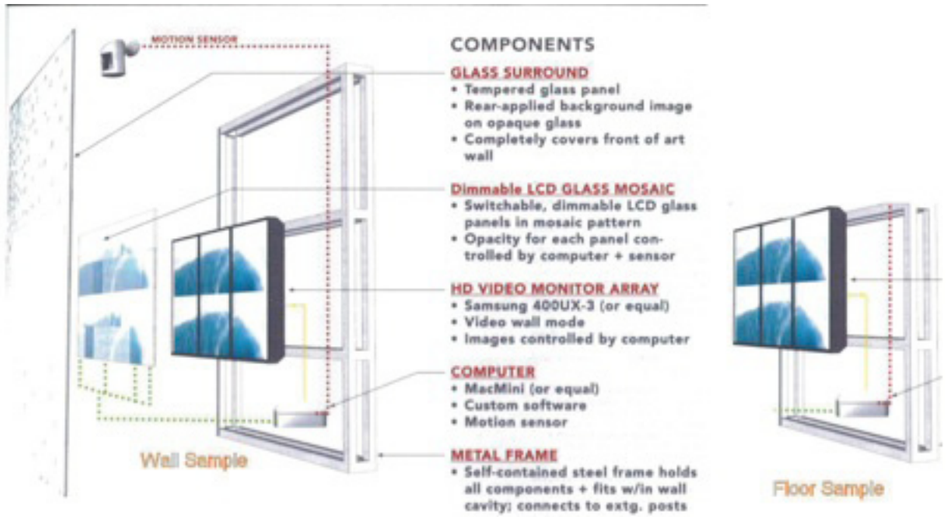


6.3.3 MULTIMEDIA DISPLAYS

The evolution of art in the late 20th century and into the 21st century includes the need to integrate new art media into a terminal design. More art today is being created digitally, to be experienced by the public using multimedia systems requiring "plug and play" accessibility.

Large media walls would require computer interfaces to handle the audio and visual aspects of a digital work of art. A multimedia specialist, along with HAS, and the Houston Arts Alliance, will need to research the requirements for a large media wall space. This locale should include, at the very least, high-speed internet connectivity, ample power supply, and ventilation to handle the operation of dozens of large screen monitors, and computer, audio, and lighting systems. The space should also be flexible allowing for future technological systems to be installed. An example of a multimedia station is seen in **Figure 6.18**.

Figure 6.18 – Example of a multimedia station



6.3.4 GALLERY

The possibility of a fixed gallery space within an airport terminal where local and regional artists would be featured has been a goal of HAS and the Houston Arts Alliance. This space, entirely dedicated to the display of art, would allow for a relaxing and reflective space that would enhance the passenger experience and reinforce the sense of place for Houston. Ideally the gallery space would be an open space where either medium to large installations could be set up in the center or smaller works displayed in display cases as mentioned above. The walls would have the integrated cases, as described above, as well as multimedia installations also described above. The location of this gallery would ideally be close to a high passenger traffic flow.

6.3.5 CIVIC ART

The following section provides examples of art pieces and artists currently on display in different locations around George Bush Intercontinental Airport (IAH) and William P. Hobby Airport (HOU).

Location :
Terminal B at
George Bush
Intercontinental Airport

Elevator Core, by Rachel Hecker, is a redesign of the cladding of the Terminal B elevator core, creating an accordion lantern-shape to the elevators in stainless steel. Blue lighting referencing runway lights are used to further define this art.

Location: Customs and Border Protection Building,
partition between Sterile Corridor and the Customs Area at George Bush Intercontinental Airport

This large scale wall piece captures the small details of the movement of water, both real and imagined. Light and fluid-action are exaggerated through the hypnotic reflections created by the special effects inherent in the materials with plexi-glass art panels inserted between two sheets of glazing.

Countree Music, by Terry Allen, is a multimedia artwork consisting of four primary elements: a bronze tree, a terrazzo map of the world, an original sound system, and enhanced lighting.

The individual elements are artistic creations that are part of the artwork as a whole and each of the elements is intrinsic to the piece. The bronze oak tree was the species chosen because of its prevalence in the Houston area. The terrazzo map was designed by the artist and encompasses an altered configuration of the continents of the world. The sound system music, indigenous to a specific continent, is audible when standing on or near a particular continent on the map.

Location: South concourse of Terminal A at George Bush Intercontinental Airport.

Countree Music by Terry Allen.

Call Ernie, by Houston artist Jim Love (1927-2005), is a steel sculpture of a single-engine prop plane with an oil-well pump jack as the nose.

It is dark blue in color and is 10 feet by 29 feet by 19 feet. The sculpture was donated to the City of Houston by Southwest Airlines in 1985.

Location: Main entrance of William P. Hobby Airport

Houston Bayou, by artist Dixie Friend Gay, consists of a Byzantine glass mosaic mural on a serpentine wall and adjacent columns, terrazzo floor design, and cast bronze reliefs.

Houston Bayou is located in the connector walkway from the A/B parking garage into Terminal B on the ground level. The mural measures 8 ft by 73 ft.

The five columns, each 12 ft high with a circumference of 18 ft, are wrapped in Byzantine glass and the terrazzo floor design enhances the mural and bayou theme.

There are 37 cast bronze reliefs of native creatures including lizards, turtles, frogs, and fish inserted throughout the terrazzo floor. Installation on the work was completed in 2002.

Location: Connector walkway from the A/B garage into Terminal B at George Bush Intercontinental Airport.

Lights Spikes was conceived by Jay Baker of Llewelyn-Davies Sahni, Inc., a member of the American Institute of Architects (AIA), for the 1990 Economic Summit of Industrialized Nations held in Houston.

The large abstract flags that represent the European Economic Community as well as the seven countries that participated in the summit were originally installed in front of the George R. Brown Convention Center in downtown Houston.

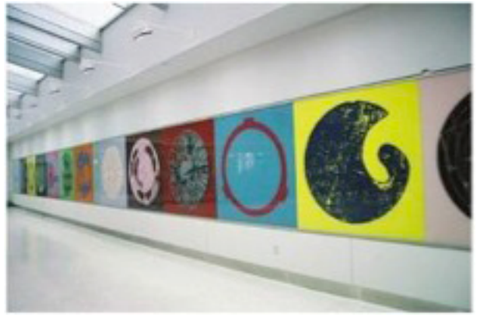
This sculpture consists of eight flags that are individually wrapped around square columns. Each "spike" is supported by an aluminum grid structure and a 10 foot concrete pier below the ground. The columns lean at a ten degree angle toward a central point that represents Houston.

The distance between each "spike" and this point is relative to the distance between Houston and the capital of the country the flags represent. The countries represented are the United States, the United Kingdom, France, Japan, Canada, Italy, and Germany, as well as the European community.

Location: Near Terminal E and the Mickey Leland International Arrivals Building at George Bush Intercontinental Airport

One Bounce, Two Bounce has 48 circular designs in two long murals that were inspired by the aviation industry, the City of Houston, and many other artistic sources. Their size, simplicity, and color are meant to work with the immense scale of the baggage hall, engage the passerby, and reflect the vibrancy and diversity of the City of Houston.

Bounce Location: The north and south walls of the
CBP building's baggage hall at George Bush Intercontinental Airport



Beads Location: International Arrival Hall
at George Bush Intercontinental Airport

Beads are the focal points in the International Arrival Hall. Each architectural column in the area has been transformed into colorful beads within the radial design of the space, providing color within the softer palate of the space. While most generally consider beads as adornment, they have been used throughout the world to express social circumstance, political history, economic structure, and religious beliefs. They have also been enlisted as symbolic repositories of sacred knowledge; thought to have curative powers; used in barter or as standard monetary units; traded from culture to culture, and have traveled across continents and oceans. Because they are used by so many contemporary and ancient cultures, beads often mirror the sociological, psychological, economic, and religious aspects of a society's technical skill. There are certain universal features of beads and the handling of them that cut across cultural differences. Houston, Texas is a community built around diversity. This is reflected by the Beads in the International Arrival Hall.

Timeline, a sculpture, that when viewed primarily from moving vehicular traffic, is designed to accommodate changes in perspective relative to the APM station at George Bush Intercontinental Airport. Reflective material utilized in the design tracks the sun's positions throughout the day. Alternatively, headlights of incoming vehicular traffic illuminate the design at night. Illuminated patterns of the sculpture's composition are reminiscent of flickering, reflective markers defining the runway approach experienced by arriving and departing pilots and passengers. The piece is 40 feet high by 33 ft long by 11 ft wide.

Timeline Location: Roadway in Front of Automated People Mover (APM) Station at George Bush Intercontinental Airport

Wind Trees is an installation of 30 metal tree forms which line the bus approach to the Consolidated Rental Car Facility. Each three finned tree is 23 ft tall and constructed of painted aluminum fins on stainless steel shafts. Mounted to the concrete abutment on either side of the roadway, the trees spin freely in the breeze. The intention was to create a monumental enhancement of the arrival experience to the rental car facility, adding color, motion, and visual interest to the otherwise monotone architecture.

Leopard Sky, by Sheila Klein, was installed in 2004. It is an environmental concept for a 50,000 sf arrival roadway at George Bush Intercontinental Airport's Terminal E. The roadway ceiling is leopard print rendered as architecture. A series of suspended panels create the dark spots seen in a leopards body pattern or textile print. The panels are arranged in an undulating fashion throughout the roadway. Behind these panels, on the ceiling, is a painted super graphic of the remaining portion of the print. The suspended metal panels are sequined with 24 inch convex parking lot safety mirrors and matching round surface mounted lights. Behind the leopard spot panels the remaining print is painted with shadows of the spots (yellow) and the mix of striations that complete the leopard print (denim). Leopard Sky creates a dramatic transitional environment that is an ever-changing instant replay of everything that is going on in the roadway.

Wind Trees Location: Bus Ramp Entrance to the
Consolidated Rental Car Facility, George Bush Intercontinental Airport

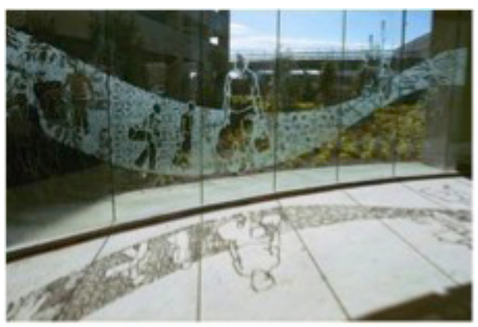
Leopard Sky Location: Exterior Roadways of Terminal E
in the Arrivals Area at George Bush Intercontinental Airport

Passing Through is inspired by two elements of the pedestrian connector: the transitional mood of its environment, as travelers pass through en route to various destinations, and the full light of its architectural design. Artist, Leamon Green, has etched this great expanse of glass walls with illustrations of travelers passing through the different cultures of the world. In addition to the large panels of etched glass, the artist also created a series of wall-mounted, fiber-optic light boxes utilizing colorful printed acrylic interlayers laminated between sheets of glass.

Over Houston consists of six 12 by 20 foot art glass pieces composed of imagery artist Gordon Huether abstracted from aerial photographs of Houston and the surrounding region, which he photographed from a small aircraft. As he expressed, "When traveling by air, I have often been amazed by the different patterns and colors formed both naturally and by man's manipulation. Rows of crops, natural grasslands, and cars on a highway all become part of the view surrounding us, which is revealed only when viewed from above."

Art glass techniques of etching, fusing, laminating, and painting all were used to fabricate the 48 individual panels of Over Houston.

Passing Through Location: Pedestrian Connectors in Terminal A at George Bush Intercontinental Airport



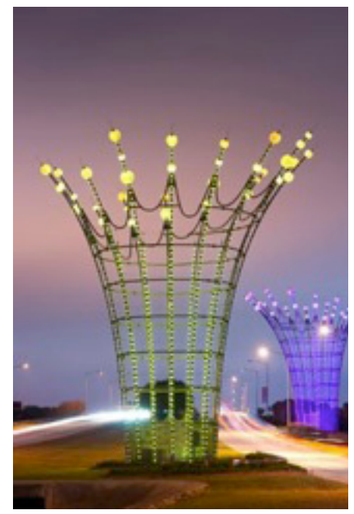
Over Houston Location: Along the Moving Walkways, Connector Bridge, at William P. Hobby Airport

Travel Light, by The Art Guys, Michael Gailbreth and Jack Massing, consists of approximately 400 cast-resin, LED-illuminated suitcases dancing across the galactic images atop the 12 baggage claim units of this enormous baggage hall. The Hubble telescope provides the patterns and elaborately programmed LEDs bring beautiful and colorful dances of light throughout this inscrutable project.

Vector HH, is inspired by humanity's ancient desire to fly without the aid of external devices. The sculpture represents the contrail generated in the air by a human figure flying with open arms. The orange figure is visible from the central ticketing area and the observation deck; however, when taking the escalators leading to the baggage claim area, the piece becomes progressively abstract giving the impression of a vibrant three-dimensional zigzag overhead.

Travel Light Location: Baggage Hall in the CBP Building at George Bush Intercontinental Airport

Vector HH Location: Suspended Above the Escalator Leading from the Main Concourse to the Baggage Area, William P. Hobby Airport



Radiant Fountains, the dynamic work by Dennis Oppenheim, establishes a vibrant and forceful presence for George Bush Intercontinental Airport, both on land and in the air. For those leaving the airport, this iconic display exudes the energy and vibrance that awaits visitors as they enter the vast city of Houston. The work also offers an eye-catching brilliance for those who are taking their first or last glimpse of Houston, from the air. A dramatic cascade of droplets of light falling through the center of each column, while powerful bursts of radiant energy bursts upward, on the outer walls, is achieved through the use of environmentally sensitive, programmed LED lights in all three towers. The rhythmic action of both falling and rising light energy creates a universal structure, of enormous presence.

Radiant Fountain Location: John F. Kennedy Boulevard at George Bush Intercontinental Airport

Making A Mark is an exhibition of art and creative writing by children touched by cancer and blood disorders at Texas Children's Cancer and Hematology Center. Making a Mark enables children with cancer and their siblings to celebrate self-expression and empowerment through creativity as a vital part of the healing process.

Making a Mark is open to children from treatment centers all over the world. We have been proud to display over 200 entries annually since the first exhibit. This year, the exhibit features over 330 pieces of art representing six different countries. To highlight Childhood Cancer Awareness Month, the artwork is exhibited at Texas Children's Hospital which is the first stop on the way to traveling to venues throughout the country.

The Periwinkle Foundation Presents:
Making a Mark Location: Rotunda, William P. Hobby Airport

Passages 1, 2, 3, 4 Location: Over Roadway Bridges
Between Terminals D and E at George Bush Intercontinental Airport

Passages 1, 2, 3, 4 has a concept of etched glass design that is meant to convey a pleasant sense of transition for the travelers who are the viewers of this installation. Travelers should feel a gradual sense of flight before or after their travels. Each bridge, titled Passages I, II, III, IV, has a different presence of space, conveying its own intimate statement of motion. Passages 1, 2, 3, 4 is by Bertram Samples and Leslie K. Elkins. The glass medium demonstrates the elements of air and flight. The glass' luminosity places the traveler in a transitional space while journeying from one terminal to another.

6.3.6 PORTABLE WORKS

The following works are a non-exhaustive sample of the portable works the airport has acquired and commissioned. Works include pieces from:

- Jonathan Leach
- Mary Helene Gagneux
- Karin Broker
- Jeff Forster
- Dixie Friend Gay
- Katrina Moorhead
- Howard Sherman
- Damon Thomas
- Randy Twaddle

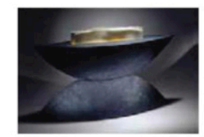
Jim Keller
"Barritz"
Evolution of the Wheel
Series # 67
Mesquite
16" x 16" x 10"

Jim Keller
"Delahey"
Evolution of the Wheel
Series # 64
Mesquite
15" x 15" x 7"

Jim Keller
"Cactus Quandry"
Mesquite
23" x 16" x 9"
$3,200.00

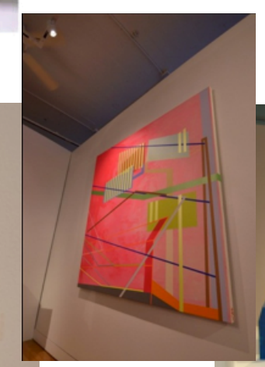
Lebeth Lammers
Double wall bowl,
Lichen over slip,

Lebeth Lammers
Limb Pod
Between 28" &
36" high



Lebeth Lammers
Half Moonlight, 28" x
16" x 8"

Portable Works Sample



6.4 Wayfinding

Airports can be complex and difficult spaces to navigate. Numerous factors affect public perception and levels of customer service with the associated airport. This is particularly true when airport modifications or upgrade programs are undertaken. Older terminals and roadways typically have outdated and inconsistent wayfinding and signage systems not reflective of current world principals and standards. Improvement projects create even more challenges for individuals functioning within the airport's wayfinding processes.

As an airport continues to evolve, it is important that its wayfinding and signage systems be designed to accommodate changes in a holistic manner. It must be understood that regardless of an individual facility's demarcation, the wayfinding pathways extend to and from the surrounding roadways, parking, curbsides, terminals, and concourse areas. Facility architecture, services, functions, and amenities, as well as vertical and horizontal routes, must always be carefully considered and viewed as part of the airport's interconnected and overall wayfinding system. A solid understanding of graphic/visual cues and human behavioral responses to wayfinding processes is paramount, and the established wayfinding system must also function seamlessly, within the built environment, without user hesitation or confusion, regardless of which area of the airport is being navigated.

6.4.1 BACKGROUND

Over the next several years, IAH will be going through several major transformations due to multiple airport-wide improvement projects. Terminals and their associated facilities, as well as the surrounding roadway systems, will be improved and/or expanded. These projects will create ever-changing and challenging wayfinding conditions. Among these improvements is the combining of Terminal C's North area and Terminal D into the new MLIT (to be called Terminal D), which will require several phases of fluctuating interim and final wayfinding conditions over the course of several years.

Recognizing the complexity of IAH's redevelopment plans, HAS commissioned Labozan Associates, Inc. (LAI) to provide wayfinding analysis, evaluation, and design criteria for IAH's overall existing wayfinding signage system, which will include the MLIT program. During an early multi-phased consensus-building process, LAI developed and presented several conceptual signage options that establish a new holistic, refreshed, and branded HAS wayfinding signage system that can be implemented holistically at any of HAS' airport properties, including IAH, Houston Hobby (HOU), and Ellington Field (EFD). Through the use of computer-rendered "before and after" walk-through simulations (which focused on several typical wayfinding pathways throughout terminal facilities and roadway areas), the analysis identified potential discrepancies that may occur as a result of the airport's redevelopment plans, as well as how the new wayfinding system would address those issues holistically. HAS staff and stakeholders reviewed and approved the final wayfinding system option during the consensus-building process. This newly approved wayfinding system will be implemented airport-wide and during each phase of the Mickey Leland International Terminal program.

6.4.2 PURPOSE

This chapter presents information regarding the general development and planned implementation of the new HAS Wayfinding Signage System within the MLIT program. It will briefly discuss design criteria, how the new wayfinding signage system is to be used, and how it holistically relates to the overall wayfinding program at IAH. For additional details, references, and information regarding the updated HAS Wayfinding System, see the latest edition of the document "HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications."

6.4.3 SCOPE

This section's scope includes the general description and design for the new HAS Wayfinding System as it pertains to its implementation within the priority public-accessible areas of the MLIT facilities. The following is a list of general topics included within this chapter:

- Wayfinding Analysis
  - Evaluation Criteria
  - Signage Philosophy
  - Standard Terminology
  - Message and Sign Type Hierarchy
  - Color Coding
  - Symbols
  - Scale of Copy
  - Sign Placement

- Wayfinding Plan – MLIT program
  - Sign Types – General Overview
  - HAS Wayfinding Sign Family
  - Sign Type Identification System
  - Design Description – Wayfinding Signage
  - Graphic Standards and Guidelines
  - Conceptual Wayfinding Plans
  - Transitional Wayfinding
  - Final Wayfinding Plans and Signage Design Intent

- MLIT program signs regulated by this chapter
  - All landside exterior and interior directional, identification and informational wayfinding signs within public areas (static and dynamic)
  - Associated roadway/curbside wayfinding signs
  - Associated parking wayfinding signs
  - Associated terminal and concourse area wayfinding signs

- MLIT program signs not regulated by this chapter
  - Tenant/concession/retail signs and standards
  - Directory artwork
  - Vehicular and pedestrian regulatory or life safety/egress signs
  - Rental car facilities/areas
  - Non-public, airside, or back-of-the-house areas
  - TSA and/or CBP standard, federal and required signage

6.4.4 WAYFINDING ANALYSIS

Prior to developing updated wayfinding plans, signage guidelines, typical applications or recommendations, it was fundamental to understand the existing wayfinding signage at IAH. In order to establish a clear direction in which to move forward with the updated Wayfinding Signage Program, LAI analyzed all relevant existing materials through site visits, photographic captures of existing wayfinding signage/conditions, and reviews of existing/planned sign program documentation airport-wide.

6.4.4.1 Evaluation Criteria

It is important for wayfinding signs to adhere to a basic guideline of copy styles/sizes, maintain consistent terminology, use recognizable and universally accepted symbols, incorporate uniform color systems, and utilize consistent recognizable sign types. This section covers key elements that impact the effectiveness of a Wayfinding Signage System, as well as overall wayfinding processes at airports in general. LAI used these key elements as the criteria by which the existing signage system was evaluated, and will continue to use them for implementing new wayfinding signage within the MLIT program. Note that industry standard wayfinding and signage factors are also covered in additional detail within the following documents:

- Guidelines for Airport Signing and Graphics, Terminal and Landside, Third Edition 2001
- ACRP Report 52, Wayfinding and Signing Guidelines for Airport Terminals and Landside, 2011
- Americans with Disabilities Act, 2010 ADA Standards for Accessible Design, Latest Revisions
- Manual on Uniform Traffic Devices (MUTCD), Latest Edition/Revision

The following are general descriptions of the evaluation criteria used for analyzing the IAH wayfinding program:

Signage Philosophy
Establish an integrated framework that would produce one comprehensive, holistic, and aesthetically attractive signage system that can be easily identified, understood, and followed.

Standard Terminology
Experience the same terms and sign types from one terminal/facility/area to the next, which will assist in rapid public comprehension of various airport functions/destinations. Message content must be in layman's language, equally understandable by first-time and frequent travelers.

Message and Sign Type Hierarchy
Clear and concise information presented by primary, secondary, and tertiary sets of messages greatly improves efficient passenger flow. Utilizing a system of consistent sign types organized by and placed within the environment, based on message priority, also contributes to increased wayfinding efficiency.

Color Coding
Colors have great effect on human behavior and deciphering of wayfinding information. Thoughtful consideration and consistent, disciplined implementation should always be utilized when using a color within a wayfinding sign system.

Symbols
The use of short verbal messages in combination with symbols is typically more effective than the use of messages or symbols alone. The use of consistent graphic representations and sizing of symbols and arrows maintains system cohesion and rapid information deciphering. Limiting the number of arrows at a given decision point also greatly improves information processing and passenger flow.

Scale of Copy
In a fast paced, often congested environment such as an airport, a conservative pedestrian viewing distance of 25 ft of viewing distance to each inch of capital letter height should be used.

Sign Placement
Placement of signs at key decision points and in the direct line-of-sight of the traveling public reduces decision times. A reasonable range of 75 to 125 feet between major directional overhead signs is acceptable and meets the general intent of ADA guidelines using 3 inch to 4 inch high capital letters. Placing signs at regular intervals within longer contained corridors reinforces wayfinding information and also improves traffic flow.

6.4.5 WAYFINDING PLAN – MLIT

This section will focus on the general wayfinding plan as it pertains to the new Wayfinding Signage System to be developed for the Mickey Leland International Terminal program. It highlights several ideas, but the primary goal of this section is to provide a condensed set of general guidelines that are to be used when developing and implementing all wayfinding signage within the modernization program.

6.4.5.1 Design Description – New HAS Wayfinding Signage System

The new HAS Wayfinding Signage System has been developed to make all airport wayfinding signage an extension of HAS' world class branding and wayfinding philosophies. It was developed to be universally adopted at all three HAS-owned Houston Metropolitan Area airports (IAH, HOU, EFD), as well as to meet the established principles of the "HAS Mission and Vision for Wayfinding":

- Provides safe, efficient, and appealing wayfinding at all HAS Airport facilities (IAH, HOU, and EFD)
- Reinforces HAS as the "Airport Standard of Excellence in the Americas"
- Unifies signage as one holistic wayfinding system, both interior and exterior
- Shares a consistent, positive "tone-of-voice" at all HAS Airports
- Creates a consistent and shared "sense of arrival" and a "sense of place" at each airport facility and property

These same principles will be used for all wayfinding signage being implemented within the MLIT program. To see a visual design description of the HAS Wayfinding System and examples of the general concept applied (in **Figure 6.19)**.

6.4.5.2 Sign Types – General Overview

There are several elements that make up a clear and recognizable sign. Even though the message and its copy size/clarity are of great importance, so too is the actual sign entity that it is placed on. Having consistent and distinct sign types enhances a wayfinding system by being more recognizable as a virtual "breadcrumb" to its users within unfamiliar environments. Many travelers can decipher the type of information that will be given based on the size, shape, mounting location, or color of the sign. This shortens the decision making process, creating smoother traffic flow, and increased trust in the overall wayfinding system.

Sign types will typically be used based on their message priority and basic wayfinding function:

- Primary Sign Types: Signs used for priority destinations/functions of the airport are considered "primary" signage, and should be the most visible and visually dominate to other wayfinding signage.
- Secondary Sign Types: Secondary messaging (such as phones, ATMs, etc) should typically be reserved for sign types pre-determined as "secondary" in nature, and should appear visually subordinate to the primary signage.
- Tertiary Sign Types: Tertiary messaging (such as regulatory, safety related information, etc) should also be placed on sign types pre-determined for "tertiary" use, and should typically appear visually subordinate to both primary and secondary signage.

6.4.5.3 Wayfinding Sign Family

HAS' new wayfinding system uses a comprehensive sign typing system that is based on categories of a sign's function. It has been developed into a holistic family of signs with each member having their own specific use and purpose, while also utilizing a "kit-of-parts" design philosophy (see **Figure 6.20**). It is designed to be manageable, seamlessly integrated with all of IAH's facilities, and can be updated on a continuing basis as needs arise.

See **Figure 6.21** for examples of the planned wayfinding sign family that will be utilized for the Mickey Leland International Terminal program (this is not a complete or final list; the sign family will be expanded and further developed during future IAH and Mickey Leland International Terminal improvement project phases).

Wayfinding sign types at HAS properties will be categorized as directional, identification, informational, regulatory, life-safety/egress and temporary. Major sign type classifications (as categorized by function) and general descriptions of each include:

- Directional: signs that display standardized directional messaging to assist in finding one's way through a defined area or environment (i.e. an overhead sign at a decision point with arrow/symbol/destination messages listed).
- Identification: signs used as unique markers to identify specific locations within a defined area or environment (i.e., a gate identification sign).
- Informational: signs or graphic systems that display specific and very detailed information to assist in orientation within a complex or unfamiliar environment (i.e., a directory map or FIDS).
- Regulatory: signs that display regulatory information (i.e., "No Parking" or "Loading Zone Only" signs).
- Life-Safety/Egress: signs that display life-safety and vertical circulation/egress related information as required by local and national codes (i.e., fire escape stairway core level identification signs).
- Temporary (aka "Transitional"): signs that can be directional, identification, informational and regulatory, but are made of temporary materials and mounting methods.

6.4.5.4 Sign Type Identification System

Sign type identification for all IAH wayfinding signage program implementation is to be grouped into the following categories:

- Pedestrian Signs (*Note: Certain vehicular signs also fall within these series numbers)
  - Series 1: Terminals/Concourses: Includes: All public-accessible Terminal and Concourse related areas
  - Series 2: CBP Required Signage: Includes: Areas as controlled by the U.S. Customs and Border Protection
  - *Series 3: Curbside/Ground Transportation: Includes: All Curbside and Ground Transportation related areas
  - Series 4: Roadways: Includes: All on-property public-accessible roads
  - *Series 5: Parking: Includes: All on-property public-accessible garages and surface lots
- Vehicular Signs
- Other Areas
  - Series 6: Support Facility Areas
  - Series 7 (and above): Are to be assigned as needed and based on unique requirements of individual projects. Note: All expanded series numbering and categorization must be coordinated with HAS for final approval.

6.4.5.5 Graphic Standards and Guidelines

It is important to maintain and use a consistent set of graphic standards and guidelines when implementing the new IAH Wayfinding Signage System. The following is a brief list of graphic standards and guidelines that will be used for implementing all wayfinding signage within the Mickey Leland International Terminal program:

Wayfinding - Design Description

1 Design is inspired by the existing HAS logo & branding:

Key Descriptive/Inspirational Words and Design Shape-Language:

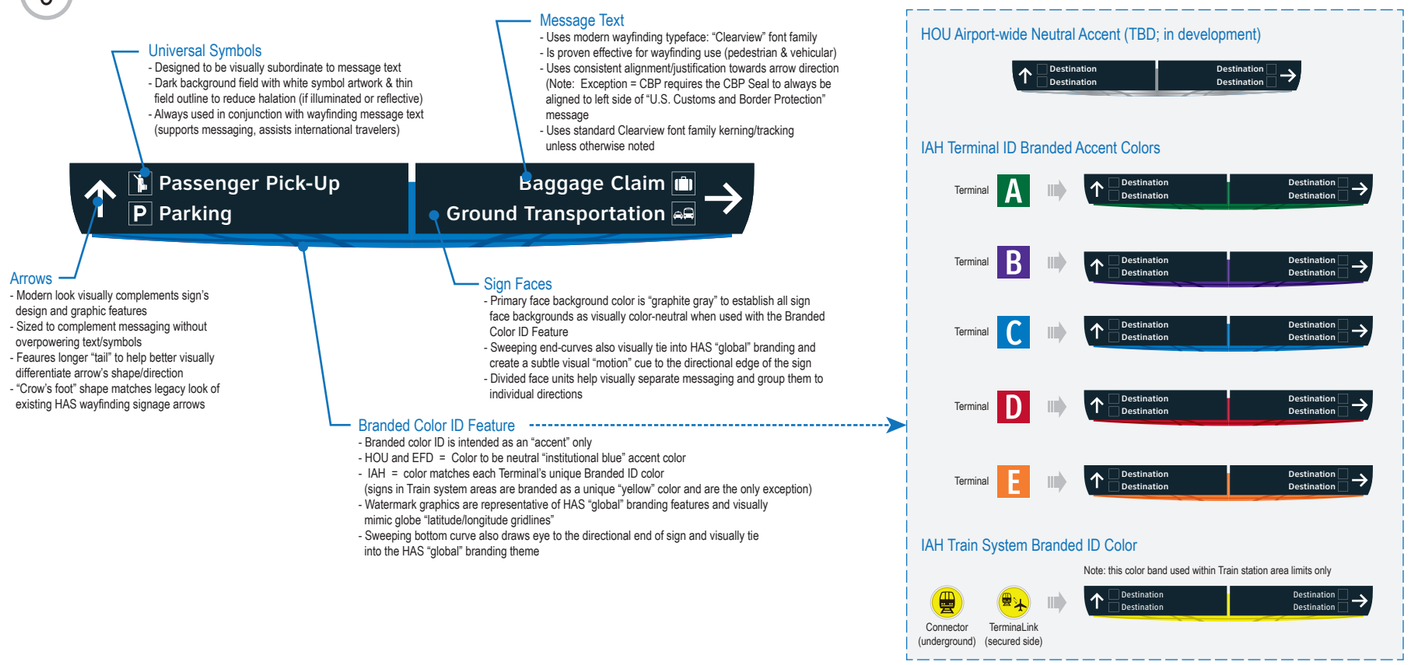
- Clean
- Fresh / New
- Branded
- Modern
- Holistic
- Efficient
- Curves / Motion
- Arcs / Arches
- Swooshes
- Global
- Gridlines
- Distinct / Unique

2 Design follows established HAS branding and "Wayfinding Vision/Mission":

Creates a subtle and abstracted visual connection with established HAS Wayfinding Philosophies:

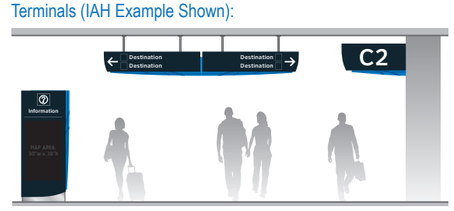
- Provides safe, efficient and appealing wayfinding at all HAS Airport properties (IAH, HOU, EFD)
- Reinforces HAS as the "Airport Standard of Excellence in the Americas"
- Unifies signage as one holistic wayfinding system (both interior and exterior)
- Shares a consistent, positive "tone-of-voice" at all HAS Airports
- Creates shared "sense of arrival" & "sense of place" at each Airport facility/property

3 New wayfinding signage design features, graphics and elements:

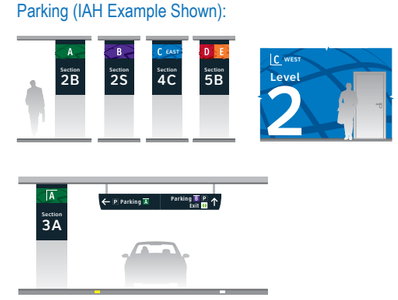


4 Designed as a holistic Airport-wide sign family:

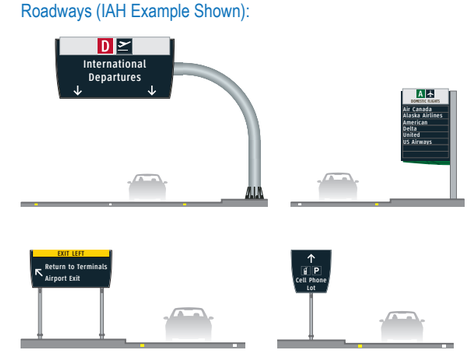
Terminals (IAH Example Shown):



Parking (IAH Example Shown):



Roadways (IAH Example Shown):



SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

Kit of Parts

KIT-OF-PARTS SIGNAGE SYSTEM

The HAS wayfinding system has been designed as a series of modular sign types that utilize a general "kit-of-parts" system. In most instances, the same and/or similar parts can be used to create multiple differing sign types and mounting configurations.

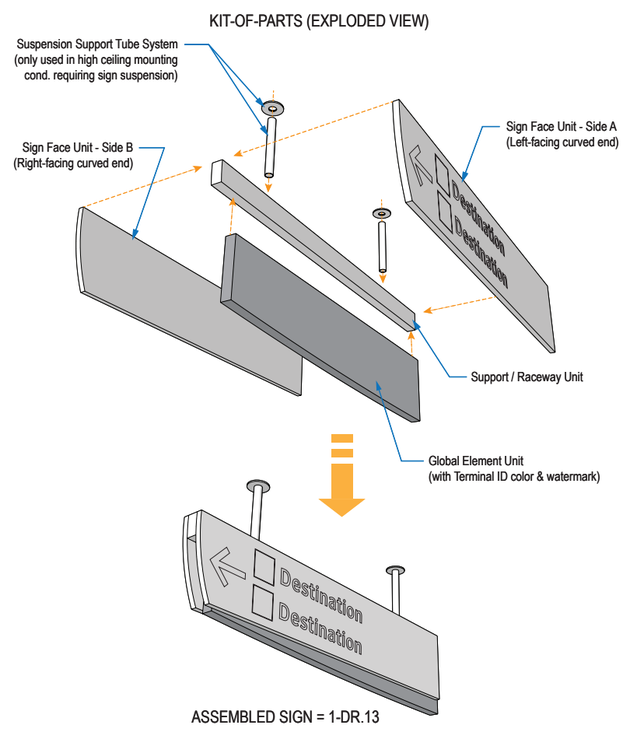
For example, a Sign Type "1-DR.13" (aka "Ceiling Mount Directional - Suspended, 2-sided with 1 direction and 1-2 messages") is assembled by using a specific set of parts, which includes two Sign Face Units (sides A and B), a Support / Raceway Unit (i.e. for primary structural support and/or routing internal electrical components if needed), a Global Element Unit (i.e. for Terminal ID color branding accent) and a Suspension Support Tube System (i.e. used if sign is to be located in high-ceiling areas). See Assembly Example 1 below.

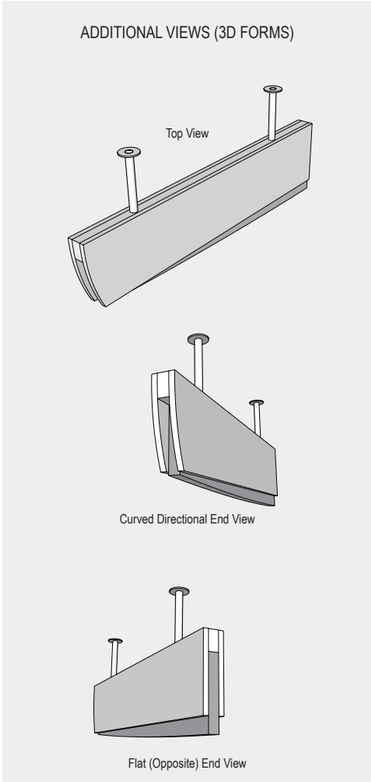
Another example is the assembly of a Sign Type "1-DR.12" (aka "Ceiling Mount Directional - Suspended, 2-sided with 2 directions and 1-2 messages"). This sign type can be assembled by using two sets of the same parts that make a Sign Type "1-DR.13." These two "1-DR.13's" can then be fastened together on the two flat ends of the Global Element Units with an internal connection system (see Assembly Example 2 below).

Other mounting configurations and part sizes/shapes can be utilized in a similar manner across the entirety of the HAS wayfinding system. For example, a Sign Type "1-DR.23" (aka "Wall / Soffit Mount Directional, 1-sided with 1 direction and 1-2 messages") can be made by using the same Sign Face Unit as used on the "1-DR.13." However, it would instead use a Support / Raceway Unit and Global Element Unit that are configured specifically for wall mounting conditions.

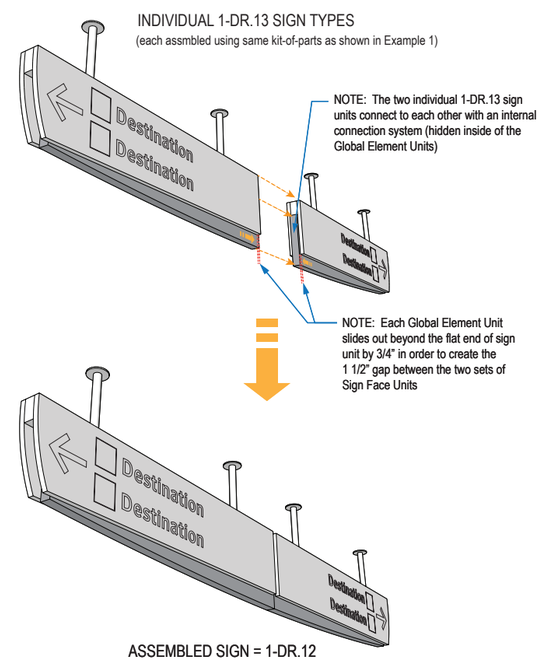
SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

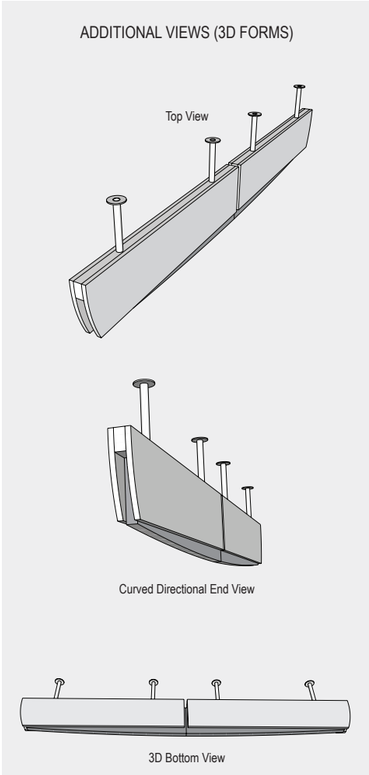
Kit-of-Parts Assembly Example 1: **Sign Type 1-DR.13**



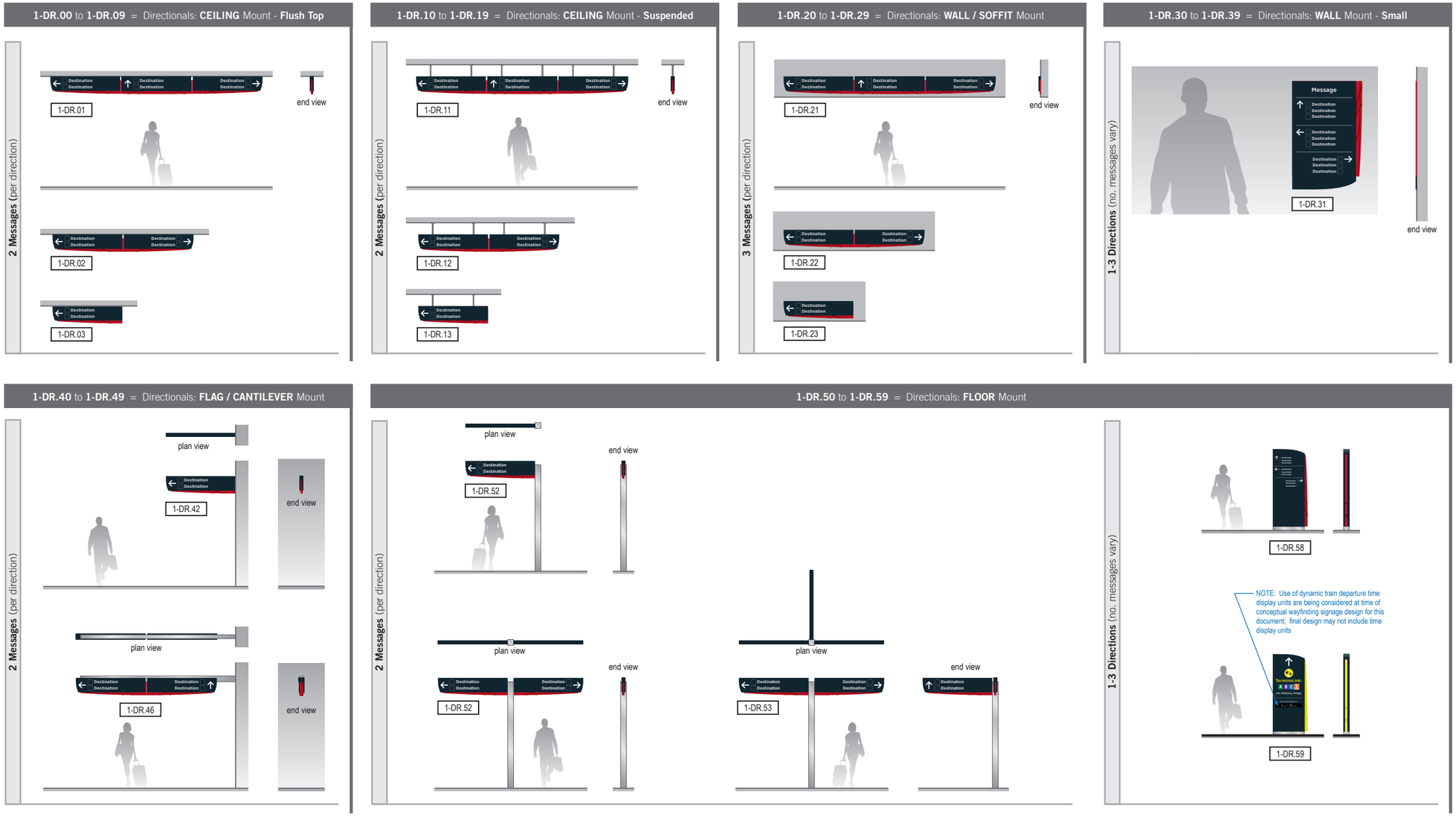


Kit-of-Parts Assembly Example 2: **Sign Type 1-DR.12**





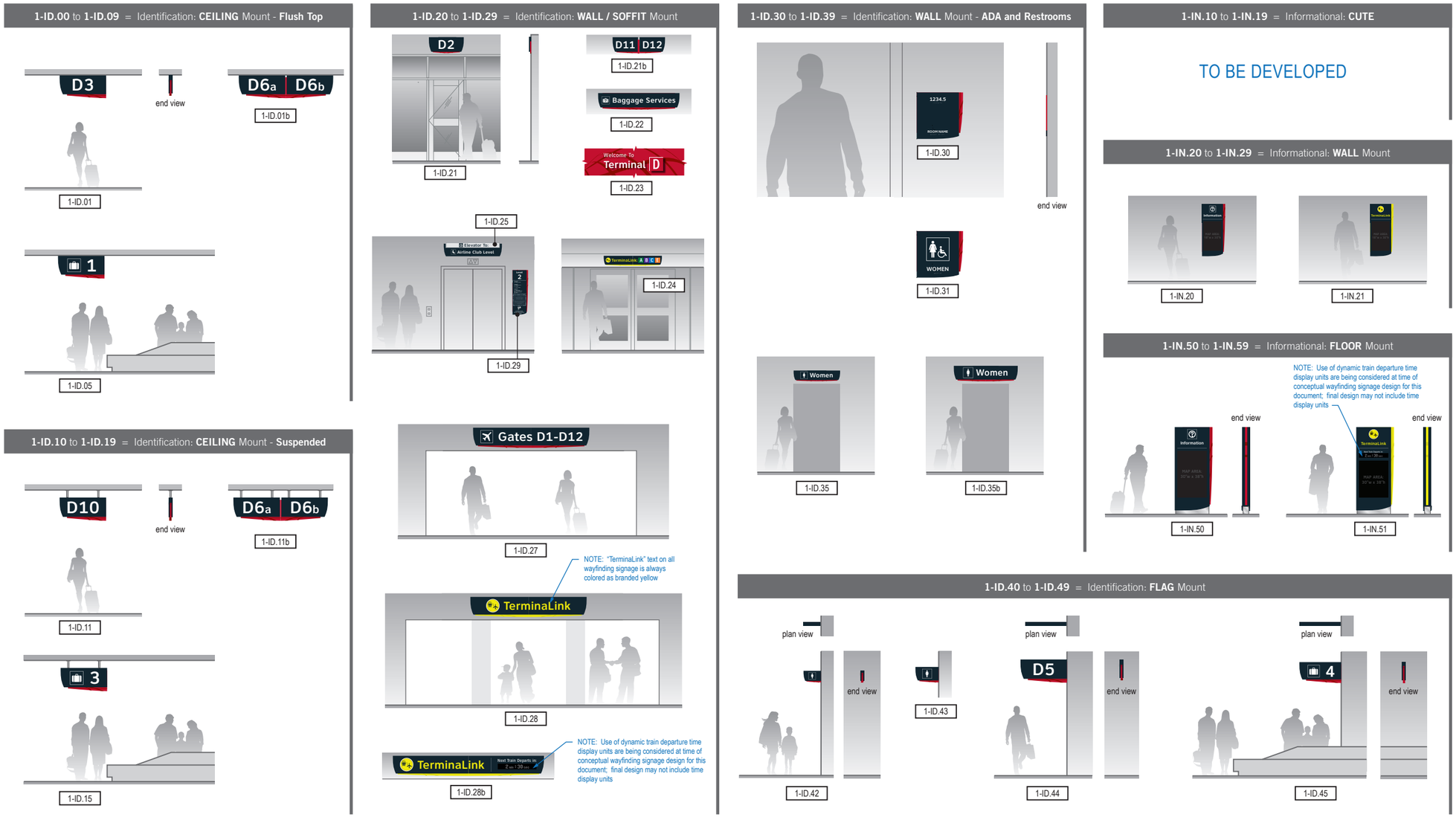
Planned Sign Family 1 of 2



SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

Scale: Not to Scale

Planned Sign Family 2 of 2



SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

Scale: Not to Scale

Consistency and Standards Based

- Consistent visual/graphic presentation across entire wayfinding system to include:
  - Graphics/Colors/Fonts/Symbols
  - Shapes/Proportions/Sign Types
  - Placement/Orientation & Rotation Philosophy/Decision Points

- Subscribe to established industry design standards and requirements:
  - Accessibility (ADA)
  - Sustainability (LEED)
  - TxDOT/MUTCD (vehicular signage)

Sign Types (see **Figure 6.21**)

- Configuration, sizing and placement relative to message priority/function
  - Primary destinations = priority overhead
  - Secondary destinations = secondary overhead or wall mount
  - Tertiary destinations = tertiary wall mount
  - Simplicity = declutter, less is better

Color Coding and Application (see **Figure 6.22**)

- Sign Background = Neutral "Graphite" or "Charcoal" Gray (PMS 433C)
  - Minimizes confusion with branded terminal ID colors
  - Creates neutral backdrop for messaging/symbols/arrows and branded ID colors
  - Least visual impact to other existing airport signage during phases of updating
- Multi-Color Discipline = IAH branded colors used as terminal and train-system related identification "accents" only
  - Helps to highlight and differentiate terminals and associated parking facilities, as well as inter-terminal train/people-mover systems
  - Limited to a small number of priority areas/functions
    - Terminal A = "Green" (PMS 349C)
    - Terminal B = "Purple" (PMS 2597C)
    - Terminal C = "Blue" (PMS 300C)
    - Terminal D = "Red" (PMS 187C)
    - Terminal E = "Orange" (PMS 1655C)
    - TerminaLink (secured side) and Connector trains = "Yellow" (PMS 3965C)
  - For additional color standards, see the latest edition of the document "HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications;" No other colors may be used for IAH wayfinding signage unless otherwise noted and approved by HAS

Typefaces, Arrows and Symbols (see **Figure 6.22**)

- Clearview font family
  - Established as effective for pedestrian and vehicular use
  - Variety of styles that apply to vehicular & pedestrian traffic
  - Sized/kerned appropriately for predicted viewing distances and speeds
- Using modern industry standard AIGA/DOT Universal Symbol System
  - Reinforces destination text
  - Assists international travelers
  - Graphic presentation/format reduces possible halation (if illuminated)

Message Hierarchy (see **Figure 6.23**)

- Primary – priority destinations (largest, most visible)
- Secondary – secondary destinations (supplemental)
- Tertiary – auxiliary/support destinations

Message Functions

- Directional – direct to destination point(s)
- Identification – identify destination point(s)
- Informational – convey detailed information
- Regulatory – describe regulations, warnings & requirements
- Temporary – may be any of the above, but used in interim conditions only

Illumination

- HAS wayfinding signage will always utilize consistent and standardized illumination methods. This will enhance and provide holistic visibility and legibility across the overall wayfinding system, while also meeting applicable ADA and MUTCD/TxDOT requirements for wayfinding signage.
- The following are examples of typical wayfinding signage illumination types:
  - Non-Illuminated
  - External Illumination (aka "Front-lit")
  - Reflective Illumination
  - Internal Illumination (aka "Back-lit")
- Note that at the time of this document's publication, final universal illumination implementation standards for the HAS wayfinding system are still in discussion and development with HAS. However, in the interim and for the purposes of general design intent, the following recommended guidelines and standards for illumination implementation shall be used whenever designing and/or specifying HAS wayfinding signage (Note: these recommendations are based on wayfinding industry typical best practices at time of this document's publication, and may change in the future as advancement of illumination technologies occur):
- Interior Pedestrian Signage:
  - Primary/preferred method = use internal illumination whenever possible.
- Exterior Pedestrian Signage:
  - Primary/preferred method = use internal illumination whenever possible, or where it's most beneficial and/or required (i.e. within parking garages and/or under architectural covers where ambient lighting conditions vary radically the closer/further signage is located in proximity to the projection of daylight).
  - Secondary method = use external illumination via nearby or dedicated lighting sources when internal illumination is not viable or possible.
  - Note: Use reflective graphics when nearby or dedicated lighting sources are not available.
- Vehicular Signage - Roadways and Parking Garages/Lots:
  - Primary required method = on all overhead and roadside wayfinding signage, always use highly reflective sign face graphics by utilizing products such as 3M's DG3 line of reflective roadway sign films.
  - Specialized applications = use internal and/or external illumination on specialized signage, such as Airport property entrance gateways and architectural/building identification as applicable.
- Vehicular Signage - Curbsides:
  - Primary/preferred method = use highly reflective sign face graphics by utilizing products

Graphics 1 of 2

COLORS

TERMINAL IDENTIFICATION

Terminal A **PMS 349C**	Terminal B **PMS 2597C**	Terminal C **PMS 300C**	Terminal D **PMS 187C**	Terminal E **PMS 1655C**	TerminaLink & Connector Trains **PMS 3965C**
Terminal A Watermark Accent **PMS 3435C**	Terminal B Watermark Accent **PMS 2695C**	Terminal C Watermark Accent **PMS 294C**	Terminal D Watermark Accent **PMS 188C**	Terminal E Watermark Accent **PMS 180C**	TerminaLink & Connector Trains Watermark Accent **PMS 3975C**

SIGN GRAPHICS / STRUCTURES / MISC. OTHER

Sign Face Background **PMS 433C**	Divider Rule-Line Graphic **PMS 432C**	ID Header Background **PMS 427C**	White Text/Graphics **White**	Suspension Hardware **Bright Silver:** to match MAP paint # 41342SP	Safety Red **PMS 186C or 3M 4092 DG3 Red**	Warning Yellow **PMS 116C or 3M 4091 DG3 Yellow**	Black Text/Graphics **PMS Black C or C:50 M:40 Y:40 K:100**

ARROWS

0 degrees (3 o'clock): - Right	45 degrees: - Ahead on the Right - Up to the Right	90 degrees (12 o'clock): - Ahead Forward - Up	135 degrees: - Ahead on the Left - Up to the Left	180 degrees (9 o'clock) : - Left	225 degrees: - Here on the Left - Down to the Left	270 degree (6 o'clock): - Ahead Here - Down	315 degrees: - Here on the Right - Down to the Right

TYPEFACES

PEDESTRIAN WAYFINDING TEXT

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789@#$%^&*():;

Font = ClearviewText Medium
Use = Primary typeface for all standard pedestrian wayfinding word messages

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789@#$%^&*():;

Font = ClearviewOne Book Condensed
Use = Supplemental pedestrian wayfinding word messages (i.e. "via," "to:" and CBP notification text)

VEHICULAR WAYFINDING TEXT

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789@#$%^&*():;

Font = Clearview Highway 2-B
Use = Primary typeface for all standard vehicular wayfinding word messages

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz
0123456789@#$%^&*():;

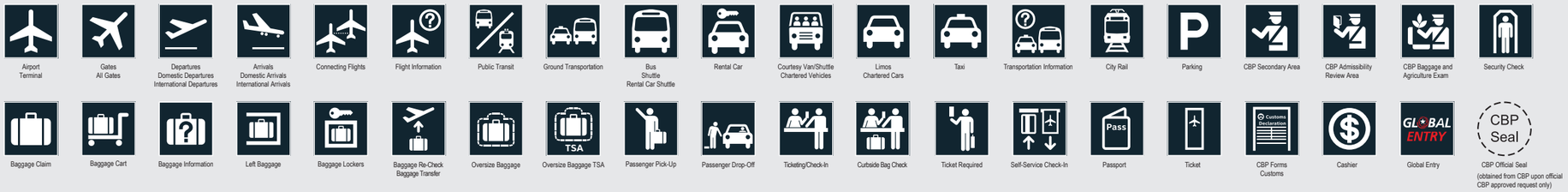
Font = Clearview Highway 1-B
Use = Supplemental vehicular wayfinding word messages

SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

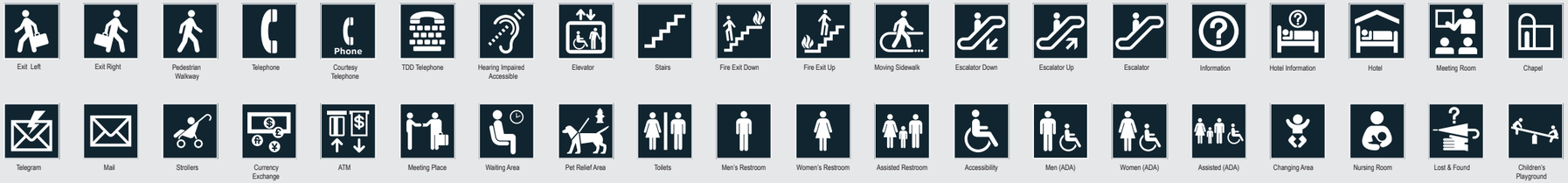
Graphics 2 of 2

UNIVERSAL SYMBOLS

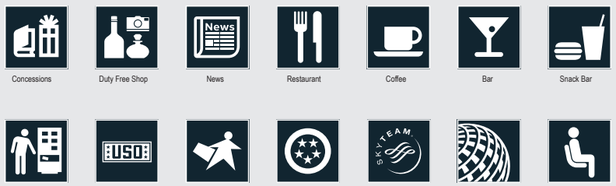
TRAVEL SYMBOLS



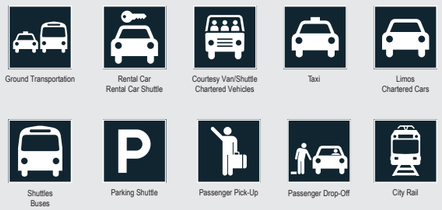
PUBLIC SERVICE SYMBOLS



AMENITIES & CONCESSIONS



GROUND TRANSPORTATION



TERMINALS: IAH Only

TXDOT HIGHWAY SHIELDS: IAH Only

INTER-TERMINAL TRAINS: IAH Only

REGULATORY

SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

Messages

MESSAGE HIERARCHY - HAS Terminals / Concourses / CBP Areas

PRIMARY	SECONDARY	TERTIARY	REGULATORY/STATUTORY
Directional - Terminal X *(used only at IAH: "X" = terminal letter)* - Terminal X via Walkway *(used only at IAH: "X" = terminal letter)* - TerminaLink XXXXX *("X" = ABCDE per terminal area)* - Ticketing/Check-In - Baggage Claim - Ground Transportation - Gates X#-X# *(IAH: "X" = terminal ltr.; "#" = gate no.)* - Gate X# *(IAH: "X" = terminal ltr.; "#" = gate no.)* - All Gates *(used at HOU and EFD only)* - X Gates *(IAH: "X" = terminal letter)* CBP Areas (Special Required Directional Messages): - U.S. Customs and Border Protection *(NOTE: must always be accompanied by the official CBP seal on left side of text; "and" must always be spelled out, no ampersands allowed)* - Global Entry - CBP Secondary Area - CBP Exit - Baggage Re-Check	**Directional** - Connector - International Departures - International Arrivals - Domestic Flights - Parking - Parking Garages - Bridge to Parking - Connecting Flights - Airline Clubs *(i.e. Presidents Club, etc)* General: - Restrooms - Elevator	**Directional** - Telephones - ATM	All required CBP, TSA & FAA related regulatory/statutory information, including (but may not be limited to): - U.S. CUSTOMS AND BORDER PROTECTION SECURITY AREA... - ILLEGAL DRUGS... - ASSAULTING AN OFFICER OR EMPLOYEE OF THE UNITED STATES... - SEARCH AND DETENTION OF PERSONS, BAGGAGE, VEHICLES AND CONVEYANCES... - CURRENCY AND MONETARY INSTRUMENTS... - SMUGGLING... - AGRICULTURAL DECLARATION... - EXPLOSIVES, FIREARMS, AND WEAPONS ARE PROHIBITED... - CURRENCY AND MONETARY INSTRUMENTS... - Etc... Notifications: - AUTHORIZED PERSONNEL ONLY - DO NOT ENTER - Warning: Restricted Area, Do Not Enter - Warning: Emergency Exit Only, Door Monitored by Alarm - Etc... Other / General: - No Smoking - All life safety/egress - Elevator escape route maps/notifications *(with ADA code compliance)*
Identification - Terminal X *("X" = terminal letter)* - Airline Names - All Gates - Gates X#-X# *(IAH: "X" = terminal ltr.; "#" = gate no.)* - Gates #-# *(HOU: "#" = gate no.)* - Gate numbers *(i.e. IAH = A1, A2 ...; HOU = 1, 2, ...; etc)* - Baggage Claim - Ticketing/Check-In - Curbside Bag Check - Bag carousel numbers *(i.e. 1, 2, 3, etc)* - Self-Service Check-In CBP Areas (Special Required ID Messages): - U.S. Customs and Border Protection *(NOTE: must always be accompanied by the official CBP seal on left side of text)* - WELCOME TO THE UNITED STATES - Global Entry - CBP Secondary Area - CBP Exit - Baggage Re-Check	**Identification** - TerminaLink XXXXX *("X" = ABCDE per terminal area)* - Connector - Restrooms - Men - Women - Assisted - Information - Level # at elevators *(i.e. 1, 2, 3, etc)* - Elevator - Stair # *("#" = stair no. per individual bldg numbering system)*	**Identification** - Oversize Baggage - Baggage Re-Check - Telephones - Emergency Phone - Paging Phone - Fire Extinguisher - AED - ATM - Concessions - General room name/number IDs *(with ADA code compliance)*	
Informational - FIDS - BIDS - GIDS - Self-service check-in kiosks information CBP Areas (Special Required Notification Messages): - Please Have Your Documents Completed and Ready to Present to an Officer - Thank You for Your Cooperation	**Informational** - Terminal X Directory *("X" = terminal letter)* - Airport Directory - General bag carousel information - Clocks - Visual Paging	**Informational** General: - All general safety related information	

SOURCE: HAS Wayfinding System: Signage Design Guidelines, Standards and Typical Applications (Latest Ed.)
PREPARED BY: Labozan Associates, Inc., May 2014

such as 3M's DG3 line of reflective roadway sign films.
- o Secondary method = use internal illumination for other specialized signage at terminal curbsides (i.e. curbside airline/meeting place ID).

6.4.5.6 General Sign Placement

A general rule for placing wayfinding signage is that a designer visualizes themselves as an average departing or arriving passenger within a given airport environment, while thinking about decision points and required messaging expected at a given location. This guideline is of course very general in context. Other disorienting conditions may occur, which in turn may require placement of additional signage. These typically include:

- Complex architecture/interior environments
- Competing pedestrian wayfinding traffic
- Visual/environmental distractions
- Congested/contained corridors

Conversely, more favorable conditions which typically reduce need for repetitive signage are:

- Efficient architecture/interior environments
- Single direction wayfinding traffic flow
- Ceiling, wall or floor treatments reinforcing single-direction traffic flow
- Lighting treatments emphasizing travel corridors or other destinations

Directional sign placement will be perpendicular to wayfinding traffic, and will occur at all decision points and areas where people become disoriented by architectural or environmental conditions. Directional signs will also be placed at reassuring intervals within a captive corridor to reinforce directional messaging to wayfinding traffic. Note that architectural/interior conditions or competing pedestrian traffic flow may also inadvertently imply a change of direction. In these situations, additional directional signs will be used to reinforce the intended direction as needed.

Identification sign placement will typically occur at or near all priority destinations and entrances. Identification signs, such as gate ID signs or corridor/building entrances, will also typically be placed perpendicular to wayfinding traffic.

Informational sign placement will typically be located nearest to major decision points. Directories will typically be located to the side of a major decision point and will be parallel/in-line with wayfinding traffic. FIDS and other dynamic informational systems should also be typically located parallel/in-line with wayfinding traffic unless otherwise deemed beneficial to be perpendicular in a given situation.

6.4.5.7 Conceptual Wayfinding Floor Plans

Figures 6.24 (Baggage Level), **Figure 6.25**(Ticketing Level), **Figure 6.26** (Departures Level) and **Figure 6.27** (Club Level) identify conceptual wayfinding pathways, decision points and sign locations for wayfinding signage for each public-accessible level/area of the main Mickey Leland International Terminal facility. These floor plans will be used only as a general starting point/guideline for initial conceptual sign location reference. More finalized/precise locations will be implemented during the forthcoming design development process, and coordinated with the Project Team and HAS.

6.4.5.8 Transitional Wayfinding

In addition to the established new IAH Wayfinding Signage System, a transitional sign system should also be developed and employed during Mickey Leland International Terminal's multiple phases of interim wayfinding conditions. A standardized conceptual transitional wayfinding sign family should be developed and utilized during each design phase as needed.

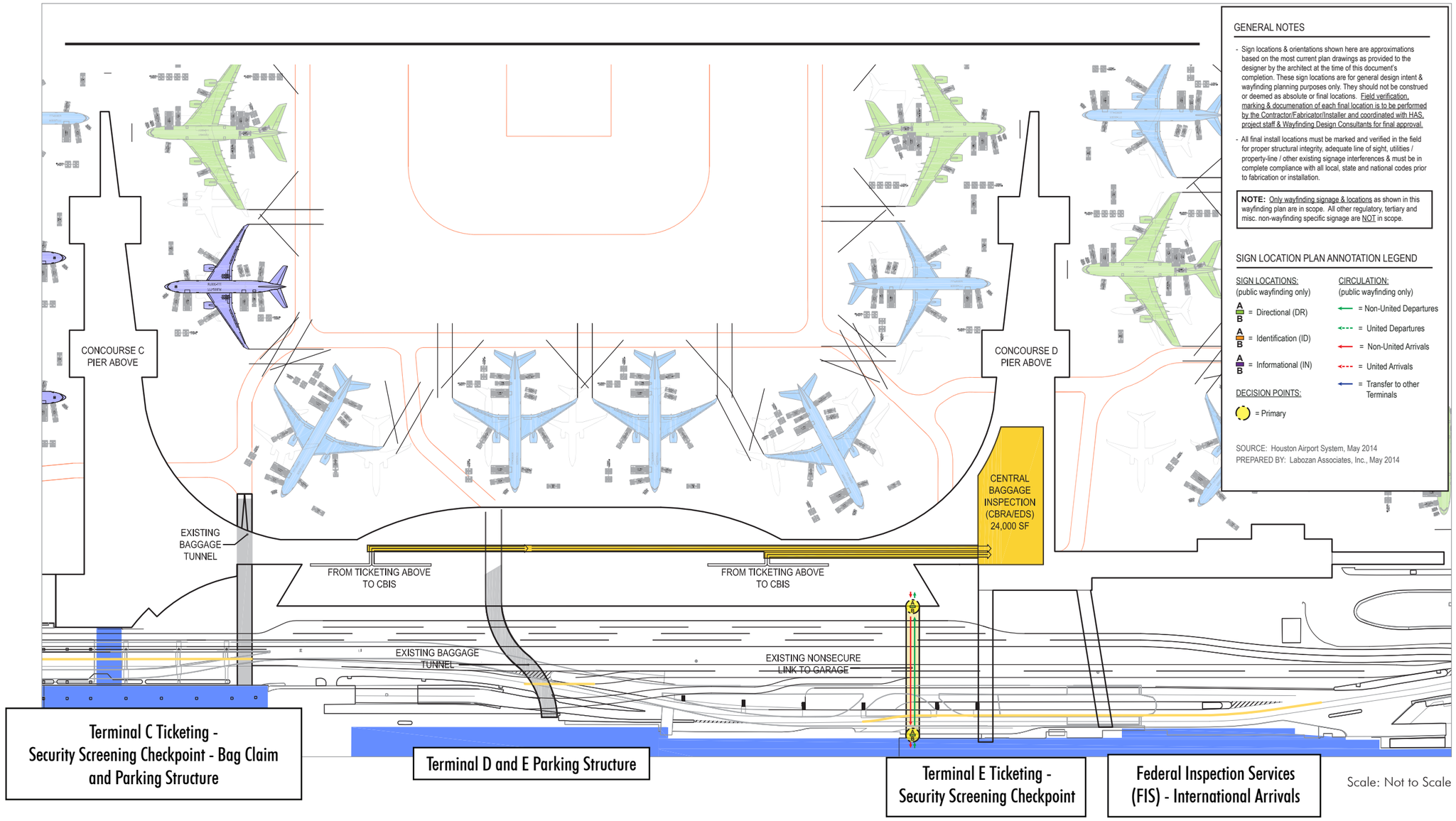
The following are initial recommendations for an effective transitional Wayfinding Signage System:

- A stand-alone or supplemental graphic/wayfinding "roll-out" campaign
- Emphasis on highly visible transitional signage that matches the general design, graphic content and aesthetics of the final permanent signage
- Fabrication, installation and revision time = very fast/expedited
- Allows for easy on-site and "on-the-fly" revisions and sign adjustments
- Will educate users with the new wayfinding program's graphics, shapes, terminology, etc.
- Will allow time to properly study, evaluate & address the most effective permanent wayfinding signage locations and solutions, while not compromising passenger circulation efficiency
- Fabrication considerations:
  - o Constructed of low-cost materials to last the duration of the transitional period
  - o Light-weight inexpensive sign face/background materials
    - Gator-Foam, Sintra, MDO plywood, etc
    - Graphics = 1st surface applied digitally cut vinyl, or full-bleed graphics printed on surface applied vinyl
  - o Temporary printed sign face cover-wraps to cover permanent signage with transitional messaging/graphics during fluctuating conditions
    - Banner materials
    - Over-the-face "wrapped" configurations with temporary printed messaging on temporary materials; removed when transitional conditions end
  - o Temporary surface applied vinyl "super-graphics"
    - Draw additional attention to important vertical and/or horizontal travel areas and destinations; to be seen from greater distances for earlier traffic queuing
  - o Freestanding moveable sign base systems
    - Gator Foam with aluminum clamp bases
    - Pre-fabricated (aka "off-the-shelf") units with slide-in graphic panel areas
    - Transitional implementation phasing based on Mickey Leland International Terminal program scheduling (TBD)

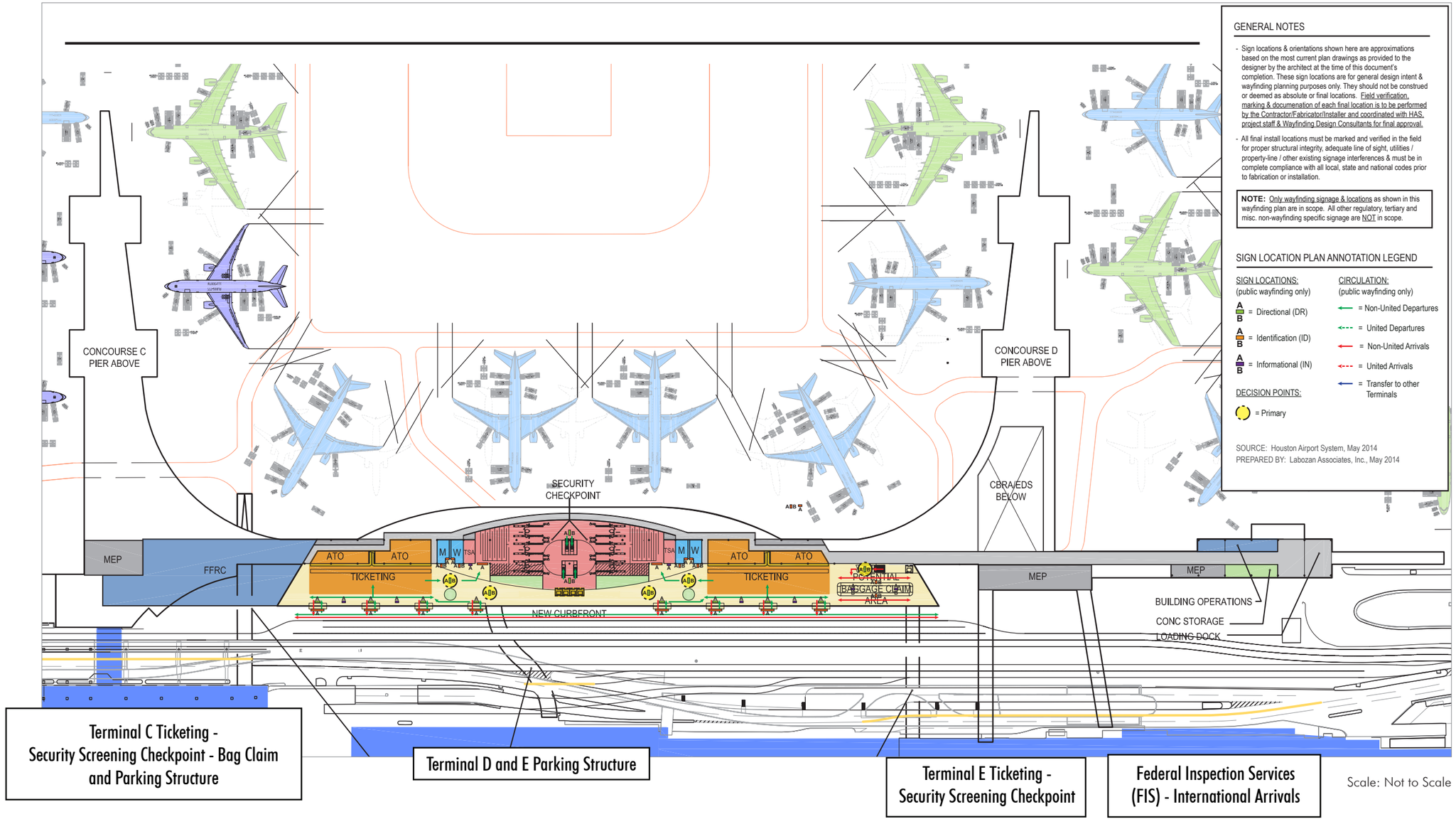
6.4.5.9 Final Wayfinding Plans and Signage Design Intent

The wayfinding plans shown in this chapter are conceptual only and are based on the most recent files as provided by the Project Team to LAI at time of this PDM document's publication. The sign family shown in this chapter is also conceptual and may require further refinement and/or additional sign types as deemed necessary during future design development processes. Final wayfinding plans, sign location plans and signage design intent drawings will be further developed and refined during each phase of the MLIT program.

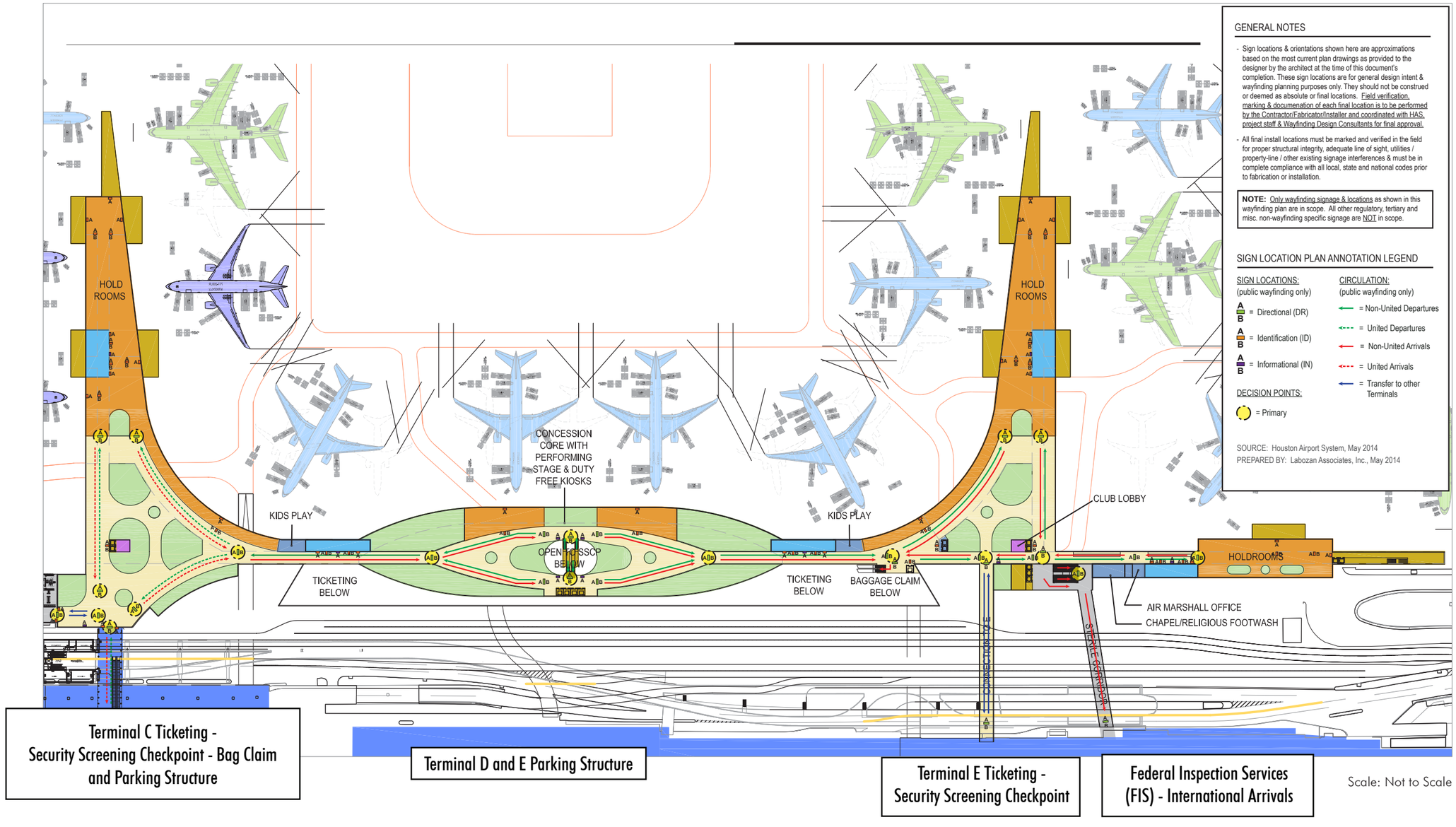
Wayfinding Plan Baggage Level



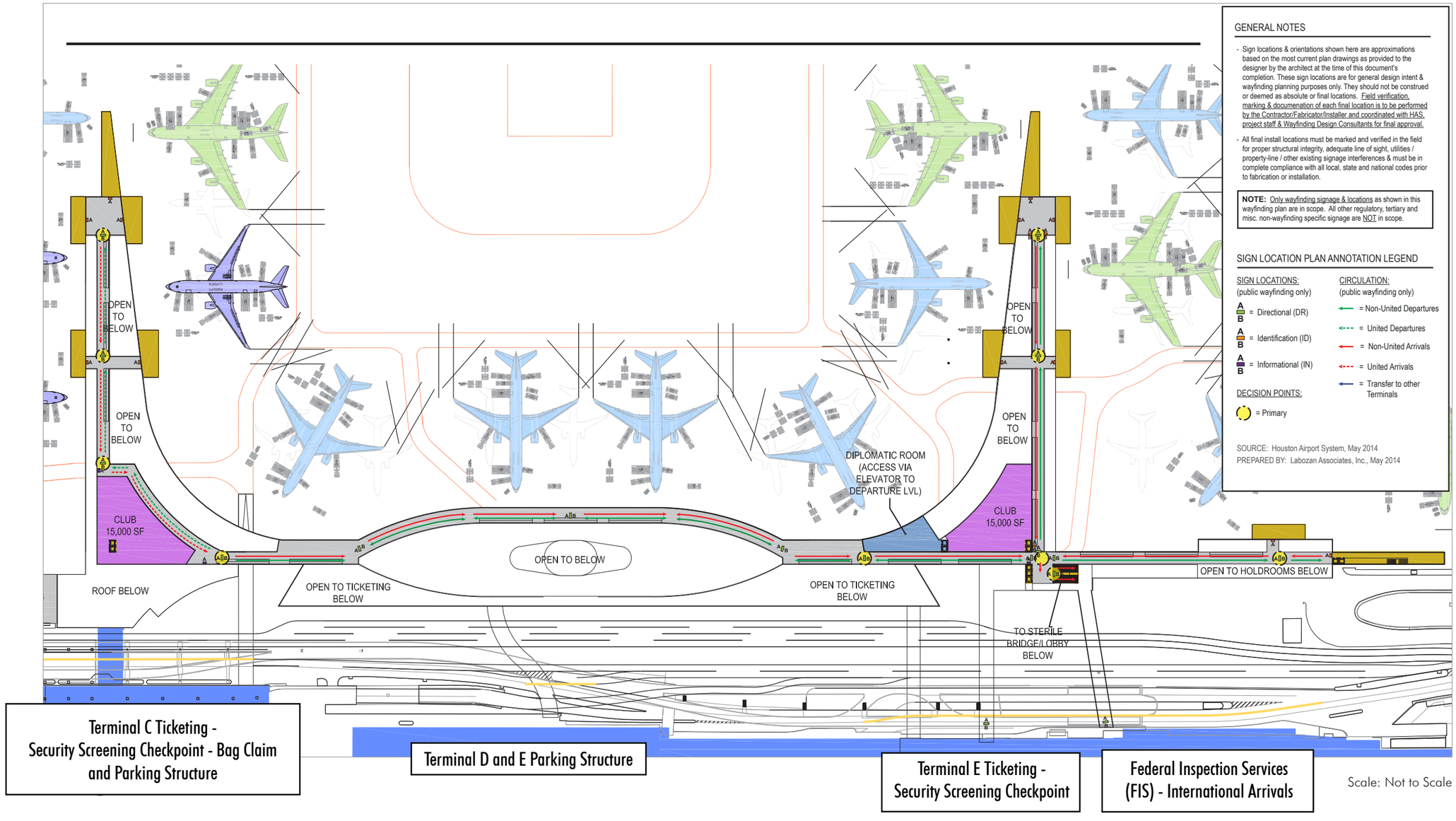
Wayfinding Plan Ticketing Level



Wayfinding Plan Departures Level



Wayfinding Plan Club Level



6.5 Best Practices/Sustainability

The Houston Airport System is proud of having achieved significant environmental sustainability goals and intends to incorporate sustainability procedures and practices in all areas of HAS operations. The Terminals D1/D2 Project provides a unique opportunity to include sustainability procedures and practices in planning, design, construction, and operation and maintenance phases of each project. These will be evaluated right from the start rather than as an afterthought when each phase of each project has almost been completed. Current sustainability practices applicable to each phase of the program include

- Leadership in Energy and Environmental Design (LEED)
- Envision rating systems expertise
- CenterPoint Energy rebate programs
- Economical renewable energy strategies
- Building commissioning services
- Monitoring and Verification (M&V)

HAS understands the value of life cycle costs and the trade-offs between construction budget reductions at the expense of operations and maintenance.

Design criteria, for "Sustainability Best Practices (SBP)," include the following:
(1) SBPs will be implemented to the maximum, cost effective extent possible during design, construction, and post-construction phases.
(2) The SBP short list will be measured in a balanced scorecard approach, utilizing ACI-NA recognized criteria, which includes the Economic Impact, Operational Impact, Natural Resources Impact, and Societal Impact (EONS).
(3) The MLIT will be designed and constructed in consideration of the guidelines provided by ACRP Report 42 (Sustainable Construction Practices), ACRP Synthesis 10, and ACRP Synthesis 21, in addition to other recognized industry guidelines.
(4) Third party, independent, commissioning meeting LEED NC enhanced and fundamental commissioning standards of building and utilities systems will be performed prior to receiving a Certificate of Occupancy.

Best practices in sustainability include:

- **Renewable Energy:** Increase generation of electricity from renewable resources.
  Texas established its Renewable Portfolio Standards (RPS) as part of the legislature's restructuring of the state's electricity market in 1999. In August 2005, Senate Bill 20 (S.B. 20) increased the renewable-energy mandate to 5,880 MW by 2015 (about 5% of the state's electricity demand), including a target of 500 MW of renewable-energy capacity from resources other than wind. Wind accounts for nearly all of the current renewable-energy generation in Texas. S.B. 20 also set a target of reaching 10,000 MW of renewable energy capacity by 2025. Texas has done the most of any state with its RPS and has rapidly outpaced its original goals. The state has added 4,268 MW of wind power since 2001. Not only is that more than any other state (California is a distant second with 2,376 MW), it is more than in any other country except Germany, Spain, and India. Other than wind, renewable energy opportunities to consider for IAH include solar, biomass, landfill gas, and municipal solid waste.

- **Energy Conservation:** Improve energy conservation.
  The Public Utility Commission is heading down a path to increased electricity costs for most of Texas. In February of 2011, a combination of bitterly cold weather and generator shutdowns led to a sudden shortage of electricity in the power grid supervised by the Energy Reliability Council of Texas, which covers most of the state. The shortage led to "load shedding" (rolling blackouts) across the grid. Texas Building Energy Performance Standards follow ASHRAE 90.1, which require major facility projects in the state to be constructed to "high energy efficiency standards" in order to reduce energy use. CenterPoint Energy Company has Energy Rebate Programs that need to be reviewed for application to the terminal project. For terminal buildings, energy savings may be realized through efficient lighting, lighting controls, single duct variable air volume systems in customer lobbies and office space, low emissivity glass, energy efficient equipment, and sustainable operating strategies

- **Self-Generation Opportunities:** Review self-generation opportunities.
  Utility Companies in Texas are required to disclose their fuel sources and adopt net metering to credit customers' utility bills for electricity they provide to the grid from renewable sources. Review self-generation opportunities including cogeneration systems that use digester gas from waste water treatment plants or landfills, and solar PV arrays to determine if these options are attractive, including third party investment strategies.

- **Demand-Shifting Strategies:** Plan for demand-shifting strategies.
  Electricity generation costs in Texas are going up. Thermal Energy Storage is a demand shift strategy that benefits from "time-of-day" strategies covered in ASHRAE 90.1. Strategies like thermal energy storage systems, power shedding controls, and optimum chiller operation are strategies to shift on-peak demand charges to save costs.

- **Greenhouse Gas Reduction:** Reduce GHGs.
  Senate Bill 184 established a report to determine, "No Regrets" Greenhouse Gas Emissions Reduction Strategies for the State of Texas. Several GHG emissions reduction strategies were developed or both stationary and mobile sources. Look for ways to increase energy efficiency and reduce emissions during construction and operation of the Terminal project.

- **Waste to Energy Strategies:** Look for waste to energy opportunities.
  Waste to Energy strategies in Texas include municipal solid waste, anaerobic digestion and biogas (landfill gas). Generation from those sources contributes only minimally to the electricity grid. Consider opportunities regarding a waste water treatment plant or landfill to clean up digester gas or landfill gas to pipeline quality to receive carbon offset credits at the airport.

- **Recycling:** Improve recycling.
  Look for ways to enhance the recycling program at HAS including composting carbon waste and recycling paper, glass and metals for revenue based recycled scrap.

- **Grant Funding:** Obtain available Grant Funding.
  Look for available grant funding to support sustainable projects for the terminal.

6.5.1 Sustainability Regulations

Just as the understanding of the interconnections between economic, social and environmental aspects of sustainability drives successful projects so does the application of sustainability regulations. Several sustainability requirements have been incorporated into the relevant Houston Codes for renovation or construction of non-residential buildings. A listing of such codes is summarized for buildings similar to the MLIT Project at the end of this section.

LEED requirements for New Construction and Major Renovation projects address design and construction activities for both new buildings and major renovations of existing buildings. This includes major HVAC improvements, significant building envelope modifications and major interior rehabilitation.In addition, there are several LEED certified airport terminal buildings to review as case studies including two of the most recent U.S. examples being Terminal 2 West (SAN) and Bradley-West (LAX). LEED criteria are best suited for projects involving buildings.

Infrastructure projects, including roads, bridges, airports, etc. do not fit easily into the LEED program. The Envision rating system was created to better evaluate these infrastructure projects. Harvard researched over 120 different sustainable rating systems in practice worldwide as part of the Zofnass research program which is now the research group for Envision. A select few of the more familiar and widely used rating systems were analyzed including LEED (US based – Leadership in Energy & Environmental Design), CASBEE (Japan based - Comprehensive Assessment for Building Environmental Efficiency), Cascadia (Pacific Northwest based - the Living Building Challenge/Net Zero Energy Goal), Green Globes (Non-profit Worldwide Organization - Green Building Initiative), BREEAM (UK based - Building Research Establishment's Environmental Assessment Method) and CEEQUAL (UK based - Civil Engineering Environmental Quality & Award). This analysis provided a rich source of research material and a great perspective and context in thought leadership, regarding sustainability, across the planet.

Harvard, the International Sustainability Institute (ISI) and Sustainable Infrastructure Advistory Board (SIAB) members built upon the Zofnass research to develop the Envision rating system. The intent of the rating system is to be able to assess the sustainability of a project over its entire life-cycle, from the "evaluate need" phase, where project alternatives are examined, through design, construction, commissioning, operations and finally to rehabilitation and decommissioning. At each phase, the impact on sustainability is quantified, compared with national standards, local context, and benchmark projects, supporting more efficient decision-making.

The structure of Envision includes multiple credits under the umbrellas of five primary areas of analysis, including the impact of an infrastructure project on Leadership, Climate Change, Resource Allocation, the Natural World, and Quality of Life. The categories are described as follows:

Effective Leadership helps drive successful sustainable projects using a new way of thinking about how projects are developed and delivered. Project teams are most successful if they communicate and collaborate with other team members early in the project, involve a wide variety of people in creating ideas for the project, and understand the long-term holistic view of the project and its life cycle. This category encourages and rewards these actions under the view that together with traditional sustainability actions, such as reducing energy and water use, effective and collaborative leadership produces a sustainable project that contributes positively to the world around it.

Climate Change is the top issue facing the globe today, but today's decision making methodology does not adequately address it. Decisions are driven by economic and social considerations without adequate consideration of their impacts on greenhouse gas emissions. Addressing climate change includes mitigation and adaptation. However, adaptation may prove too expensive. Metrics for measuring mitigation and adaptation are total greenhouse gas emissions in CO2e generated over the full lifecycle of each project and the ability of a project to cope with stresses beyond a normal design basis (flooding, structural loading, temperature fluctuations, etc.)

Resource Allocation deals with the optimal allocation of resources that has the least impact on the current environment and resource availability and maximizes the potential of future generations to have access to the resources they will need. The subcategories within Resource Allocation are materials, energy, and water. Life-cycle assessment is an accounting tool used to track, quantify, and summarize environmental and social impacts of resource-use by products over their entire supply chain.

Natural World deals with the impacts of people on nature. Landscape ecology, with its emphasis on how spatial patterns impact the movement of materials, energy, water, and animals across the landscape, is the ideal foundation for this category. Negative impacts of people on nature include polluting, and degrading the landscape. The orthogonal, planned patterns of design are very different from the irregular, finely textured, fractal, and meandering patterns of nature that are the result of non-random natural processes. Road ecology is an example of applying a landscape ecology perspective to infrastructure.

Quality of Life principles include doing no harm, being nurturing, and being enduring. Existing guidelines (such as the Endangered Species Act) include aspects of Quality of Life but are inadequate to address its complete scope. New quantitative techniques are emerging to measure the impact of infrastructure on the quality of life of residents, but these tools still fall short in addressing the full scope of quality of life. Health impacts can be quantified, but fully accounting for the intrinsic value of nature is beyond the ability of tools today. Development patterns, roads, airports, and power plants impact quality of life. Congestion, noise, and pollution create negative health impacts. Over-consumption works against this category. Using less has economic and environmental benefits.

A partial listing of applicable codes, rating systems and standards include:

- LEED for New Construction & Major Renovations
- Envision Rating System
- Sustainability Plan for the City of San Francisco
- City & County of Houston Building Codes International Building Codes (IBC, IFPC, IPC, IMC, IEEC)

- NEC
- NFPA
- ASHRAE 90.1

6.5.2 Comprehensive List of International Rating Systems

Common Systems
ENVISION
BREEAM CASBEE CEEQUAL GB Tool
Green Globes
LEED
RMI

U.S. Government Initiatives & Guidelines
California Integrated Waste Management Board - Green Building Program
Collaborative for High Performance Schools (CHPS) Database of State Incentives for Renewables & Efficiency
Chicago Department of Aviation Sustainable Airport Manual
Federal Energy Management Program - Greening Initiatives/Tools
Federal Greening Toolkit
Field Guide to Sustainable Construction
Green Buildings BC Greening Federal Facilities
Maryland Environmental Design Program Minnesota Sustainable Design Guide National Renewable Energy Laboratory New Jersey Clean Energy Program
New York State Energy Research & Development Authority (NYSERDA) New York State Green Building Tax Incentive Initiative
OECD Project on Sustainable Buildings
Oregon Department of Energy
Pennsylvania Buildings - Governor's Green Government Council
Performance Contracting Legislation by State
U.S. Air Force Environmentally Responsible Facilities Guide
U.S. DOE and U.S. EPA -- Energy Star Program
U.S. DOE Building Technologies Program
U.S. DOE Energy Efficiency and Renewable Energy (EERE)
U.S. DOE High Performance Commercial Buildings: A Technology Roadmap
U.S. EPA's Environmentally Preferable Purchasing (EPP) U.S. GSA - Great Lakes Region - Build Green
U.S. GSA Sustainable Design and LEED
U.S. National Park Service - Guiding Principles of Sustainable Design
U.S. Naval Facilities Engineering Command - Design Policy
Whole Building Design Guide

Life Cycle Analysis & Costing Products
ATHENA Sustainable Materials Institute
BEES (Building for Environmental and Economic Sustainability) [NIST] BuildingGreen.com - Life Cycle Assessment
California Life Cycle Cost Assessment Model
Cradle to Cradle
ENVEST (environmental impact estimating design software) [UK BRE] GREENGUARD Environmental Institute
LCA Center
Life Cycle Analysis of Wood Products LISA (LCA in Sustainable Architecture) MBDC
UNEP SBCI (Sustainable Buildings & Construction Initiative)

Sustainability Principles
Biomimicry Principles
Charter of Rights and Responsibilities for the Environment
Deep Ecology Principles
ICC Charter and ISO 14000
International Council of Local Environmental Initiatives Ontario Round Table on Environment and Ecology (ORTEE)
Permaculture Principles
The CERES Principles
The Earth Charter
The Five Principles of Ecological Design
The Hannover Principles The Houston Principles The Natural Step
The Netherlands National Environmental Policy Plan (NEPP) The Precautionary Principle
The Sanborn Principles

6.5.3 Technical Sustainability Tools

Life Cycle costing (LCC) analysis is key to sustainable design. The approach that follows is suggested for the MLIT project.

Performing Life Cycle Assessments:
LCC is a decision tool used to evaluate building or improvement alternatives that incorporates initial capital outlay and future costs. Alternative results are compared to a baseline design or a current condition. LCC can be as simple as a capital cost estimate compared to future cost savings, often referred to as simple payback. The simple payback method is commonly used for small investments so clearly economical that more detailed LCC is not worth analyzing. More commonly, sophisticated clients prefer to review all capital and future recurring costs and will make their decisions based on the sensitivities of the many assumptions needed to perform the analysis.

The LCC summary for each alternative is often presented as a reflection of net present value of future cash flows (NPV). NPV reflects the value of proceeds (benefits) less the present value of capital outlays (costs). Using a common LCC approach, a variety of alternatives can be considered, costs can be prioritized, and benefits optimized using regression tools.

Every member of a project team has a different bias. LCC changes these biases with emphasis by working for the lowest long term cost of ownership.

Consider these perspectives on many projects:
- Project Managers and estimators want to reduce capital costs as the only criteria
- Facilities Engineers want to minimize repair as the only criteria
- Users want to maximize uptime hours and avoid failures
- CFO wants to maximize project net present value as the only criteria
- Shareholders want to increase wealth as the only criteria

The best sustainable approach looks to harmonize these biases by looking for the lowest long term cost of ownership. LCC focuses on facts, money, and time. There is no single method for conducting LCC. Organizations have the flexibility to implement LCC as established in International Standard ISO15686, in accordance with the intended application and the requirements of the organization. LCC is different from many other techniques such as environmental performance evaluation, environmental impact assessment life cycle analysis (LCA), and risk assessment. Why is LCC different from Life Cycle Cost Analysis? These techniques seek to evaluate the triple bottom line of alternative design and construction approaches.

Approach: Evaluating short term and long term costs requires steps that can be broken down into more detail as the complexity and size of investment grows.

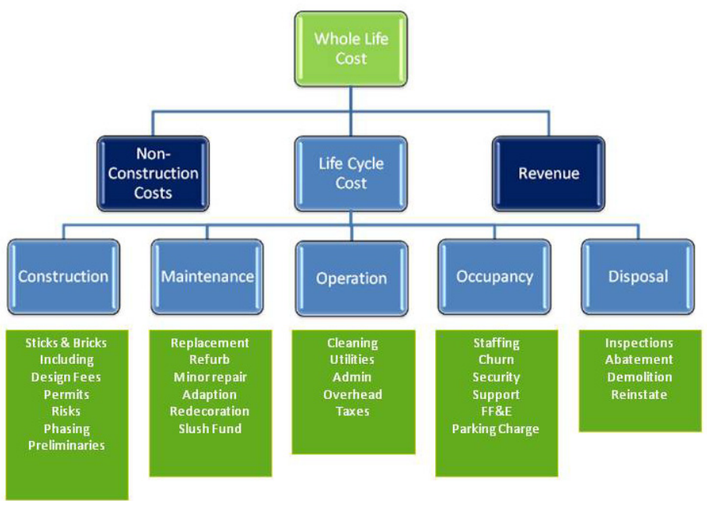
Definition: Work with the team to identify the recommended analysis approach. Agree on the appropriate financial criteria, the numbers of alternatives, and the study life period prior to starting the analysis.

Analysis: Coordinate and assess the initial capital costs, recurring capital costs, and ongoing maintenance or energy costs through the life of the study. This stage is often called "brainstorming" because of alternatives generated and the need to avoid making recommendations. Often synergies are developed where one alternative affects others.

In the simplest sense, the LCC can be conducted on building elements, energy saving alternatives, or entire building systems. Most studies conducted are for two to three alternatives for four to five major building systems. LEED studies consider all initiatives required to achieve a level of certification, but there are many overlaps in building systems that make this task less intuitive to analyze.

Scope, Risk and Uncertainty: Figure 6.28 identifies the possible elements of life cycle costing. Any or all can be incorporated, depending upon the level of complexity and detail needed.

Figure 6.28 – Elements of Life Cycle Costing



Risks of cost variation are most certain because of the numerous assumptions that need to be made during the course of a study. One of the most critical risks, linked to each listed below, results from the human nature of modifying the plan data to suit a predicted outcome.

- CapEx – design incomplete
- OpEx – variable
- Inflation - %
- Obsolescence
- Plan ≠ Actual
- Quality of data
- Lifetime – how long?
- Discount Rate - %

Reporting: Produce the results and recommendations in a simple graphic summarizing cost and benefits for all alternatives. Impact assessment statements should include the implications to incorporating the recommendations. Sensitivities can be run on the many assumptions that need to be made in order to calculate the LCC.

6.5.4 Energy

Energy conservation and renewable energy are keys to sustainable design. Consider the following steps when designing MLIT.

1) **Expand Energy Efficiency**
   Meet the requirements of ASHRAE 90.1-2013 Energy Standard for Buildings. New requirements in 2013 include:
   - Revised, stricter opaque element and fenestration requirements at a reasonable level of cost-effectiveness
   - Improvements to daylighting controls, space-by-space lighting power density limits, and thresholds for top lighting
   - Revised equipment efficiencies for heat pumps, packaged terminal air conditioners (PTACs), single package vertical heat pumps and air conditioners (SPVHP and SPVAC), and evaporative condensers
   - Improved equipment efficiencies and controls for chillers
   - Improved controls for heat rejection and boiler equipment
   - Improved requirements for expanded use of energy recovery, small-motor efficiencies, and fan power control and credits
   - Clarifications for the use of prescriptive provisions when performing building energy use modeling, and revisions to enhance capturing daylighting when performing modeling calculations

2) **Optimizing the Design of the HVAC Systems**
   Design HVAC systems that are appropriately sized for the loads. Include control schemes to set back temperatures during unoccupied time periods along with optimizing the use of the most energy efficient equipment.

3) **Maximizing the Generation of Renewable Energy**
   Look for opportunities for the utility company to incentivize renewable energy systems on the project. In addition, consider third party Buy-Own-Operate-Maintain strategies for installing large Solar PV arrays.

4) **Designing Highly Energy Efficient or Zero Net Energy Buildings**
   Review ASHRAE standards for High Performance Building Design.

5) **Specifying Future-Looking Building Automation Technology**
   The key to long lasting energy conservation is to maintain the building operations at the commissioned level. Many buildings let the HVAC systems drift out of tolerance over time which can waste up to 3% of the system energy per year. Building Automation Systems (BAS) need to include metering and verification technology to help operators recognize when key parameters run outside of commissioned set points. Sub-

meters can track real time energy and demand usage on HVAC equipment. The BAS needs energy trending dash boards to show energy consumption in real time and contrast the data with the commissioned benchmarked data. This information will help establish "demand-shift" strategies to reduce electric bills. HAS can contract the monitoring service remotely or do it in-house. The key is to define the project M&V plan early in the design in order to include key meters and software in the project so energy consumption can be tracked when needed. Meters and instrumentation will need to be maintained within accepted tolerances in order to provide accurate feedback on energy usage.

6.5.5 Project Specific Design Strategies for MLIT

The following specific items will be evaluated during the project design to further the project's sustainability goals:

1. Highly efficient insulated building skin
2. Enhanced windows with shading and glazing
3. Reflective (cool) roofs
4. Consideration should be given to the benefits of Green Vegetation (Green Roof).
5. Energy metering at CenterPoint Energy's 34.5 kV/12.5 kV Substation for comparison with electrical bills from Reliance Energy.
6. Sub-metering at terminal buildings and tenants
7. Supervisory Control and Data Acquisition (SCADA) system
8. Efficient light fixtures, including LEDs
9. Daylighting
10. Lighting controls (such as timers, photo sensors, motion, and occupancy sensors, etc.)
11. Building Automation Systems to control and monitor HVAC and lighting systems:
    - More precise DDC control of pumps and fans to match demands
    - Improved outside air quantity control
    - Improved lighting controls and use of daylighting to reduce power consumption
12. Measurement & Verification (M&V) program to maintain HVAC, Building Management, and Lighting Control systems as commissioned in the future years
13. Variable Frequency Drives (VFDs) on pump and fan systems.
14. Increased differential temperatures for chilled water in AHUs.
15. Run CUP Chillers in parallel during normal operating hours and in series during peak demand. Running in series will increase differentials between chilled water supply and return temperatures and improve overall system efficiency by:
    - Older chiller efficiency increases because they get warmer chilled water return (56 degrees Fahrenheit to 59 degrees Fahrenheit) and cool it down 10 degrees Fahrenheit.
    - New chiller efficiency is realized because they take older chiller supply temperature (46 degrees Fahrenheit to 49 degrees Fahrenheit) and cool it down to 39 degrees Fahrenheit for distribution.
    - More cooling effect can be distributed in existing pipe network because differential temperature is now 17 degrees Fahrenheit to 20 degrees Fahrenheit (versus 12 degrees Fahrenheit). The higher delta T allows for the increased cooling with the same chilled water flow rate.
    - AHU coils will be upsized in Terminal D to account for the higher delta-T
16. Indoor chemical and pollutant source control
17. Indoor air quality management plan
18. Electrical charging stations for aircraft ground service equipment
19. Highly efficient baggage systems
20. Powered and preconditioned air at jet gates
21. Low-flow water fixtures
22. Low-water use landscaping
23. Use of alternative fuel vehicles during construction
24. Program to maximize recycling of on-site construction waste
25. Chilled Beam does not work in a positive pressure ventilation system. Airport terminals must maintain a positive pressure to prevent undesirable outdoor aircraft emissions from migrating into the space. In addition, atmospheric water vapor often condenses on chilled beams causing dripping when they operate in humid climates
26. Displacement ventilation involves supplying conditioned air into a space near the floor and exhausting from the ceiling. The supply airflows can be reduced as they only need to cool the occupied zone. Air temperatures rise as they move to the ceiling. Displacement ventilation does not work well for airport terminals due to the varied mix of occupancies. Supply and exhaust needed for passenger ticketing, security, baggage handling, concessions, and boarding

DEMAND RESPONSE CONSIDERATIONS

IAH is served by CenterPoint Energy Company. They currently supply power to IAH as part of a COH flat rate agreement. No demand or time of day charge is provided in the current rate structure.

1. Cogeneration:
    - Flat electrical rate does not help self-generation, economics.
    - IAH is in a non-attainment pollutant zone, which does not help self-generation using fossil fuels.
    - All the power must be consumed at IAH in order to optimize economics. This requires additional electrical distribution costs.
2. Thermal Energy Storage: No demand charge in the current electric rate which renders TES solutions not economical.
3. Battery Storage: Consider battery storage if self-generation systems are realized. Battery storage to help consume all self-generated power at the airport and provide demand response to shave peak demand time periods.
4. Network Station: Consider feeder switching station (receiving/distribution station) to receive power from CenterPoint and self-generated systems (Cogen, Renewables) to improve reliability through multiple feeder switching capability and to consume all self-generated power at the airport.

DISTRIBUTED FORMS OF GENERATION CONSIDERATIONS (Including on-site solar and geothermal heat)

1. Geothermal (Ground Source Heat Pumps): Heat pump technology is inadequate to meet peak cooling and heating demands at IAH. Supplemental systems must be added including electric resistive heating, remote boilers, and chillers. Large horizontal closed loop underground piping or Injection wells are needed. Lack of space to install the piping/injection wells is a problem.
2. Solar PV: The PUC is currently considering a rulemaking that would finally implement a provision of the RPS that would require that 500 MWs be generated by renewable resources other than wind, such as solar and geothermal power. Without a RPS provision for Solar PV or Geothermal, these technologies will be difficult to economically justify.

Chapter 7 | Program Phasing

7.0 PROGRAM PHASING: Phase Zero

This chapter outlines the process for the construction of the new Mickey Leland International Terminal (MLIT). **Figure 7.0.1** shows the existing conditions of Terminal C North and Terminal D. The program would be broken up into four phases that would span approximately six years from the initial start of design to the full build-out of the new MLIT. The program phasing was developed with the assumption that the delivery method would not be the traditional Design-Bid-Build but rather Construction Manager (CM) at Risk. The rationale behind this recommended delivery approach is the ability to design and implement enabling projects during the anticipated two-year design period for the entire program. The four major phases are:

- Phase 0: Terminal B North Pier (Not in MLIT Contract)
- Phase 1: Enabling Projects
- Phase 2: Pier D1 and Central Terminal
- Phase 3: Pier D2
- Phase 4: Terminal D East Gates

Figure 7.0.2 provides a summary of the phasing.

Note: It is the owner's intent to coordinate with design firms/contractors and provide project logistical support, such as Air Operations Area (AOA)/Non-AOA construction fencing, locations of haul routes, and other special considerations that need to be considered when working in an airport environment.

Note: It is the owner's intent to provide a consolidated and centralized office facility and support for consulting teams and contractor principals.

A key component of the phasing of the new MLIT is the construction of the new Terminal B North pier (**Figure 7.0.3**). This project is being completed by United Airlines and is not in the contract of the MLIT project; however, its' completion is critical to the MLIT phasing plan. At the completion of the Terminal B North Pier, United Airlines will vacate the Terminal B North Pier, which will provide the flexibility to move forward with the construction of the MLIT. Utility enabling projects have been identified that provide mutual benefit between the United Airlines Terminal B North and the Houston Airport System (HAS) MLIT projects. These projects are summarized below and expanded upon in the following sections:

- Utility Corridor
- Chilled Water
- Hot Water
- Domestic Water
- Natural Gas
- Fire Suppression
- 12.5 kV Site Power
- Hydrant Fuel System

7.0.1 Terminal MEP Systems

Several utilities are planned to be organized in a Utility Corridor that parallels the south edge of the terminals. The utility corridor provides a pathway for chilled water, heating water, potable water, fire protection water, electrical conduit, and communications cable tray. The utility corridor will provide access for operation and maintenance staff to the various system piping, valves, fiber, and conduit that runs the length of the new terminal buildings. At designated points the required service will branch off into the building and run to mechanical, electrical, and communication rooms.

The Utility Corridor will be a box culvert, cut and cover construction. It will be built in phases. Each phase will align with the needs of each terminal and include provisions to expand to serve future terminal building construction throughout the central terminal area.

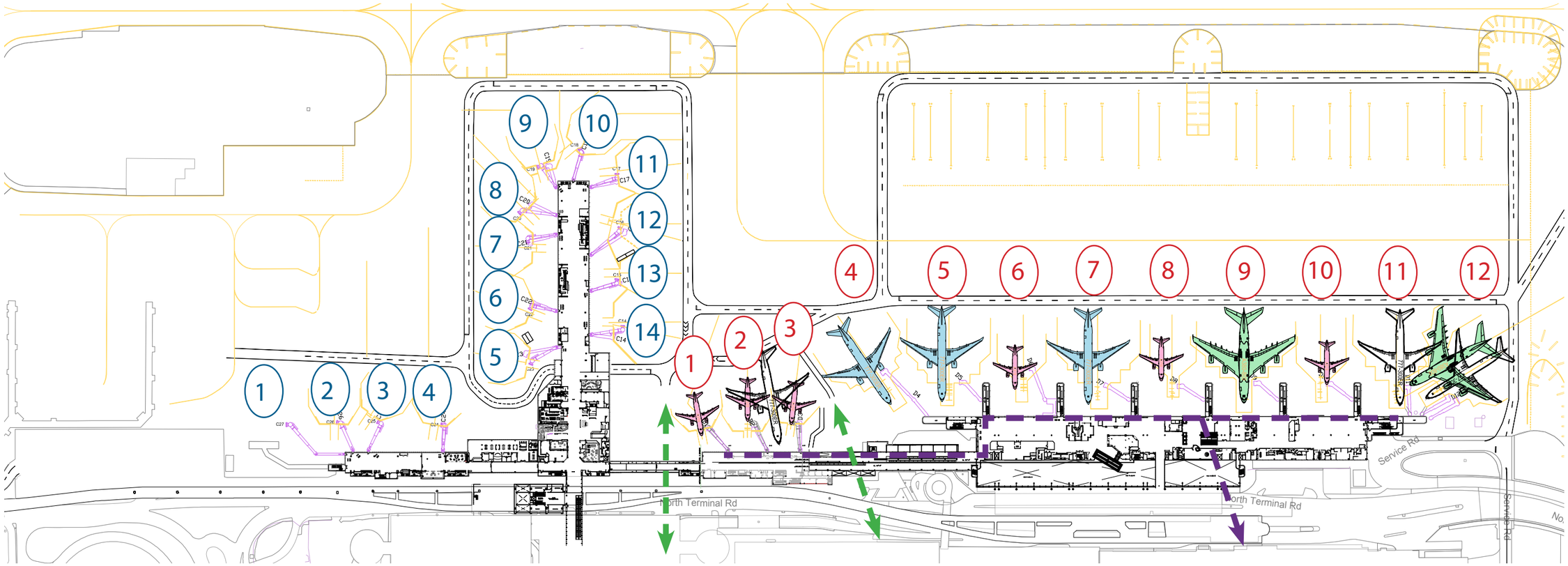
7.0.1.1 Chilled Water System

The existing Terminal C North is provided chilled water from a pump room located in the Terminal C Core building. Following removal of Terminal C North, this pump room will remain in place and continue to serve the Terminal C Core and Terminal C South. Chilled water will be supplied from the central distribution system to a new pump room located in Terminal D1. Chilled water will be provided from parallel distribution headers located in the ITT tunnel. Additionally, the existing distribution piping serving the existing Terminal D will connect to the new Terminal D1 pump room. This will provide a level of redundancy on the distribution side of the chilled water loop. The new pumps will be sized to supply secondary chilled water pumping capacity to feed the new Terminal D1 and Terminal D2. Furthermore, the pump room will be tied back to the existing Terminal C Core building pump room for an added level of redundancy.

7.0.1.2 Hot Water System

The existing Terminal C North is provided hot water from a pump room located in the Terminal C Core building. Following removal of Terminal C North, this pump room will remain in place and continue to serve the Terminal C Core and Terminal C South. Hot water will be supplied from the central distribution system to a new pump room located in Terminal D1. Heat exchangers in the pump will decouple the Central Distribution System from the terminal side loop. Hot water supply temperatures from the central utility plant will vary seasonally from 200 degrees Fahrenheit in the winter months to 185 degrees Fahrenheit in the summer months. Similar to the chilled water distribution system, the pump room will receive two full sized feeds from parallel headers located in the ITT tunnel of the Terminal C Core building. Additionally, the existing distribution piping serving the existing Terminal D will connect to the new Terminal D1 pump room. The new heat exchangers will be sized to supply secondary hot water capacity to feed the new Terminal D1 and Terminal D2. Furthermore, the pump room will be tied back to the existing Terminal C Core building pump room for an added level of redundancy.

Phasing - Existing Conditions



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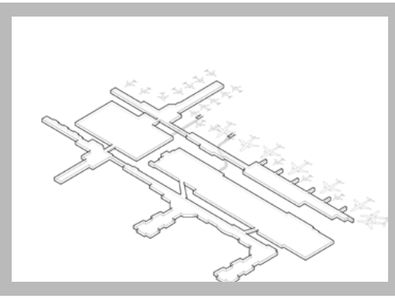


PHASE HIGHLIGHTS:

- CURRENT CONDITIONS REMAIN

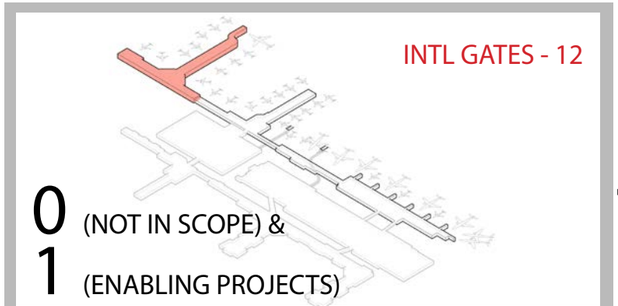
STERILE CORRIDOR

EXISTING TUNNEL OPEN
EX TUNNEL CONSTRAINED

GATES

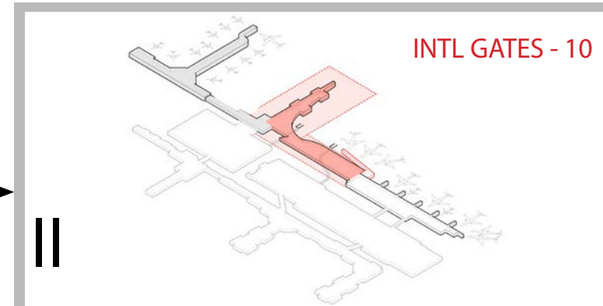
INTL GATES - 12
DOMESTIC - 14

Phasing Summary - Rebuild



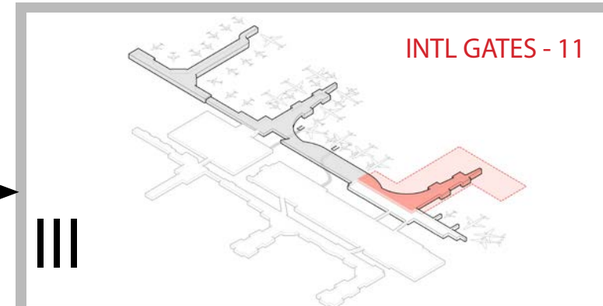
0 (NOT IN SCOPE) &
1 (ENABLING PROJECTS)

- PHASE O -
  - BUILD NEW B-NORTH PIER
- PHASE 1A -
  ENABLING UTILITIES
- PHASE 1B -
  EXISTING EAST BAGGAGE EXPANSION
- PHASE 1C -
  BUILD TEMPORARY JETBRIDGE WALKWAY



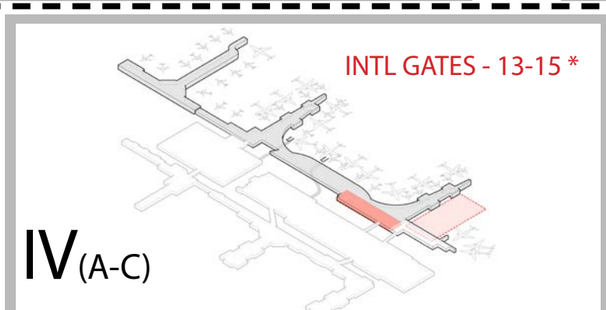
II

- PHASE 2A -
  OPEN NEW B PIER
- PHASE 2B -
  DEMO EXISTING C-PIER &C-CONNECTOR
- PHASE 2C -
  BUILD NEW D1 PIER & CENTRAL CORE



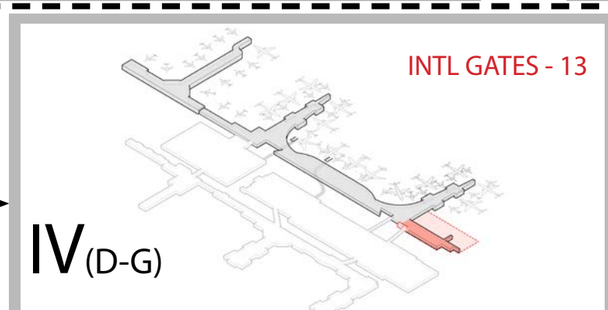
III

- PHASE 3A -
  OPEN NEW D1 PIER, CENTRAL CORE
- PHASE 3B -
  REWORK STERILE CORRIDOR THRU EXISTING D
- PHASE 3C -
  DEMO EXIST. D DEPARTURE LEVEL
- PHASE 3D -
  BUILD NEW D2 PIER



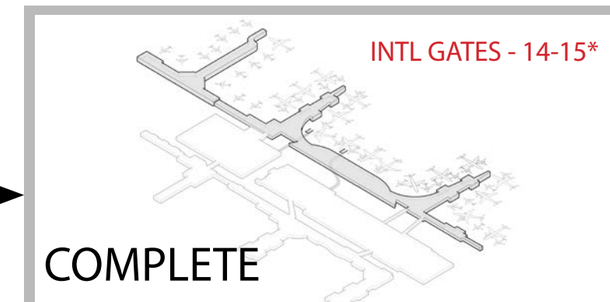
IV(A-C)

- PHASE 4A -
  OPEN D2 PIER (WEST GATES)
- PHASE 4B -
  REBUILD/OPEN D2 PIER EAST APRON
- PHASE 4C -
  DEMO EXIST. EAST LANDSIDE TICKETING



IV(D-G)

- PHASE 4D -
  BUILD TEMPORARY STERILE CONNECTOR WALKWAY
- PHASE 4E-
  OPEN NEW EAST TICKETING LANDSIDE & CURBSIDE
- PHASE 4F -
  DEMO REMAINING EX. D CONC
- PHASE 4G -
  REBUILD FIS BRIDGE & REMAINING GATES

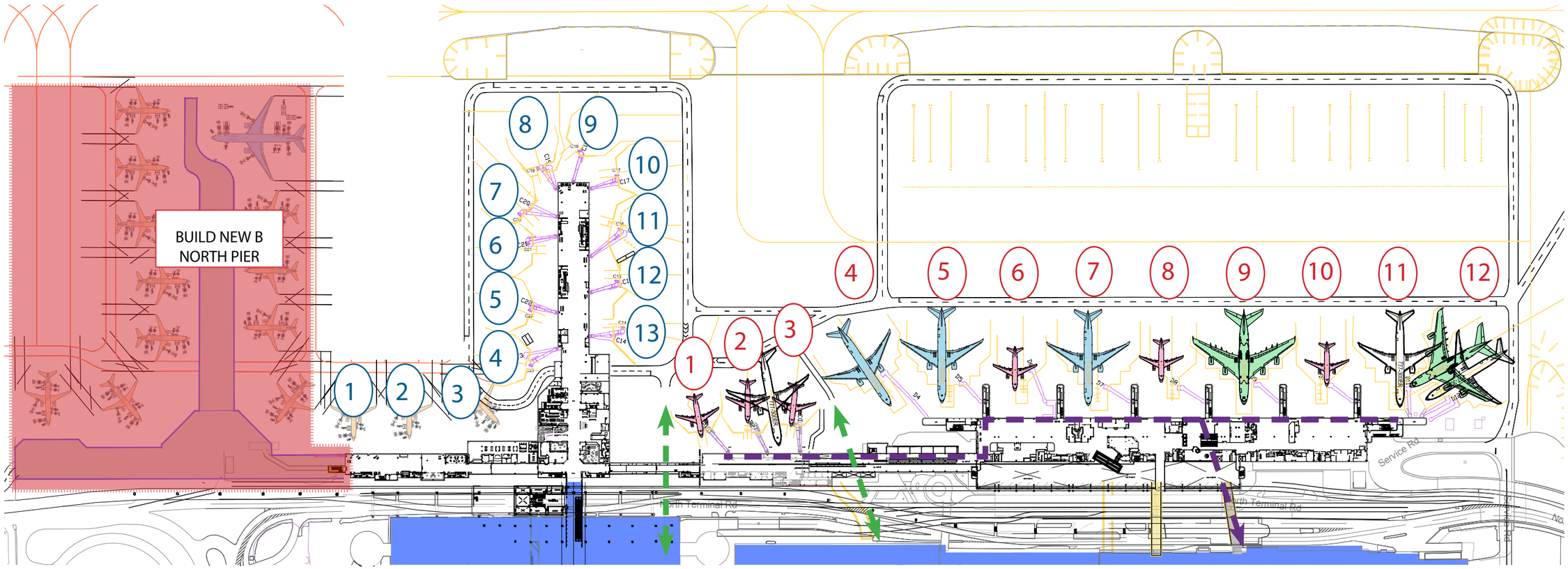


COMPLETE

- OPEN NEW FIS BRIDGE & REMAINING GATES

COMBINED PHASE

Phase 0 (Not in Scope)



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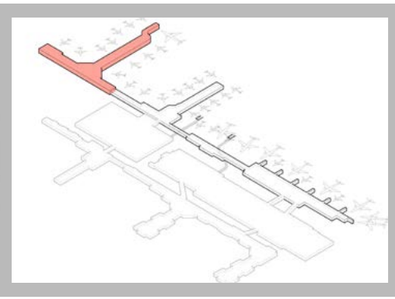


PHASE HIGHLIGHTS:

- BUILD NEW B NORTH PIER

STERILE CORRIDOR

EXISTING TUNNEL OPEN
EX TUNNEL CONSTRAINED

GATES

INTL GATES - 12
DOMESTIC - 13

7.0.1.3 DOMESTIC WATER SYSTEM

Domestic water is planned to enter Terminal B from the combined Domestic Water/Fire Protection (DW/FP) pipe loop in the utility corridor. Domestic water will enter through a HAS owned water sub meter before serving any fixtures inside the terminal. This allows the airport to monitor the terminal to track water usage. Each domestic branch line service may also require a backflow preventer to protect the water loop from potential contamination by the terminal building water service users. The central water storage system will receive water from the City of Houston (COH) 16 inch water line, which is located in North Terminal Road. The COH water line will include a city water meter and backflow preventer.

It is assumed that the combined domestic and fire protection water storage tank/booster pump station will be built in time to serve Terminal B. In addition, the utility corridor will be started with the Terminal B project.

7.0.1.4 Natural Gas

Natural Gas will enter Terminal B through a new gas meter. The meter will be located at the south side of the building. The pipe will tap into the CNP existing natural gas main located in the North Terminal Road. See **Figure 7.0.4**.

7.0.1.5 Fire Suppression

Fire protection water will enter Terminal B from the combined Domestic Water/Fire Protection (DW/FP) pipe loop in the utility corridor. Fire protection water will enter through a reduced pressure backflow preventer. This protects the combined DW/FP water loop in the utility corridor from potential back siphonage of water from the fire protection system. The fire protection water serves a combined fire sprinkler and standpipe system in the terminal.

7.0.2 Site Utilities

New utility demands will be needed to serve the construction of the proposed Terminal B North. This is also the time to construct utility enabling projects needed to support Terminal B North. HAS is interested in centralizing utility infrastructure, where it makes economic sense, to benefit multiple terminal projects. In addition, HAS wants the utility systems to be integrated, across all new projects. Establishing a central electrical substation and a central water storage/booster pump system are two examples that have the potential to benefit the entire North Terminal area including Terminal B and MLIT. In addition, aviation fuel and sanitary sewer are key utility systems that are dependent on each phase of construction in order to meet the needs of Terminal B and MLIT. The airside site utility system limit line between Terminal B North and MLIT is illustrated in **Figure 7.0.5** and the elements are described below.

7.0.2.1 12.5 kV Site Power

In order to support the estimated 20,000 kVA of additional connected load, located in the new MLIT Program, including the loads in the new Terminal B, Terminal C Core, as well as future FIS loads, a new 12.5 kV substation will be added. Prior to any construction or demolition work a thorough site utility investigation and utility re-route effort should be completed in order to ensure that all existing utilities within the substation footprint that will impact construction have been identified, decommissioned or relocated.

The new 14,000 sf substation will consist of 9,000 sf dedicated to CenterPoint for their 12.5 kV switchgear with load shedding capabilities. Included in the 9,000 sf will be a battery and control room for CenterPoint, the final layout and required square footage to be dictated by CenterPoint in their final design. (The reserved 9,000 sf is based on previous 10MW, 20MW, and 40MW, 12.5 kV substation designs completed for other utilities). It is assumed that HAS will be responsible for construction of the building and infrastructure necessary to support the 40MW substation, and once construction has been completed, CenterPoint will take over the dedicated 9,000 sf space and install and cable, transformers, meters, and switchgear that are to be CenterPoint owned and operated. It is estimated that a minimum of 24 months' notice be given to CenterPoint prior to handing over the completed construction project, in order to allow for equipment procurement and contracting. In addition, a minimum of 8 months should also be allowed for the installation of all CenterPoint cables, transformers, and switchgear.

Directly adjacent to the 9,000 sf reserved for CenterPoint will be a 3,000 sf HAS owned and operated switchgear and meter room. Within this 3,000 sf HAS will receive 12.5 kV power from CenterPoint and take responsibility for distribution to loads throughout the airport. Prior to CenterPoint taking over occupancy of the adjacent 9,000 sf, this 3,000 sf HAS owned switchgear room will need to be completed and final certificate of occupancy issued by the AHJ. In addition to the 3,000 sf HAS owned switchgear room, HAS will be responsible for completing approximately 2,000 sf of dedicated parking lot area, secure access facilities, and security fencing.

To support this new switchgear, new 12.5 kV feeders will need to be provided from the existing underground CenterPointinfrastructure back to substations GR and IT. The contractor will be responsible for providing the underground infrastructure, consisting of (12) 6 inch conduits, to the CenterPoint manhole shown on the Phase 0, 12.5 kV Site Distribution Exhibit.

Once completed the new 12.5 kV substation will provide power to the new Terminal B North project as part of Phase 0, see **Figure 7.0.6**.

7.0.2.2 Water System

The airside water demand is limited to the storm sewer environmental protection system. Though portions of the existing storm sewer, due to apron grading change, will be removed and a new line will be installed, the total water demand will not change and the majority of the existing waterlines could be reconnected and reused. Phasing shall follow the phasing for new storm sewers and apron pavement phasing.

The proposed domestic and fire protection water is composed of:

- Two 500,000 gallons tanks and a booster pump station. This facility is recommended to be constructed ahead of Phase 1.
- An 8inch looped waterline that will serve Terminal B, Pier D1, Pier D2, and the new Central Processing.

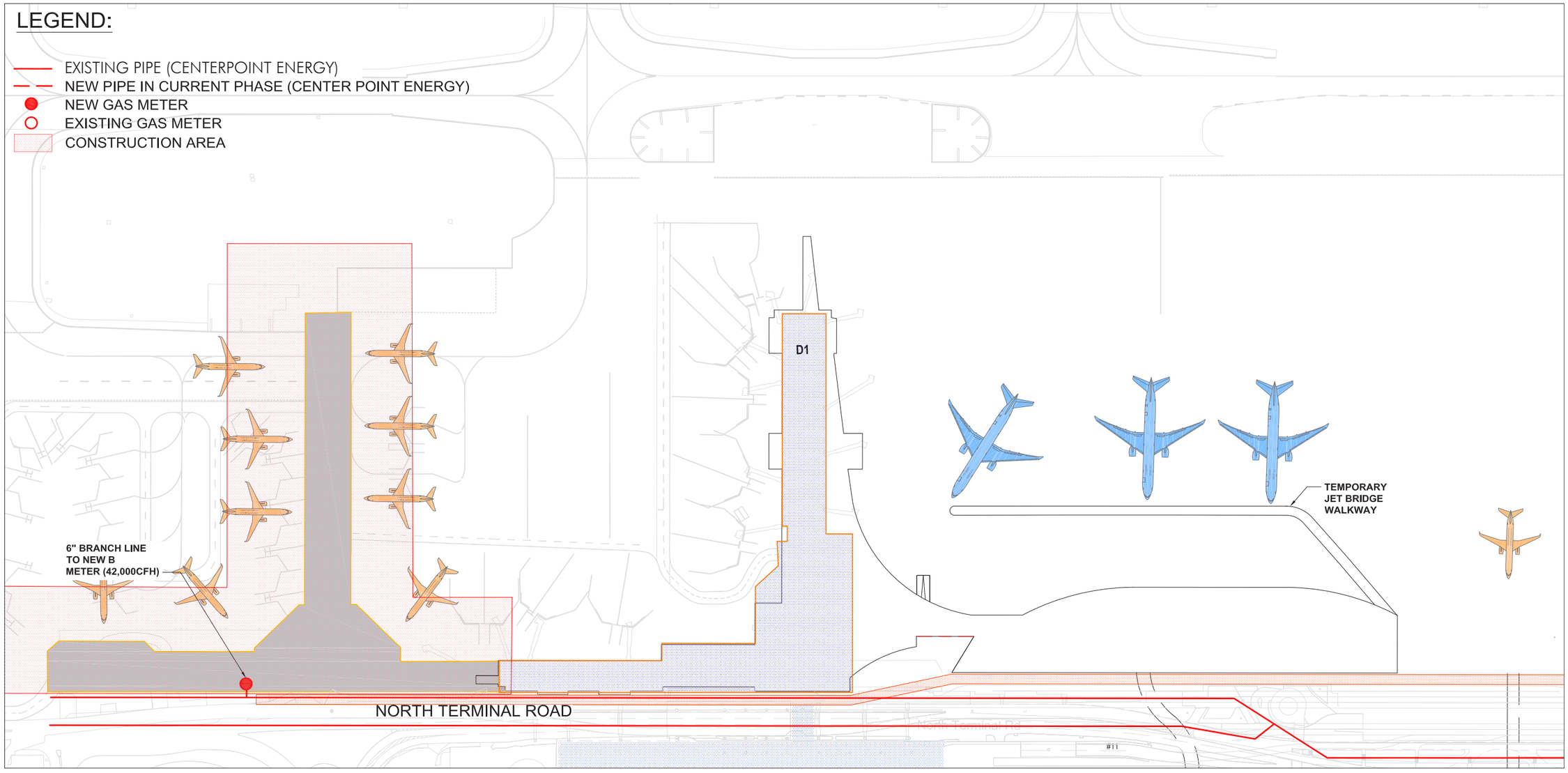
Since the line will be part of the Utility Corridor, its' construction phasing will follow the construction of the said corridor.

7.0.2.3 SANITARY SEWER SYSTEM

Sequencing of the new Sanitary Sewer System construction will closely follow that of the terminal and piers with some exemptions. The system is recommended to be constructed in four phases as depicted on Sanitary Sewer System Figures in the following Program Phasing Sections. It should be noted that existing Terminal D lift stations that will remain in service during Phase 1 and Phase 2, have been upgraded recently and have capacity to handle the existing Terminal D and the new D1 Pier sanitary sewer loads.

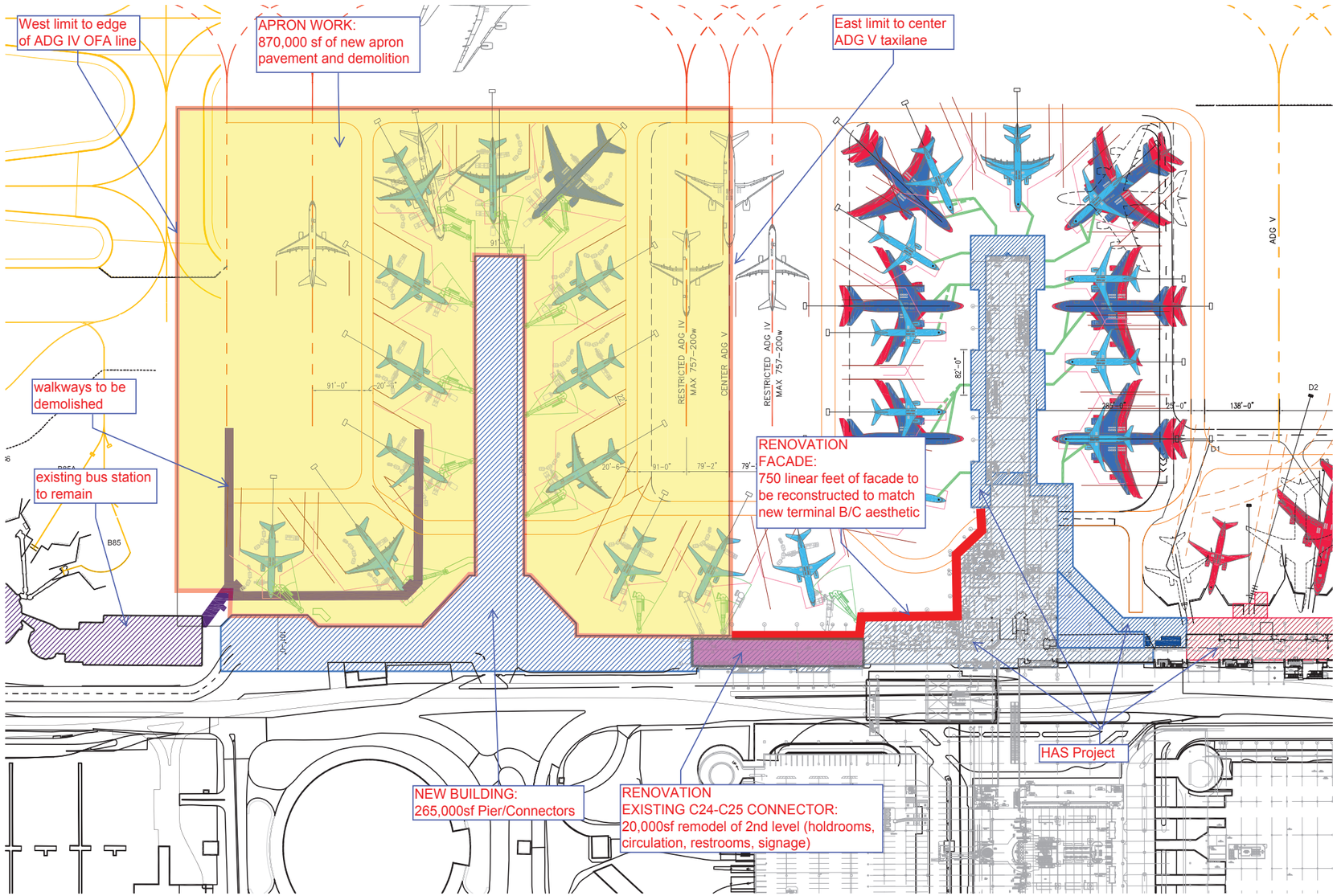
Construction of the new sanitary sewer lift station and force main, due to selected location and nature of its' use, could be constructed independently and ahead of planned Phase 2a. Similarly, the new triturator, recommended to be constructed east of Taxiway NN, could be constructed independently and ahead of Phase 1 or during Phase 1 construction duration.

Proposed Natural Gas - Phase 0



0′ 200′

MLIT/Terminal B Airside Limit Line



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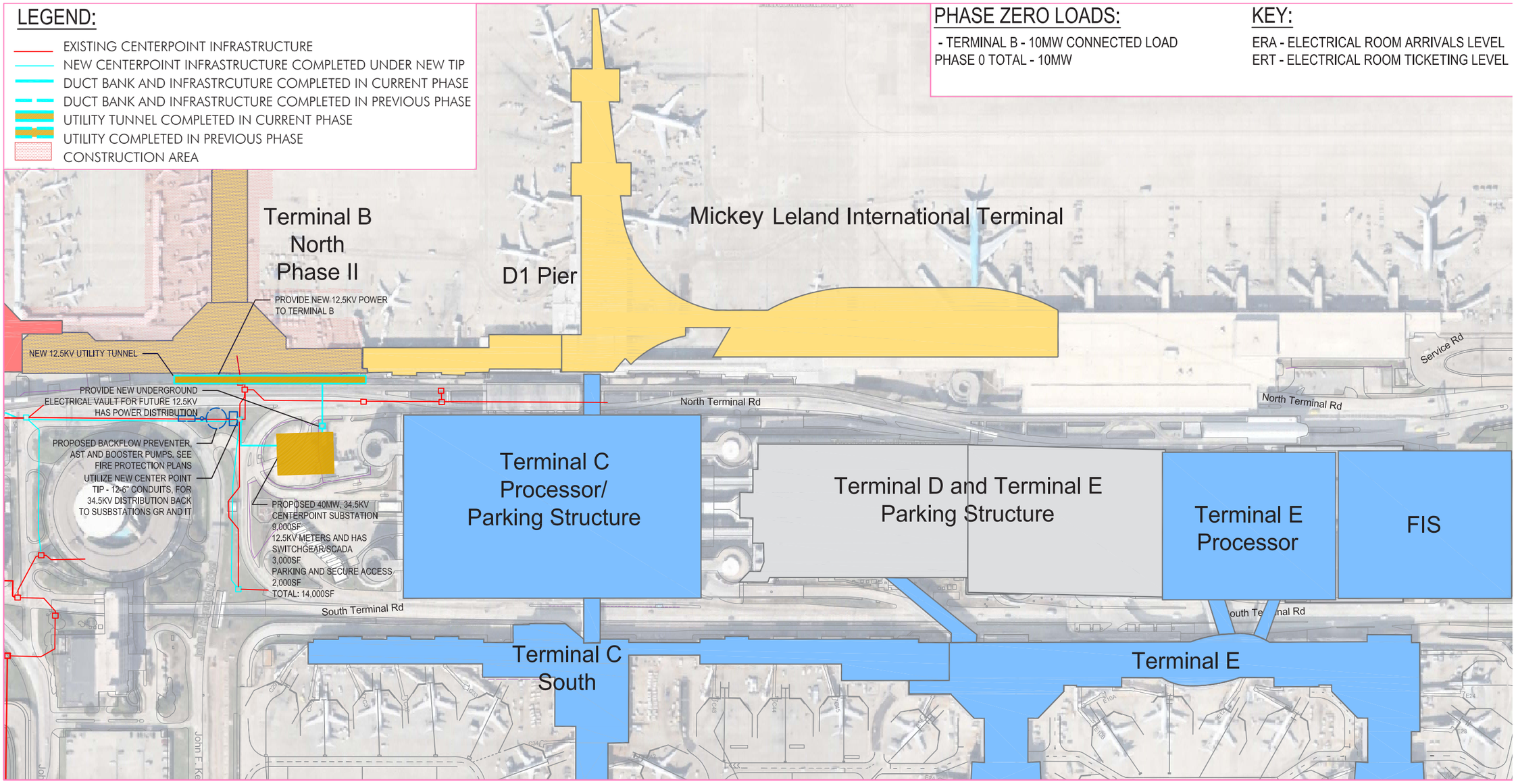
12.5 kV Site Power - Phase 0

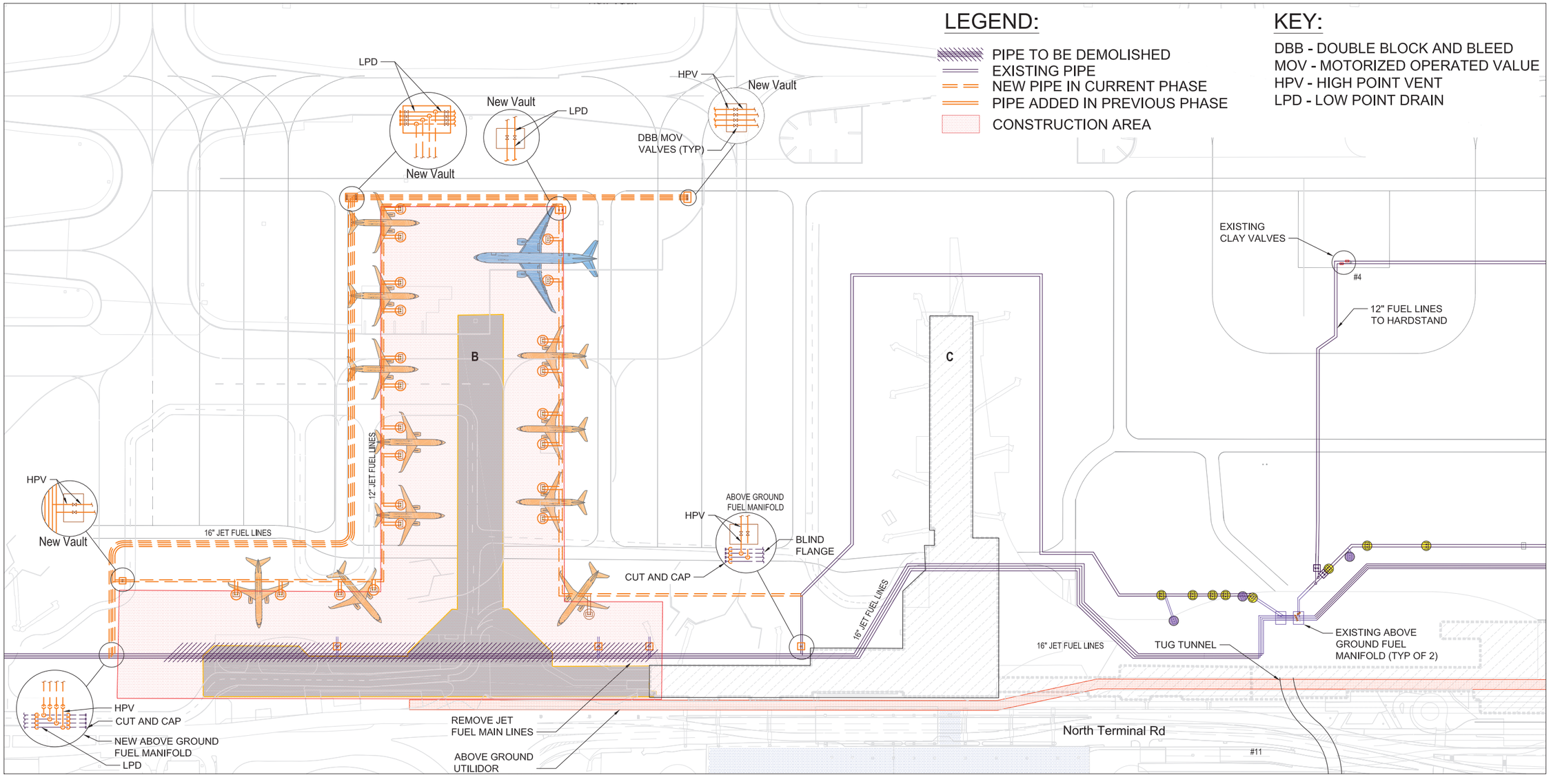


7.0.2.3 Hydrant Fueling

Figure 7.0.7 shows the rerouting of the fuel mains and hydrant lines to serve the new Terminal B. Terminal B will be designed prior to the work on MLIT. Four new 16 inch diameter main fuel lines will connect to the existing fuel mains west of Terminal B. An above ground fuel manifold will be installed at the connection point. The fuel lines will route around the terminal to the north, terminating in a new valve vault located northeast of the terminal. The main fuel lines are planned to be demolished in the Phase 0 area of concern.

A new hydrant fuel system loop will be installed to serve Terminal B. Two 12 inch diameter fuel lines will branch off the mains and route around the building at a distance of 125 ft from the building face. The lines distribute fuel to hydrant pits located at each Terminal B aircraft parking position. The hydrant fuel lines tie into the existing lines serving the Terminal C gates.

Proposed Hydrant Fueling - Phase 0



7.1 PROGRAM PHASING: Phase One (Enabling Projects)

In preparation for the implementation of the new MLIT, a series of enabling projects will need to be completed prior to the demolition of Terminal C North. There are three subphases in Phase 1 (see **Figure 7.1.1**) and each element is outlined below and described in more detail in the following sections:

- Construction of a Ramp Control Tower: The existing Terminal C North Ramp Control Tower (see **Section 3.4.2.2**) will need to be relocated prior to the demolition of Terminal C North. The relocation site will be determined during the design phase (see **Section 5.3.4.16**).
- Relocation of the Terminal D Hardstand/Deicing Area: The existing Terminal D Hardstand/Deicing Area (see **Section 3.5.1**) will need to be relocated due to the impacts of the MLIT program. The relocation site(s) will be determined during the LeighFisher Airport Master Plan process. Ground Service Equipment (GSE) required to accommodate irregular/hardstand operations during construction are:
    - Buses – minimum of three buses with a capacity of at least 75 for one wide-body arrival. For two simultaneous hardstand operations with a second wide-body, another set of three buses would be required.
    - Air Stairs – two per wide-body aircraft are required. For an A380 hardstand operation, three may be needed. Consideration should be given to switchback ramps with canopies for inclement weather.
    - Americans with Disabilities Act (ADA) Lift – one per aircraft that need to hardstand; two recommended for simultaneous hardstand operations/redundancy.
    - Mobile Ground Power Unit (GPU) – three units for two wide-body hardstand operations and two for an A380.
    - Preconditioned Air (PCA) – three units for two wide-body hardstand operations and two for an A380.

During this enabling phase, passenger and aircraft operations generally continue to function as they do under current conditions, with any specific exceptions noted in the subphase descriptions.

1. Aircraft parking studies and contact gate restriping of existing Terminal C North Gates 6, 7, and 8 (Existing Gates C19, C20, and C21) to accommodate wide-body aircraft.
2. Construction of a temporary walkway to three international carrier Passenger Boarding Bridges (PBB) designed to accommodate three wide-body aircraft contact gates, Gate D1, D2, and D3, in pushed-back position. This will permit the demolition of the existing Terminal C North and the east half of the C/D Connector Facilities in Phase 2.
3. Relocation of three Passenger Boarding Bridges(PBBs) from their positions at existing Gates 1, 2, 3, 4, and 5 (narrow-body and wide-body aircraft gates) to temporary positions, at temporary Gates 1, 2, and 3 (wide-body aircraft gates), and then back to their permanent positions.
4. Construction of temporary aircraft fueling system loop to Terminal Gates D1, D2, and D3.
5. Modification of the aircraft apron and drainage system as required for temporary Gates D1, D2, and D3.
6. Relocation of utilities and drainage systems currently located at existing Terminals C North and D. These relocations will be required to facilitate the Phase 2 demolition of the existing facilities and the Phase 1 construction of Pier D1, including electrical services and fire protection services.
7. Performance of a Hazardous Materials Survey in Terminals C North and D, as well as in Connectors B/C and C/D.
8. Expansion and modification of the existing Terminal D East Baggage Handling Facilities to provide adequate capacity to handle the existing Terminal D West baggage flows prior to the Phase 2 demolition. of Terminal C North, C/D Connector, and the northwest portion of existing Terminal D. This will allow for the construction of Pier D1 and the northwest half of the new Terminal D Central Core in Phase 2.
9. Occupancy and commencement of operations at temporary Gates D1, D2, and D3 and the temporary walkway.

7.1.1 AIRSIDE INFRASTRUCTURE

7.1.1.1 Aircraft Parking Layout

Phase 1A provides three temporary wide-body aircraft gates to assist in the upcoming Phase 2 construction. Existing Gates D1, D2, D3, D4, and D5 will interfere with Phase 2 construction of the MLIT and Pier D1. To facilitate the demolition of existing facilities and subsequent construction of the new facilities, relocation of these gates is necessary. In their current configuration, these gates can accommodate five narrow-body gates, or three wide-body gates. This relocation provides the capacity for three wide-body gates in order to maximize the number of available wide-body gates through the construction phase. These positions are proposed to be shifted north away from the existing terminal and connected back to the terminal through a temporary jetbridge connection.

During this relocation and construction of the temporary walkway, gates D1 through D5 will not be operational. When the temporary gates are activated, the existing flow along the taxilane behind the gates will require modification, and the use of the western positions of the adjacent hardstands will become restricted.

7.1.1.2 Gate Separation

Restripe Gates C19, C20, and C21 at Terminal C North Pier to accommodate two wide-body aircraft. This provides wide-body aircraft parking, if necessary, during the construction of the temporary walkway for the Gates D1 through D5 relocation.

7.1.1.3 Passenger Boarding Bridges

Relocate existing PBBs from Gates D1, D2, D3, D4, and D5 to the temporary walkway to provide PBBs for the relocated wide-body positions at relocated Gates D1, D2, and D3. The existing PBBs located at Terminal C North belong to United Airlines and will be relocated to Terminal B North. New or relocated PBBs will need to be installed at Terminal C North to accommodate wide-body aircraft during the construction of the temporary walkway. Additional analysis needs to be conducted during the design phase.

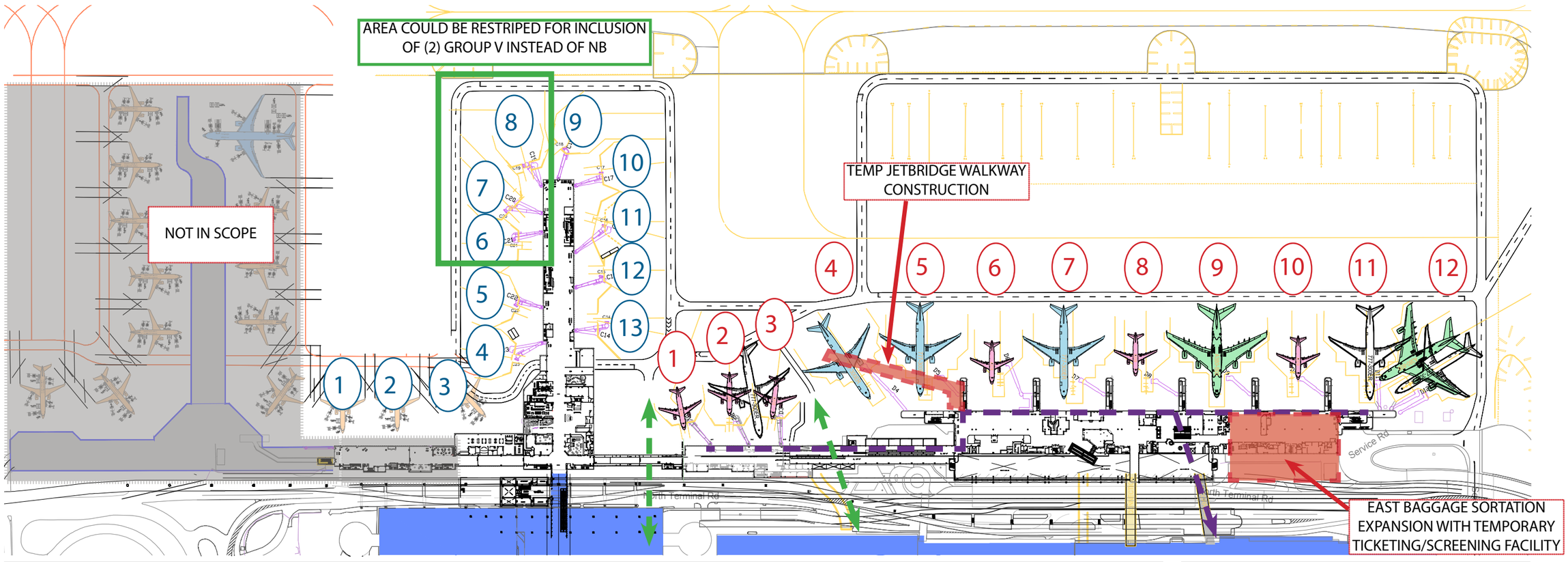
7.1.2 TERMINAL BUILDING

Phase 1C readies the site and the facilities for demolition in preparation for Phase 2 construction activities of the MLIT.

Key activities during this phase:

- Terminal Building Architecture and Airside
    - At the completion of the Terminal B North Pier, not in contract, relocate the operations of Terminal C North to the new Terminal B North Pier.
    - Decommission the existing Terminal C North. This does not include the B/C Connector.
    - Perform a hazardous material remediation process to survey the existing facilities at Terminal C North, Terminal D, the B/C Connector, and the C/D Connectors.

Phase 1 (Enabling Projects)



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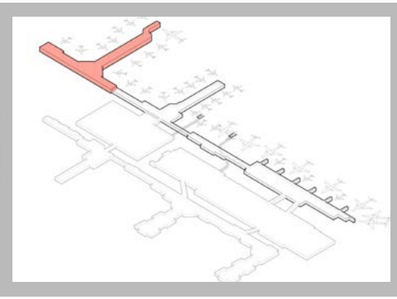


PHASE 1 HIGHLIGHTS:

- PHASE 1 - ENABLING PROJECTS
  - EXPANSION OF EAST BAGGAGE MATRIX AND TEMPORARY EAST BAGGAGE SORTATION
  - BUILD TEMPORARY JETBRIDGE WALKWAY
  - ENABLING UTILITIES

STERILE CORRIDOR

EXISTING TUNNEL OPEN

EX TUNNEL CONSTRAINED

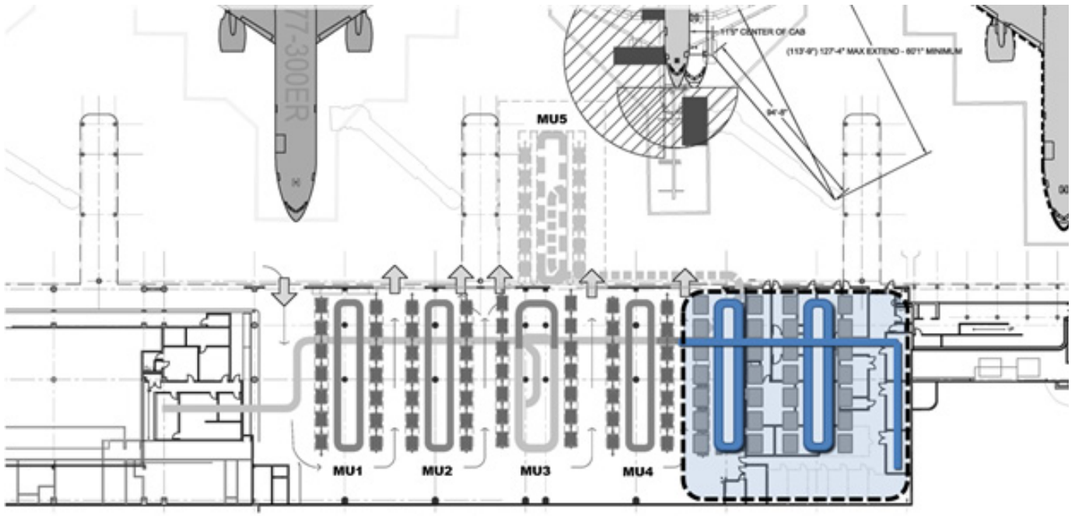
GATES

INTL GATES - 12

DOMESTIC - 13

7.1.2.1 Ticketing/Check-In Level

Before starting with Phase 2, which requires the shut-down of the west screening and sortation function, the east end of Terminal D has to be modified to enable the facility to process bags from the west ticketing with the desired redundancy and sortation capacity. These enabling projects include the expansion of the east baggage room. This will expand the sortation capacity by 28 container positions. When including the MU5 unit and replacing all incline carousels with flat plate units, the east sortation capacity can be increased from the current 40 container positions to 96 container positions. The design also allows for a run-out belt at the end of the sortation line for no-read or problem bags.

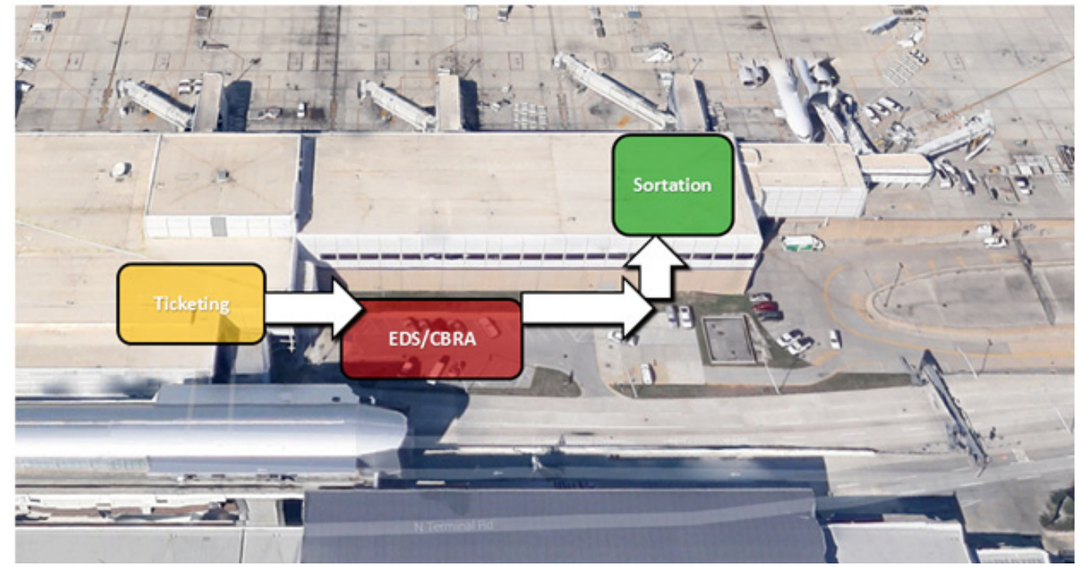


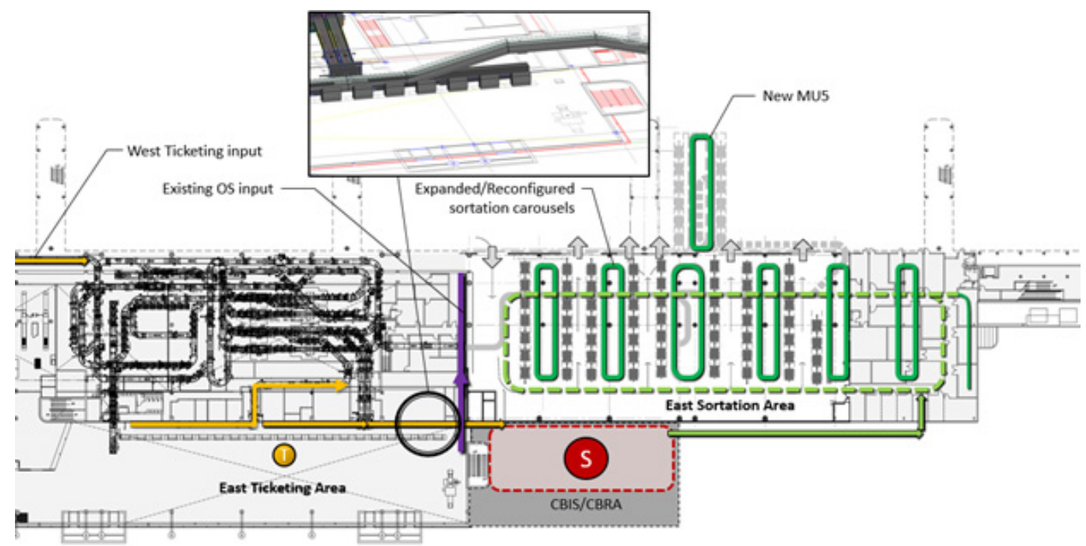
Additional Sortation Capacity in Storage Area (28 container positions)
and reconfigured carousels for a total of 84 sort positions + 12 apron positions

The two additional flat plate units and the run-out belt are located in a space which is today used as a storage area for airlines and concessionaires. Alternative storage space has to be identified and the stored items will need to be relocated before starting with the expansion of the sortation area.

With the closure of the west screening and sortation facilities, all Terminal D bags are now processed in the east screening matrix and sortation system without fall-back options. Single points of failure exist within the screening matrix and the sortation line. These single points of failure will result in a complete shut-down of the baggage operations in case of a failure. To mitigate the single points of failure, a small in-line screening system east of Terminal D will be built to allow the re-routing of ticketing operations located on the east end of Terminal D into this new screening system. The system will provide a separate screening system and sortation line allowing continued operation during a single point of failure within the legacy Terminal D baggage system.

During normal operation, half of the east ticketing and all of the west ticketing will be processed within the legacy screening system while half of the east ticketing counters will be permanently tied to the new screening system. During a failure within the legacy screening system, airlines impacted by this failure will place their bags onto the east ticketing belts for screening in the new screening facility. After being screened, these bags will be routed to the same make-up carousels without impact on the bag room operations. The same fall-back procedure is applied if the new screening system fails. In this case, impacted airlines will place their checked bags onto the ticketing counters connected to the legacy screening system for continued check-in operation.





In addition to the features above, it is possible to include a transfer input belt that will directly tie into the sortation loop. This feature will allow the system to sort domestic to international transfer bags directly onto the make-up carousels. Today, these bags are stored on the ground adjacent to the carousels.

This configuration will be kept until the new baggage system is completed and operational (Phase 3 (A-C)). At Phase 3, airline ticketing operations will move into the new facility and bags will be processed through the new baggage screening and sortation system. The baggage facilities will be in the existing east landside Terminal D and the baggage sortation area will be decommissioned.

7.1.2.2 Departure Concourse Level

Construct a temporary walkway extending from the existing Gate D5 to the west to provide access to three wide-body gate positions. Design of this temporary walkway should consider the ability to segregate arriving and departing passengers by gate to optimize the ability to utilize each gate independently for enplaning and deplaning passengers. Arriving international passengers also must be able to connect into the existing Terminal D Sterile Corridor.

7.1.3 TERMINAL MEP SYSTEMS

7.1.3.1 Domestic Water System

The combined DW/FP pipe loop in the utility corridor is planned to be continued to the east, running along the south edge of the existing C-B connector and ready to be extended to MLIT (D1), in the next phase. Domestic water will enter through a HAS owned water meter before serving any fixtures inside the terminal. This allows the airport to monitor the terminal to track water usage. Each domestic branch line service may also require a backflow preventer, to protect the water loop from potential contamination by the terminal building water service users. See **Figure 7.1.2**.

7.1.3.2 Electrical System

Disconnect power line coming from CenterPoint, which feeds the pad mounted transformer, feeding the Terminal C North (750 kVA, 12.47 kV, 277/480 V, and 3000 kVA, 12.47 kV, and 4.16 kV). Disconnect before starting Phase 2; located in the Apron area of Terminal C North.

Disconnect the electrical circuits that service areas located in Terminal C North, from the Substation C (SWBD C1 and SWBD C2), located in Terminal D. See **Figure 7.1.3**.

Propose to install new 12.5 kV CenterPoint feeders to provide power to one transformer and distribution switchgear located above ground on existing housekeeping pad. See **Figure 7.1.4**.

All of the above is required before starting the demolition Phase 2 of the Terminal C North and C Connector.

7.1.3.3 Fire Suppression

The combined Domestic Water/Fire Protection (DW/FP) pipe loop, in the utility corridor, is planned to be continued to the east, running along the south edge of the existing C-B connector and ready to be extended to MLIT (D1), in the next phase. Fire protection water will enter Terminal B from the combined DW/FP pipe loop in the utility corridor. Fire protection water will enter through a reduced pressure backflow preventer. This protects the combined DW/FP water loop in the utility corridor from potential back siphonage of water from the fire protection system. The fire protection water serves a combined fire sprinkler and standpipe system in the terminal. See **Figure 7.1.2**.

7.1.4 SITE UTILITIES

Additional utility demands are needed to support the phased construction of the MLIT. Utility system enabling projects are needed to meet these new demands.

7.1.4.1 12.5 kV Site Power

After power has been provided to Terminal B in Phase 0, additional electrical infrastructure including cables and conduit are to be added to the utilidor in anticipation of the additional loads to the east.

Temporary switchgear will need to be provided in order to support the temporary east baggage sortation expansion with the ticketing and screening facility. An above ground 12.5 kV/480V transformer and distribution switchgear on existing housekeeping pads should be provided. The two existing housekeeping pads have 6 inch conduits that go back to the existing 12.5 kV CenterPoint distribution substation. The temporary switchgear can be fed from the existing feeders that feed the existing Terminal D, however, coordination with CenterPoint for the installation of new meters as well as splicing into the existing 15 kV feeders for new 15 kV feeders to their temporary transformers will be required. See **Figure 7.1.5**.

7.1.4.2 Site Communication/IT

In order to facilitate the cut-over from the existing Terminal D MDF to the new MLIT MDF located in Pier D1, new ductbanks will have to be run along the front of the existing Terminal D, to support the cut-over, and ensure that there is no down time during critical airport activities. The temporary fiber optic connection to the existing MDF will be routed underground, in six four inch conduits, just outside the limits of construction on the landside. This new duct bank will be supported by two eight foot by 16 foot manholes at either end, used for fusion splicing the existing cables to the new re-routed extension. All fiber optic routes will be terminated back in the new terminal MDF room, located at the base of the new pier D1.

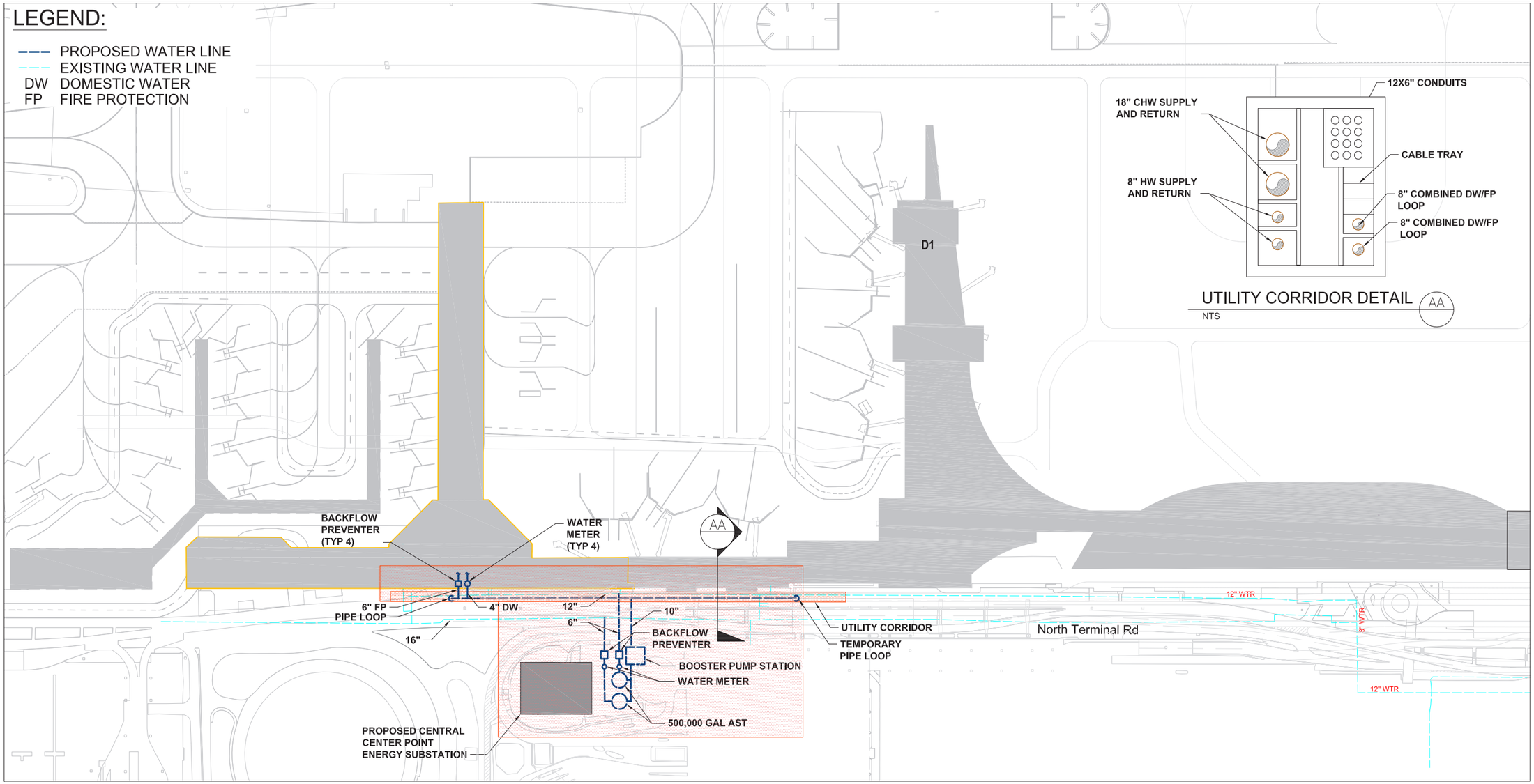
7.1.4.3 Water System

The airside water demand is limited to the storm sewer environmental protection system. Though portions of the existing storm sewer, due to apron grading change, will be removed and a new line will be installed, the total water demand will not change and the majority of the existing waterlines could be reconnected and reused. Phasing shall follow the phasing for new storm sewers and apron pavement phasing.

7.1.4.4 Hydrant Fueling

Figure 7.1.6 shows the continuation of fuel line mains and hydrant lines serving the west portion (D1) of MLIT. Part of that construction includes a segment of the hydrant distribution system dedicated to three temporary gates. These gates are needed to optimize aircraft operations while construction of MLIT continues. Additionally, the new fuel lines will need to connect into the existing fuel mains, hydrant service lines, and hardstand lines to maintain fuel operations to the east gates and cargo. Installation of new fuel isolation vaults are planned at each connection point.

Proposed Domestic Water/Fire Protection - Phase 1



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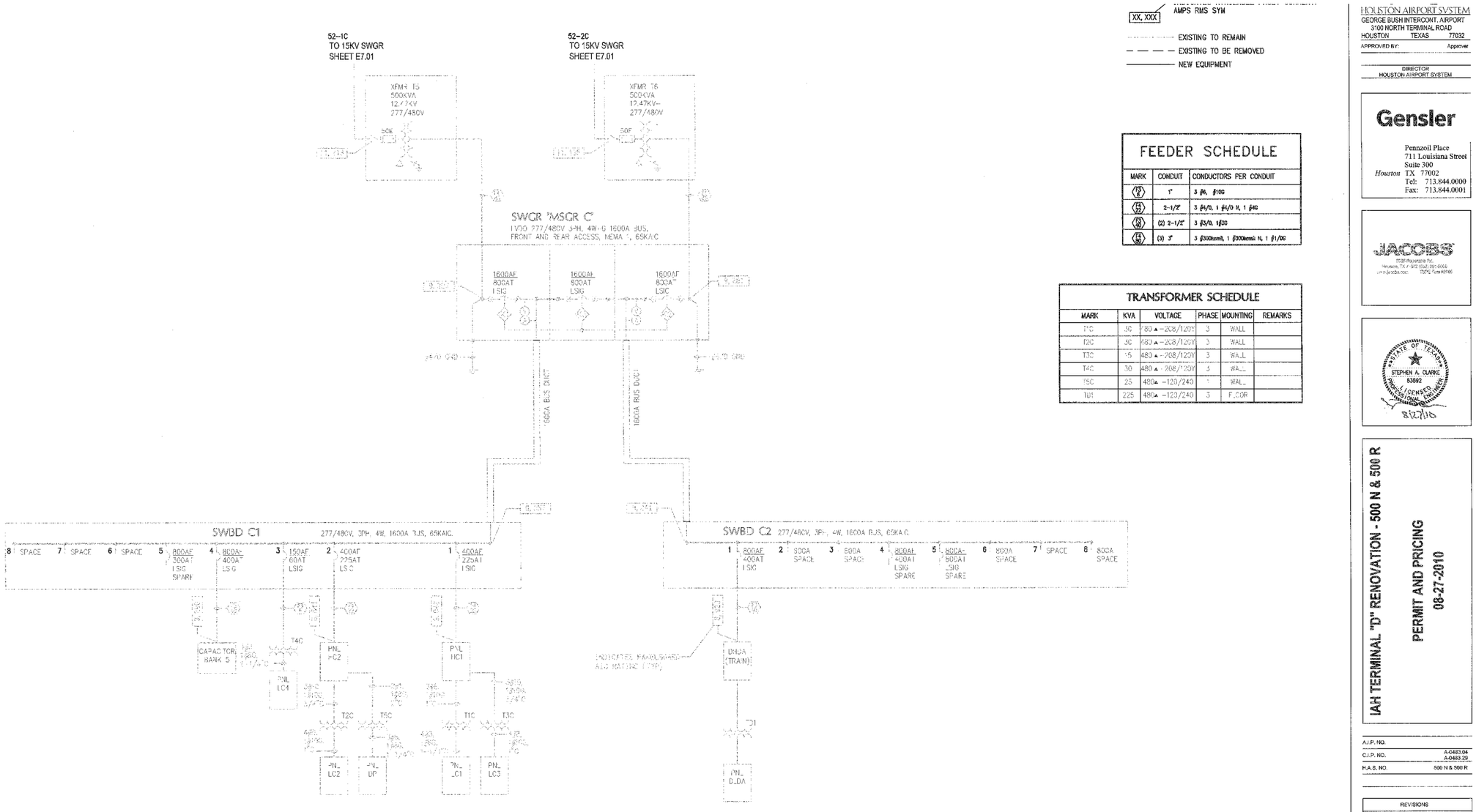
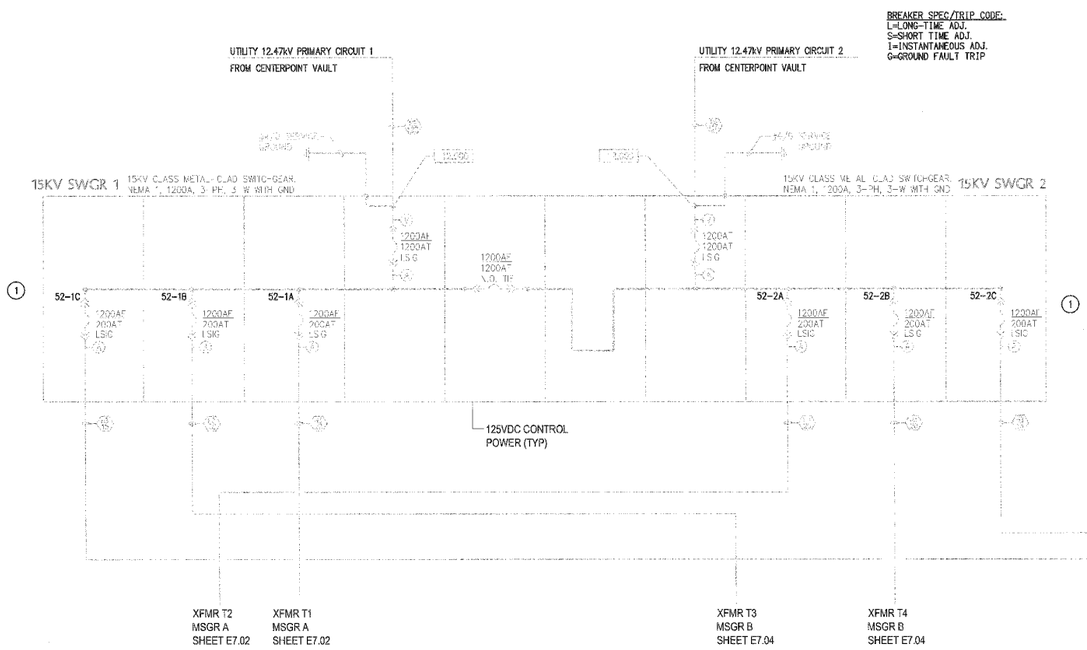
Electrical One-Line Diagram



Electrical One-Line Diagram - Main SWGR



1 ELECTRICAL ONE-LINE DIAGRAM - MAIN SWGR
SCALE: NTS

XX, XXX AMPS RMS SYM
EXISTING TO REMAIN
EXISTING TO BE REMOVED
NEW EQUIPMENT

KEYED NOTES

1. PROVISION FOR FUTURE SECTION.

FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
1B	3"	3 #1 15KV, 1 #6 600V G
2B	3"	3 #1 15KV, 1 #4 600V G
2A	(2) 6"	3 #500kcmil 15KV, 1 #3/0G

TERMINAL D EXPANSION/RENOVATION LOAD ANALYSIS											
TAG	PEAK DEMAND	LTG	REC	EQP	MTR	HTG	COOL	HT	CONN kVA	15kV kVA	AMPS 12.47kV
15KV SWGR	2278								2278	2648	152
SWB A1		0	16	26	130				174	171	8
SWB A2		23	289	143	1183			520	2115	1816	84
SWB B1		27	23	-114	731	20			687	658	32
SWB B2		-13	48	-8	-221				-192	-213	-10
25% L. MOTOR					38						
TOTAL	2278	37	356	46	1824	23		520	2766		
WITH DIVERSITY	2848	46	183	46	1861	23		325		5332	247

PEAK DEMAND AT 125%
DIVERSITY PER ARTICLE 220
LOADS SHOWN ARE NEW LOADS LESS DEMOLITION LOADS

EXISTING 1200A SERVICE IS ADEQUATE

HOUSTON AIRPORT SYSTEM
GEORGE BUSH INTERCONT. AIRPORT
3100 NORTH TERMINAL ROAD
HOUSTON TEXAS 77032
APPROVED BY: Approver
DIRECTOR
HOUSTON AIRPORT SYSTEM

Gensler
Pennzoil Place
711 Louisiana Street
Suite 300
Houston TX 77002
Tel: 713.844.0000
Fax: 713.844.0001

JACOBS

STATE OF TEXAS
STEPHEN A. CLARKE
83892
LICENSED
PROFESSIONAL ENGINEER
8/27/10

IAH TERMINAL "D" RENOVATION - 500 N & 500 R
PERMIT AND PRICING
08-27-2010

A.I.P. NO.
C.I.P. NO. A-0483.04 A-0483.29
H.A.S. NO. 500 N & 500 R

REVISIONS			
NO.	DESCRIPTION	DATE	BY

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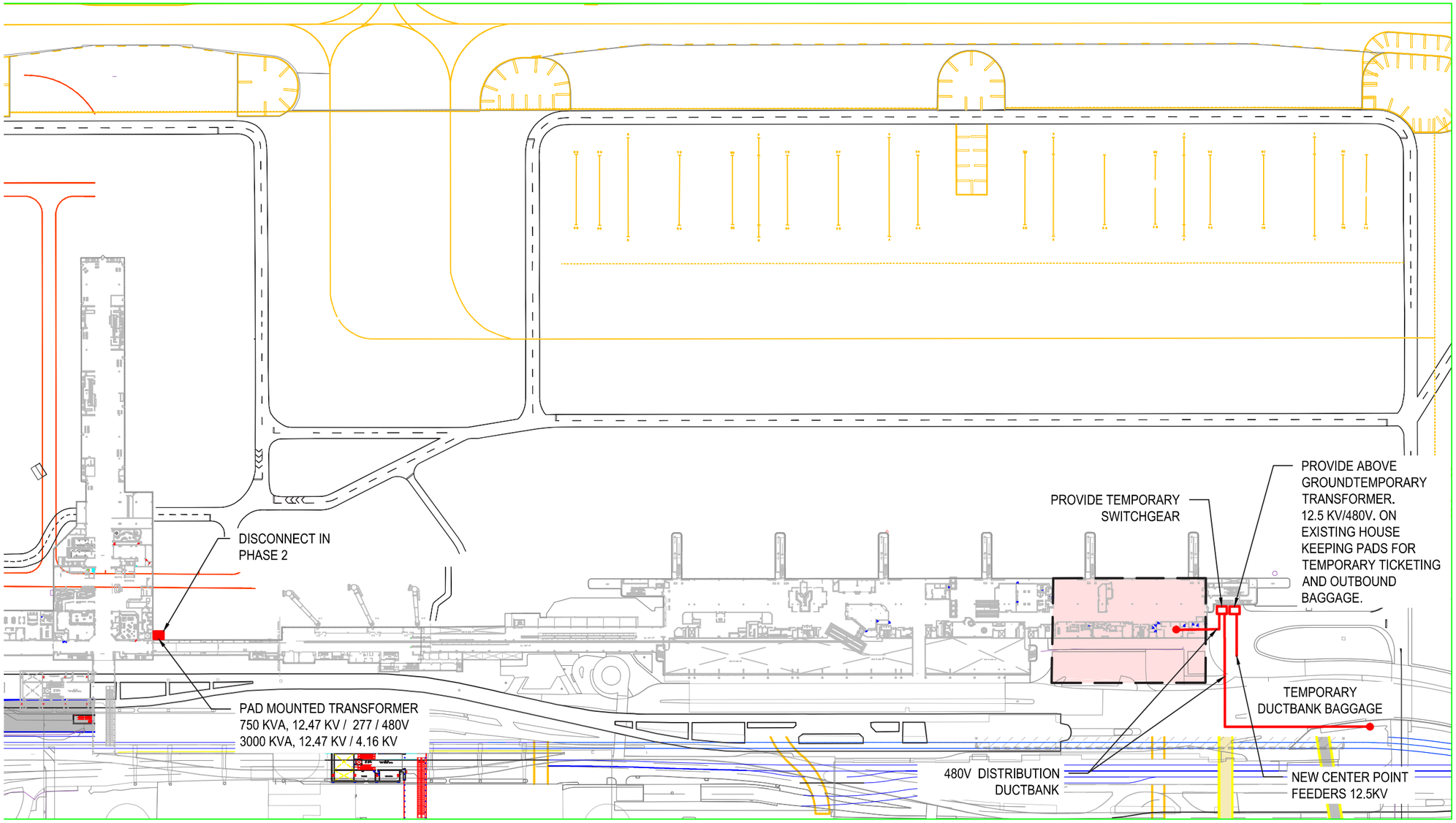
Power Distribution - Phase 1



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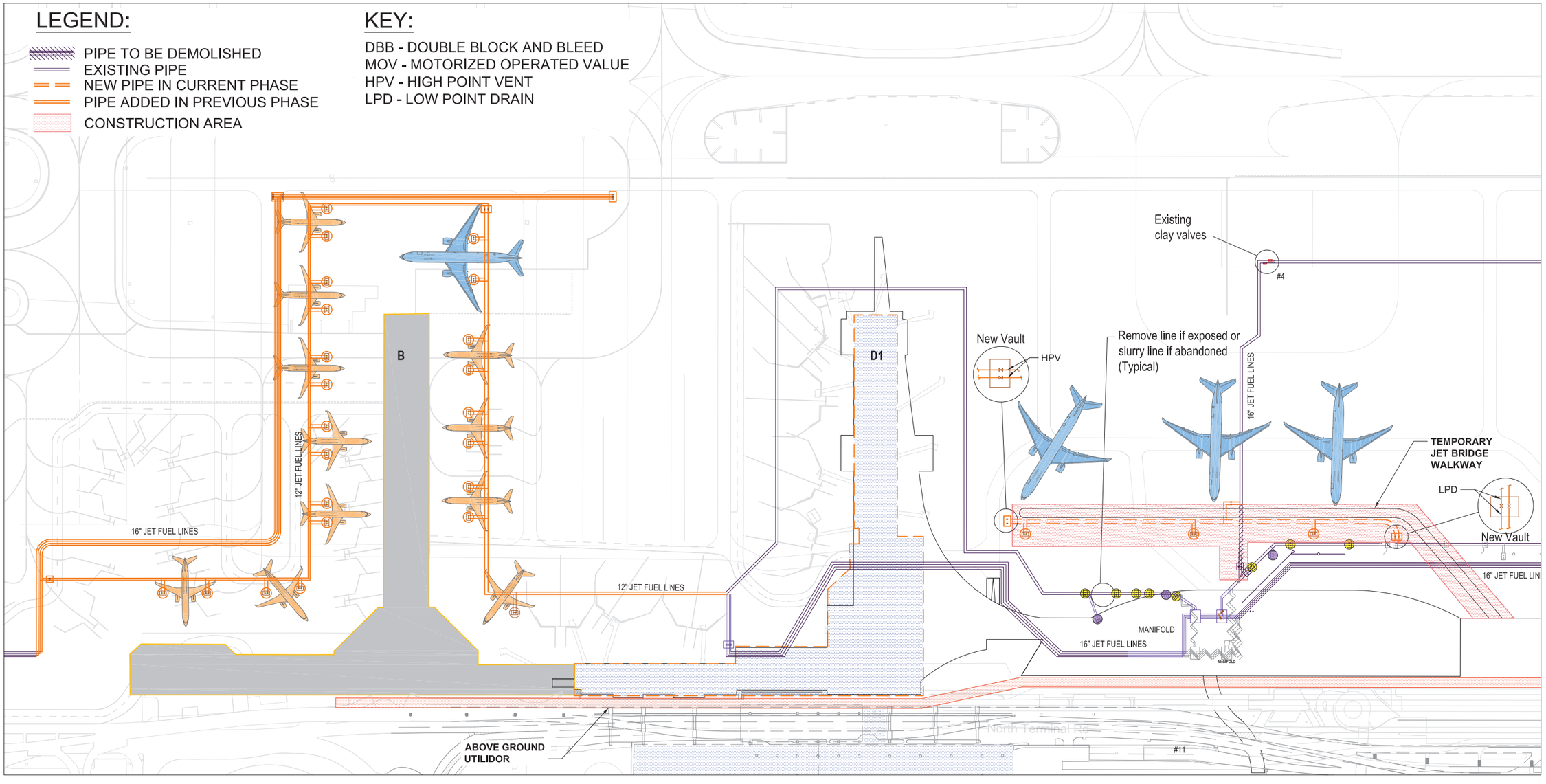
Proposed Hydrant Fueling - Phase 1



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7.2 PROGRAM PHASING: Phase Two

Phase 2 constructs the D1 Pier as well as the western portion of the new MLIT. There are three primary subphases in this portion of the construction, each of which are described below. Phase 2 constructs the D1 Pier as well as the western portion of the new MLIT. There are three primary subphases in this portion of the construction, each of which are described below. See enabling projects for Phase 0 to be included in the MLIT scope including the Utility Corridor, Central Water Storage System, Central 12.5 kV Electrical Receiving Station, Chilled and Heating Water, Hydrant Fuel System and Triturator.

During this phase, operations from Terminal C North have been relocated to the new Terminal B North Pier (not in contract). Terminal D generally continues to operate as normal with the exception of the western gates which have been relocated to a new temporary location as described in Phase 1A above. The east portion of Terminal D will continue to operate as normal through this phase with 10 international gates in operation. There will be no walking connection between the new Terminal B North Pier and the Terminal D operation during this phase. Connecting passengers will need to utilize the airport secure APM system during this phase.

Within the construction zone of Phase 2 (see **Figure 7.2.1**), there are two existing tug drive tunnels that will be impacted. The first is to and from the Terminal C Processor, while the other is to the Terminal D FIS inbound baggage delivery belts. The ongoing construction will likely constrain use of these tunnels. Additional study will be required to determine the specific impact on these tunnels and how the activity is otherwise accommodated if they are unable to remain in operation. While the existing tunnel circulation path may be constrained at certain points of construction, the intention is to keep the tunnels operational if it all possible.

1. Decommissioning of existing Terminal C North and relocation of its contact gate operations to new Terminal B North. This does not include the B/C Connector which is not in scope of the MLIT (United scope). United has existing operations (gates and lounges) in the Terminal B/C Connector. All enabling project construction shall not interrupt these operations/services without prior notice to United. Further, this B/C Connector must remain open at all times during both the enabling construction as well as the phased construction of both Terminal C and D.
2. Removal of any hazardous materials that may be found in the existing Terminal C North and north half of C/D Connector.
3. Demolition of existing Terminal C, C/D Connector and west half of existing Terminal D.
4. Construction of new Pier 1 and western 2/3s of the new Mickey Leland International Terminal's (MLIT) Central Core.
5. Demolition and reconstruction of the west half of the landside roadway and utilities.
6. Demolition and reconstruction of concrete apron pavements and underground utilities surrounding new Pier D1.
7. Selective demolition and reconstruction of above and underground utilities located from the MLIT area westward, in order to increase the capacity of existing utilities in the MLIT facility and existing adjacent facilities.
8. Demolition of temporary walkway to temporary gates D1, D2, and D3.
9. Relocation of PBBs from their temporary positions at temporary gates D1, D2, and D3 to their new contact gate locations at the west side of the new MLIT.
10. Demolition and reconstruction of the aircraft apron, drainage system, and elimination of the temporary hydrant fueling system loop that had been required for temporary gates D1, D2, and D3.

7.2.1 AIRSIDE INFRASTRUCTURE

7.2.1.1 Passenger Boarding Bridges

Relocate the PBBs at temporary gates D1, D2, and D3 to their permanent positions on the frontal gates of the new MLIT.

7.2.2 TERMINAL BUILDING

Phase 2A clears the site in preparation of the MLIT construction by demolishing Terminal C North, the western portion of Terminal D, as well as the related utilities and other functions.
Key activities during this phase include:

- Terminal Building Architecture and Airside
  - Remove hazardous material found at the sites of the existing Terminal C North as well as the north half of the B/C Connector.
  - Demolish existing Terminal C North, the C/D Connector, and west half of Terminal D.

Phase 2B is the first major construction phase of the new MLIT. In this phase the new D1 Pier and the western portion of the new MLIT is constructed.

Key activities during this phase include:

- Terminal Building Architecture and Airside:
  - Construct Pier D1 and the western portion of the new MLIT.
  - Construct west portions of new landside roadway and utilities.
  - Construct apron around the D1 Pier.

Phase 2C incrementally activates the new D1 Pier and the western MLIT. The D1 pier and the terminal processor open all at once, while the frontal gates are incrementally activated as the temporary walkway accommodating Gates D1, D2, and D3 is demolished and final airside modifications are made.

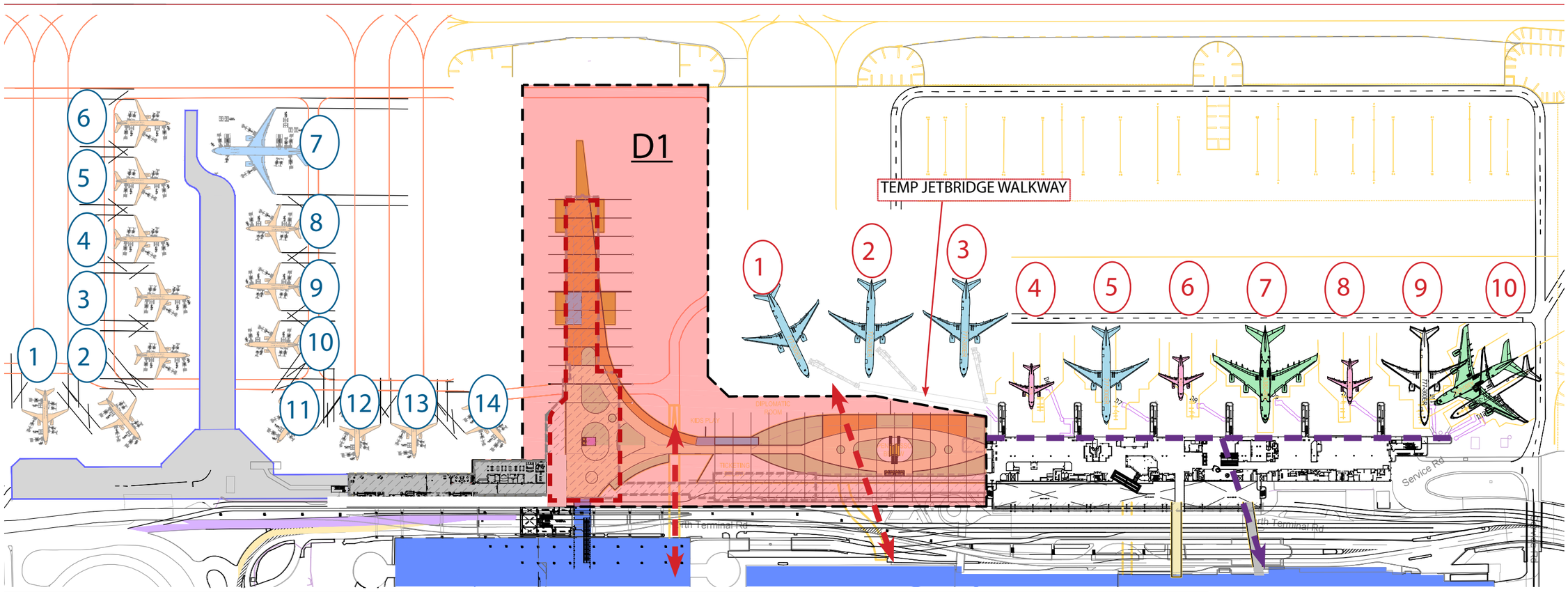
Key activities during this phase:

- Terminal Building Architecture and Airside
  - Begin operations in the MLIT utilizing the new landside roadway, utilities, and the west gates of the D1 Pier.
  - Demolish the temporary walkway that services temporary gates D1, D2, and D3.
  - Begin operations on the east side of Pier D1, and the frontal gates of the new MLIT.

7.2.2.1 Ticketing/Check-In Plan (Level 88)

The terminal building is closed off at the column line just west of the existing west ticketing counters (or at the current west ticketing curtain wall). The west ticketing area will remain operational but bags checked at the west ticketing counters will be conveyed to the eastern screening matrix via the existing west to east baggage conveyor

Phase 2



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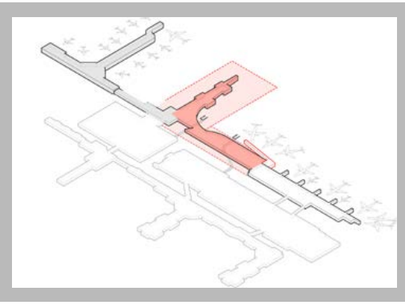


PHASE 2 HIGHLIGHTS:

- PHASE 2A - HAZARDOUS MATERIAL REMEDIATION
- PHASE 2B - DEMO EXISTING TERMINAL C NORTH
- PHASE 2C- BUILD NEW PIER D1 AND CENTRAL CORE

STERILE CORRIDOR

EXISTING TUNNEL OPEN

EX TUNNEL CONSTRAINED

GATES

INTL GATES - 10

DOMESTIC - 14

line. The bag claim device is also removed during this phase. The existing underground passenger walkway from Terminal E Parking and the ITT remains available. All airline check-in operation will remain in place. The security checkpoint will remain in its current location.

A completely new western ticketing hall will be built as part of Phase 2. The east ticketing hall will be reconfigured to allow for redundancy in screening and sortation. A centralized passenger SSCP is also constructed. In addition, the curb front is modified to provide one additional vehicle lane and greater sidewalk depth.

7.2.3 TERMINAL MEP SYSTEMS

7.2.3.1 Chilled Water System

Chilled water from the Central Utility Plant (CUP) connects to chilled water booster pumps in a mechanical room in Terminal C Central. The distribution from these pumps serves cooling coils in Terminal C Central North, and South. All chilled water lines within Terminal C North will be removed in Phase 2B as part of the demolition of the terminal. Part of the connector to Terminal D receives chilled water from booster pumps in Terminal D. The chilled water supply and return pipes from Terminal D will be disconnected and capped at the limit of demolition.

In Phase 2C a new chilled water supply and return lines from the CUP distribution system will be installed to the new mechanical room MRT-001. Based on a peak load factor of 230 sf per ton, the new terminal will have an estimated cooling load of 3,350 tons requiring approximately 6,700 gpm of chilled water flow. Four 2,250 gpm variable speed pumps, one of which is redundant, will boost the flow and maintain differential pressure throughout the terminal. The existing 14 inch chilled water supply and return from the mechanical room in Terminal C Central will be reconnected to chilled water piping from the new booster pumps. Cooling coils shall be designed for 40 degrees Fahrenheit supply and 55 degrees Fahrenheit return. Chilled water pumps are designed for a lower differential temperature to allow for possible system performance variance. New 16 inch chilled water piping will be installed from the CUP chilled water lines at MRT-001 to be extended and connected in Phase 4 with the existing CUP chilled water lines currently serving Terminal D. This is to provide redundancy and improve distribution hydraulics. See **Figure 7.2.2**.

7.2.3.2 Hot Water System

New high temperature hot water supply and return lines from the CUP distribution system will be connected to the high temperature side of the heat exchangers. Secondary hot water distribution piping will be routed to all mechanical rooms in the terminal for heating. The existing 10 inch secondary hot water supply and return from Terminal C Central to Terminal C North will be reconnected to the secondary hot water piping from the new heat exchangers.

Based on a load factor of 25 BTU/SF it is estimated that the heating load of Leland International Terminal will be 19 MBTUH. At the design temperatures, this will require a flow of 830 gpm of high temperature hot water from the CUP and 1,930 gpm of secondary hot water circulated within Mickey Leland International Terminal. The new mechanical room MRT-001 constructed in Phase 2C will house three hot water heat exchangers rated 6.5 MBTUH each and three variable speed drive secondary hot water pumps rated 970 gpm each. One of the pumps is redundant.

The high temperature hot water system is intended to operate with a supply temperature of 200 degrees Fahrenheit and a return temperature of 155 degrees Fahrenheit. The secondary hot water system will be designed with a supply temperature of 160 degrees Fahrenheit and a return temperature of 140 degrees Fahrenheit.

New 8 inch high temperature hot water piping will be installed from the high temperature hot water lines at MRT-001 to be extended and connected in Phase 4 with the existing high temperature hot water lines currently serving Terminal D. This is to provide redundancy and improve distribution hydraulics. See **Figure 7.2.2**.

7.2.3.3 HVAC

All HVAC equipment, ducts, and systems in Terminal C North shall be removed as part of the demolition of the terminal. Air handling units in mechanical rooms located in the east penthouse and west penthouse of Terminal D will remain in operation serving Terminal D. Some air distribution ducts from the west penthouse mechanical room serve parts of the west end of Terminal D that will be inside the limits of the Phase 2B demolition. These ducts shall be disconnected and capped. The design firm shall confirm that there are no air handling units within the limits of Phase 2B demolition serving parts of Terminal D that will require continued service until Phase 3.

Phase 2C will include construction of the following mechanical rooms in the new Pier D1:

- MRT-001: Located in the Ticketing Level, this room will accommodate the chilled and hot water pump stations, heat exchanger,, and air handler units which will serve the west side of the Ticketing and Baggage Levels.
- MRA-001: Located in the Apron Level, this room will be housing HVAC units that will serve the north side and part of the south side of the new Pier D1 in the Apron and Departure Levels.
- MRA-002: Located in the Apron Level, this room will be housing HVAC units that will serve the south side and southeast side of the new Pier D1 in the Apron and Departure Levels.
- MRA-003: Located in the Apron Level, this room will be housing HVAC units that will serve the west central side of the Apron and Departure Levels.

MRR-001: Located on the west side of the roof, this room will be housing HVAC units that will serve the new Pier D1 and west side of the Central Core of the Club Level. See **Figure 7.2.2**.

7.2.3.4 Domestic Water System

The domestic water lines that are serving the actual Terminal C North are coming from the Terminal C Central. During this phase these lines will be disconnected.

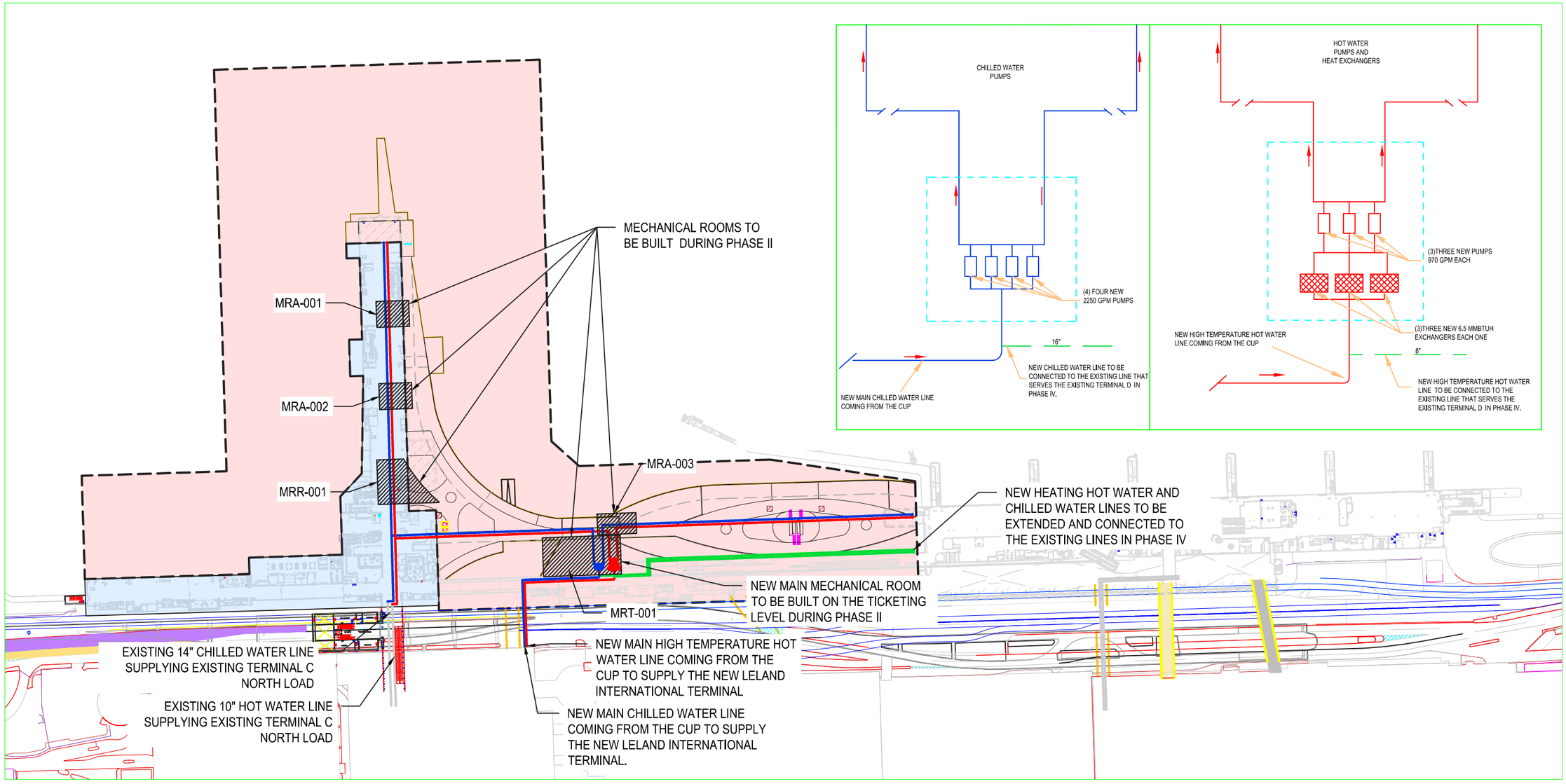
The new Mickey Leland International Terminal will have an estimated demand of 660 gpm. As the rebuilding of the new Pier D1 and central processor start, a new 8 inch water line will be connected to the existing 16 inch water line that runs along the south side of the existing terminals. This new line will be brought through room MRT-001 and will be split into one 4 inch and one 6 inch line. The 4 inch line will be routed to serve the new Pier D1 and the 6 inch line will be routed to serve the new Central Core toward the east which will then be extended into the next phase. Domestic water heaters will be installed in areas requiring them. See **Figure 7.2.3**.

7.2.3.5 Sanitary Waste and Vent System

During this phase the existing Terminal C North will be demolished; thus, the sanitary sewer collector lines that are collected in this area will be disconnected from the gravity sewer lines.

The new Mickey Leland International Terminal will have an estimated 3,084 drainage fixture unit (dfu) installed. During the rebuilding of the New Pier D1 and Central Core, 8 inch collector lines shall be installed on each level from which eight 6 inch drops will be connected. The drops in turn will be connected to a new gravity sewer line that will be installed around the new building. The lines will be routed toward the east of the New Terminal on each level, to then be extended into the next phase. See **Figure 7.2.3**.

Chilled and Hot Water Pipe Routing - Phase 2 (A, B & C)



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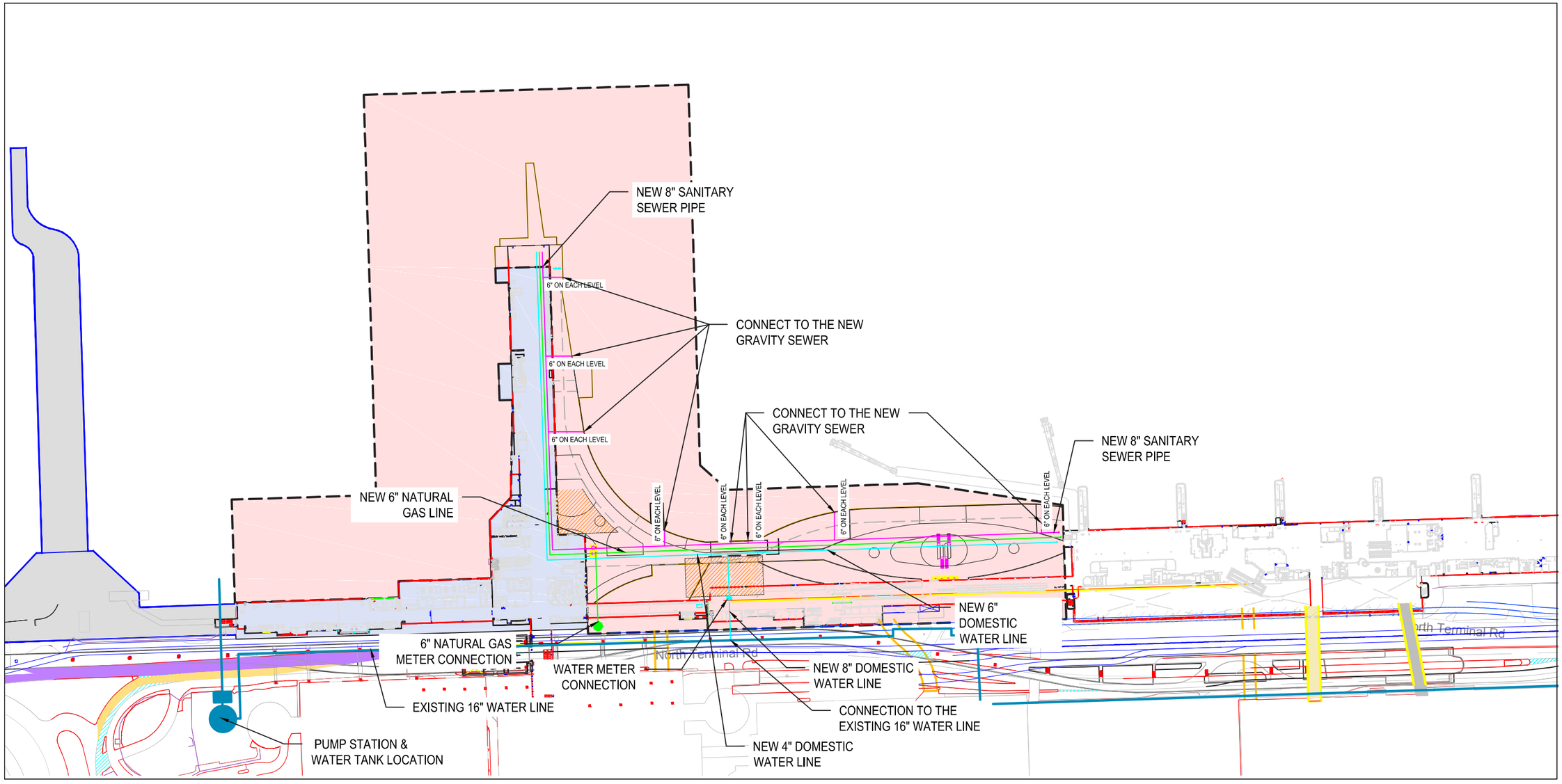
Plumbing Pipe Routing - Phase 2 (A, B & C)



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7.2.3.6 Electrical System

This section addresses the systems planning for the electrical needs of the rebuild option in Terminal C North, C Connector, and west half of existing Terminal D.

Given the proposed sequence for the reconstruction, the following should be taken into consideration.

- Distribution from main panel to secondary panels:

Prior to demolishing the Terminal C North, C Connector, and west half of Terminal D, an analysis needs to be performed to determine from which point we maintain power to the train and the exterior lighting of this area.

The design firm shall analyze the loads that are fed from SWGR C1 and SWGR C2.

The design firm shall analyze the load in Terminal C North and C Connector that is fed from the panel located in the Terminal C Core.

The design firm shall analyze the panels that are fed from Substation MSGR B1 & B2.

The design firm shall analyze the panels that are fed from Substation SWBD A2.

The systems covered in this specific portion of the report will address the electrical distribution between the main switchgear and substation.

An estimated 10,000 kVA will be required for the new Pier D1. It is recommended to place two substations along the pier D1, providing better load distribution. It will be located in the respective electrical room. See **Figure 7.2.4**.

An estimated 4,000 kVA will be required for the new Central Core area. It is recommended to place a substation as shown in **Figure 7.2.4**.

Electrical feeders are to be installed in underground duct banks. Duct bank design shall include conduits for Phase 3 feeders to Terminal D and Pier 2.

A generator may be needed to provide temporary service in the construction area.

There is a need to develop a new grounding system to cover the newest terminal building. This new grounding system shall be connected to the existing grounding loop. The final sizing shall be done during the final design phase. In addition, ground bus assemblies should be installed in all new electrical, radio antenna, and data rooms. It is recommended that ground bus assemblies be added to the existing electrical.

The ground bus assemblies should then be connected to one another. At a minimum of four points, the ground bus assemblies should then be connected to the ground loop in the ground. The contractor should test the entire system to ensure compliance with NEC.

7.2.3.7 Natural Gas

The new terminal will have an estimated natural gas demand of 62,000 CFH. Therefore, in this phase a new 6 inch natural gas line will be brought from a meter of 42,000 CFH located at the west side of the new terminal. This line will serve the new Pier D1 and the new Central Core. Natural gas will enter Terminal D1 through a new gas meter. The meter will be located at the south side of the building. The pipe will tap into the CNP existing natural gas main located in the North Terminal Road. See **Figure 7.2.3**.

The existing natural gas lines serving Terminal C North will be demolished during this phase. The existing gas lines on the west side of Terminal D will also be demolished.

- Keep existing gas branch line (former Terminal C) and replace meter to serve Pier D1.

7.2.3.8 Fire Suppression

- Install fire protection water connection to Terminal D1 from DW/FP pipe loop.
- Install fire protection water connection to Terminal D1/D2 connector from DW/FP pipe loop.
- See **Figure 7.2.5**

7.2.3.9 Fire Alarm

A new fire alarm system will need to be installed, tested, and commissioned prior to the completion of Phase 2 construction. The fire alarm control room will have to be constructed in order to provide a centralized fire department response location. This fire alarm control room will need to be no less than 150 sf. This effort will need to be coordinated with the Houston Fire Department, and the new fire alarm panel will need to be tied back in to the main airport-wide fire alarm system.

7.2.4 SITE UTILITIES

In order to support the additional utility demands due to the construction of MLIT, Pier D1 and Central Core, additional utility distribution infrastructure will need to be integrated with the construction.

7.2.4.1 12.5 kV Site Power

In order to support the estimated 20,000 kVA of additional connected load located in the new MLIT program, a new 12.5 kV double ended switchgear will be added in the new main electrical room located in Pier D1. New 15 kV feeders will be run from the new 12.5 kV substation to the main electrical room. The new 15 kV, 20 MVA feeders will run through a Utility Corridor, in 6 inch conduits, with code required clearances. Dual redundant feeders, each capable of handling the full 20 MVA load of the new terminal, will be provided. Each feeder will be a redundant feeder from separate substations, IT and GR.

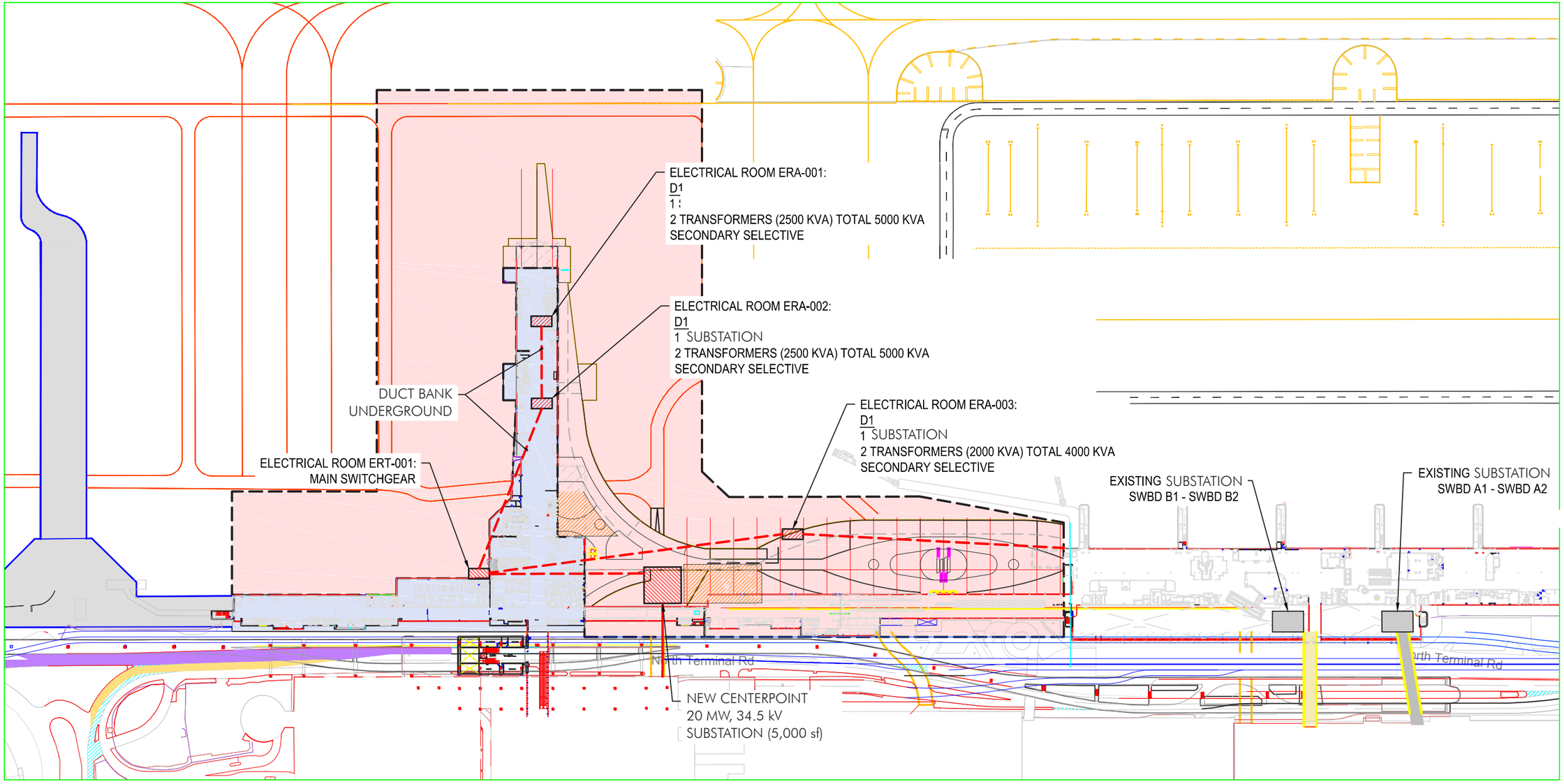
A new duct bank, capable of handling the existing Terminal C South, Vault, and Parking Garage loads will be stubbed out in this phase, for connection to the C Core CenterPoint Substation room in a separate phase.

The existing 12.5 kV CenterPoint service to the existing Terminal D will be maintained, with only those feeders to panels that feed existing portions of the terminal being demolished and removed. This drop-in load will have to be calculated by the designer, and coordinated with CenterPoint. See **Figure 7.2.6**.

7.2.4.2 Site Communication/IT

In order to support the new terminal, a new 1,500 square foot MDF will have to constructed early in Phase 2. This will allow time for the new systems to be tested and commissioned prior to starting Phase 3. During Phase 2, and prior to the demolition of the existing MDF in Phase 4C, all existing systems, including the Fiber optic Backbone will have to be cut-over to the new MDF. The existing PBX system in the existing Terminal D MDF will have to be systematically cut over to the new MDF as the airport-wide telephone system transitions to VOIP. In addition the airport FO going through the existing MDF will need to be protected in place until the new Terminal D MDF is operational, and a new FO bypass route is available that can support the systematic cut-over of the existing FO system. See **Figure 7.2.7**.

Power Distribution - Phase 2 (A, B & C)



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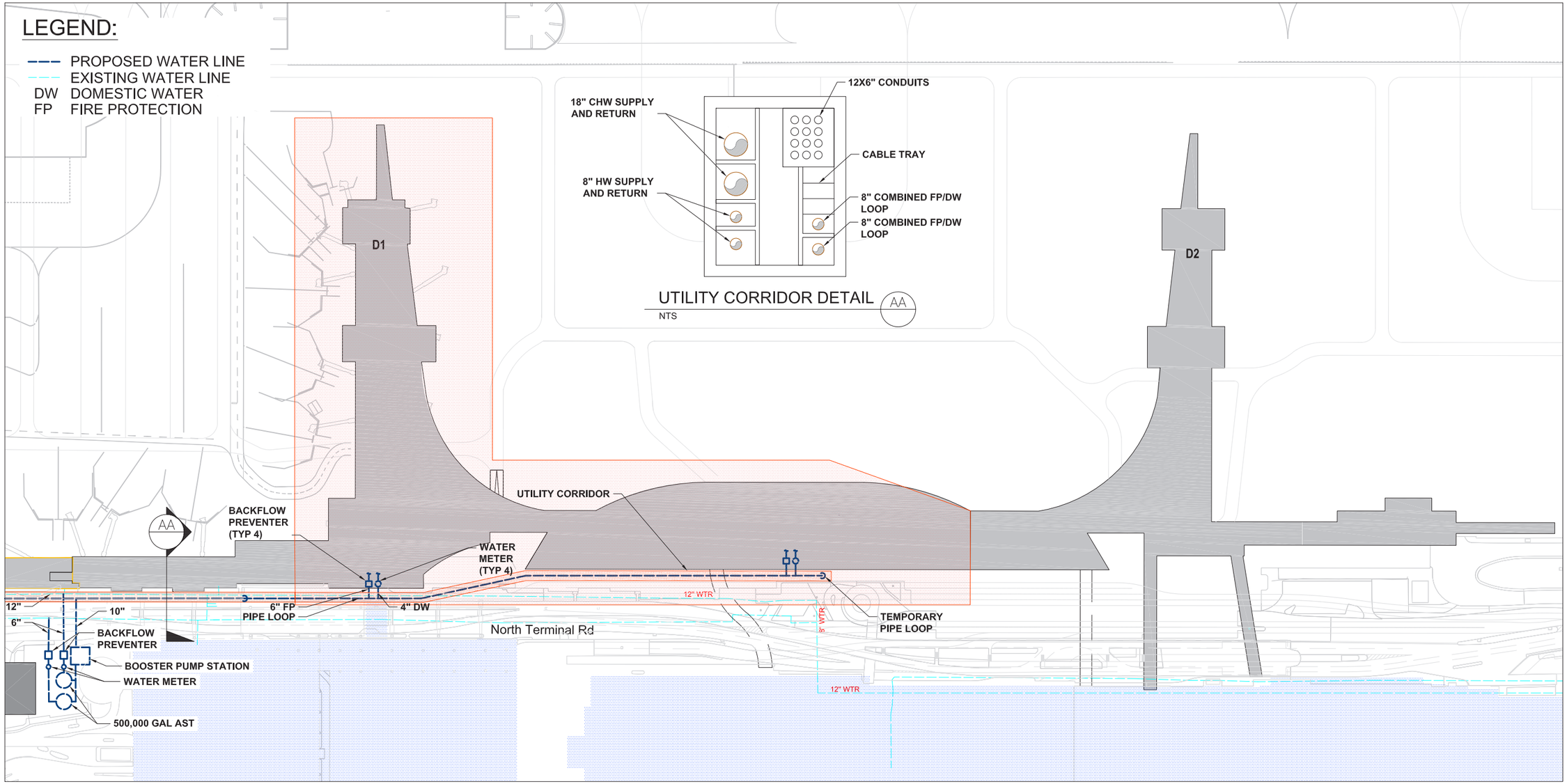
Proposed Domestic Water/Fire Protection - Phase 2



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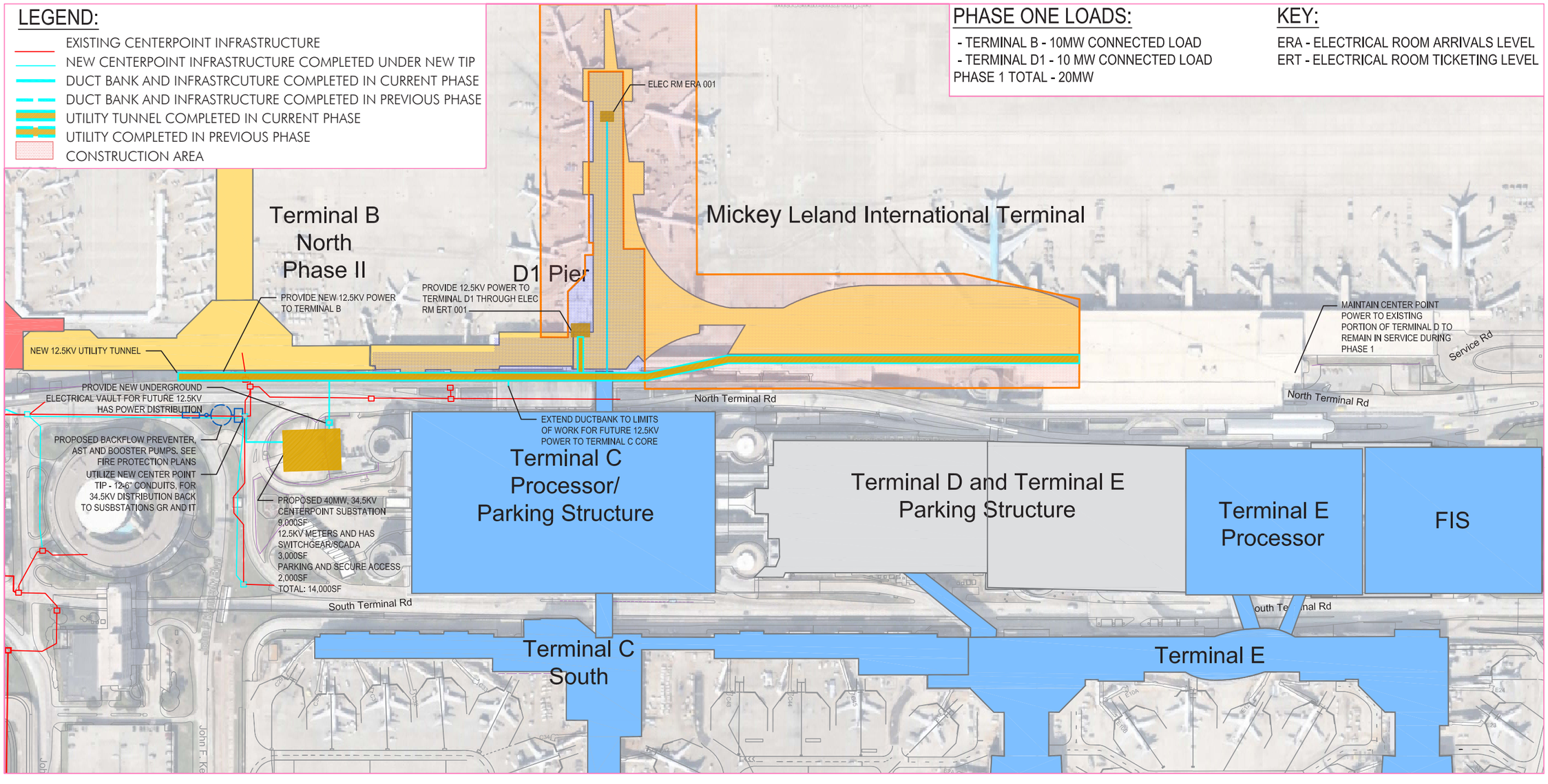
Phase 2 - Option 1 12.5 kV Distribution



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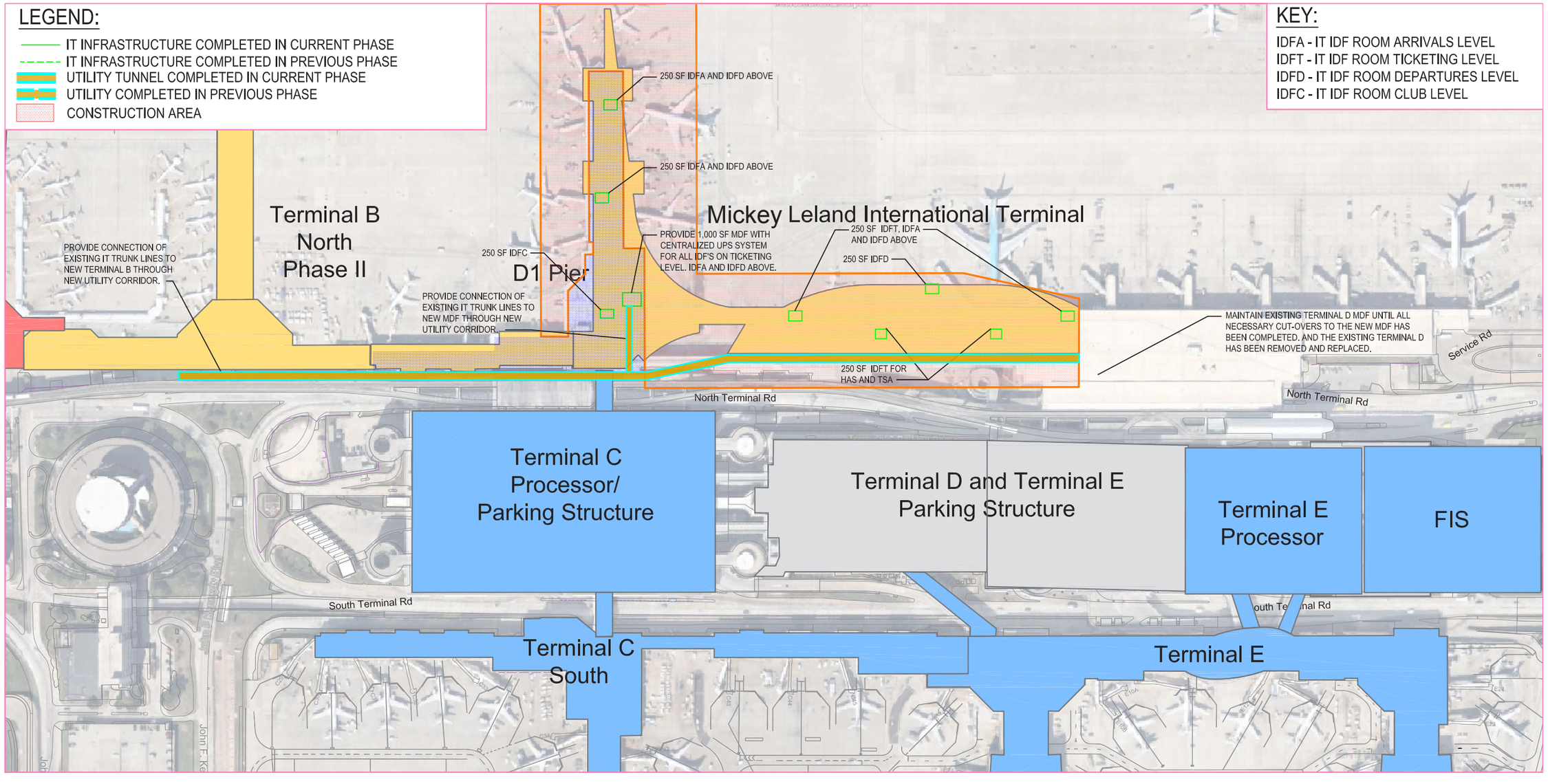
Phase 2 IT Distribution



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The new MDF room will be located at the base of the Terminal D1 pier. This location will required additional F.O. ducbanks run along the front of the existing Terminal D to allow for the cut-over of existing F.O. and copper trunk lines, allowing for a more expedient cut-over. The new MDF will also be a central connection point for all telephone and cable TV connections, including fiber optic converters, Cisco type routers and switches, centralized telephone and fire alarm interface for the PA system, central building management control center, energy management system, wireless network, radio communications, data communications, head units for eVIDS, as well as ACS and CCTV. With a basic level of service required for the baseline operation of the systems required for the new terminal, the MDF room should be no less than 1,000 sf, and be located at the first point of entrance into the terminal for all communications systems. In addition, to support the cut-over of the existing PBX system an additional 500 sf should be provided. The MDF room will provide a central hub for communications distribution to 12 smaller telecommunications rooms or Intermediate Distribution Frame (IDFs) located throughout the terminal. The MDF room shall have all systems backed up with a UPS to maintain system power during brownouts. It is recommended that a centralized UPS system be provided in the main electrical room in order to provide flexibility for future expansion or service redistribution. See **Chapter 5** for new telecommunication room locations.

The smaller, 250 square foot IDFs will be installed as construction allows, and do not need to be tested and commissioned until their respective gates need to be used. They will house routers for connections to local airline GIDS; connections to airline and passenger WiFi routers; local eVIDS systems; amplifiers, noise sensors and network switches for local PA systems; ACAMS security panels for local doors; CCTV network hubs for signal consolidation and local viewing if required by individual airlines; local fire alarm sub-panels and UPS units to maintain system power during brownouts or during generator start-up. The IDFs will then connect to smaller telecommunications closets located at each gate pod. These closets will be limited to Passenger Boarding Bridge (PBB) support and monitoring systems and phones. All other systems including ACS, VDGS, CCTV and PA shall be routed back to the nearest IDF room. This is to ensure that when the gate is being utilized for boarding an aircraft, critical systems will still be accessible without disrupting passenger traffic. Each IDF shall be connected to the centralized UPS system for emergency power.

In addition each IDF and MPOE/MDF will have a dedicated UPS powered air-conditioning unit separate from the terminal cooling system, to allow for whole room cooling during extended blackouts.

Existing fiber optic cables from the existing Terminal D MDF go to Terminal C and Terminal B, through the existing C and B Connectors. These cables will have to be intercepted and re-routed as part of Phase 1 work, prior to the start of demolition. See **Figure 7.2.7**.

7.2.4.3 Water System

- Extend utility corridor in area of concern.
- Create temporary pipe loop in utility corridor at end of construction zone.
- Install domestic water connection to Terminal D1 from DW/FP pipe loop.
- Install domestic water connection to Terminal D1/D2 Connector from DW/FP pipe loop.
- See **Figure 7.2.5**

7.2.4.4 Sanitary Sewer System

Sequencing of the new sanitary sewer system construction will closely follow that of the terminal and piers with some exemptions. The system is recommended to be constructed in four phases. **Figure 7.2.8** shows recommended sections for Phase 2.

It should be noted that existing Terminal D lift stations that will remain in service during Phase 1 and Phase 2, have been upgraded recently and have the capacity to handle the existing Terminal D and the new Pier D1 sanitary sewer loads. Construction of the new sanitary sewer lift station and force main, due to selected location and nature of its' use, could be constructed independently and ahead of planned Phase 2A. Similarly, the new triturator, recommended to be constructed east of Taxiway NN, could be constructed independently and ahead of Phase 1 or during the Phase 1 construction duration.

7.2.4.5 Apron Grading and Drainage

The proposed drainage system is composed of three subsystems serving three different parts of the facility. Accordingly, construction of each drainage subsystem needs to follow the construction of the facilities it serves. See **Figures 7.2.9**.

- Pump Stations No. 4 and No. 5: These pump stations lift the road side drainage stormwater and discharge it into the storm sewer box culverts located just north of North Ramp. Relocation of Pump Station No. 4 is recommended for Phase 1 duration and relocation of Pump Station No. 5 is recommended for Phase 3 duration.
- Roof Drainage System: The proposed construction sequences are Phase 1 through Phase 3, following the construction of the new terminal and new piers. The proposed roof drainage is composed of five (5) independent segments that will ease their construction without being dependent on other Phases.
- Apron Surface Runoff Collection System: As shown on the proposed storm sewer **Figure 7.2.9**, use of the existing collection system has been maximized. In addition, the network has been broken down into three independent segments to ease construction phasing. However, the drainage network construction sequence needs to follow the apron paving phasing.

The airside water demand is limited to the storm sewer environmental protection system. Though portions of the existing storm sewer, due to apron grading change, will be removed and a new line will be installed, the total water demand will not change and the majority of the existing waterlines could be reconnected and reused. Phasing shall follow the phasing for new storm sewers and apron pavement phasing.

7.2.4.6 Hydrant Fueling

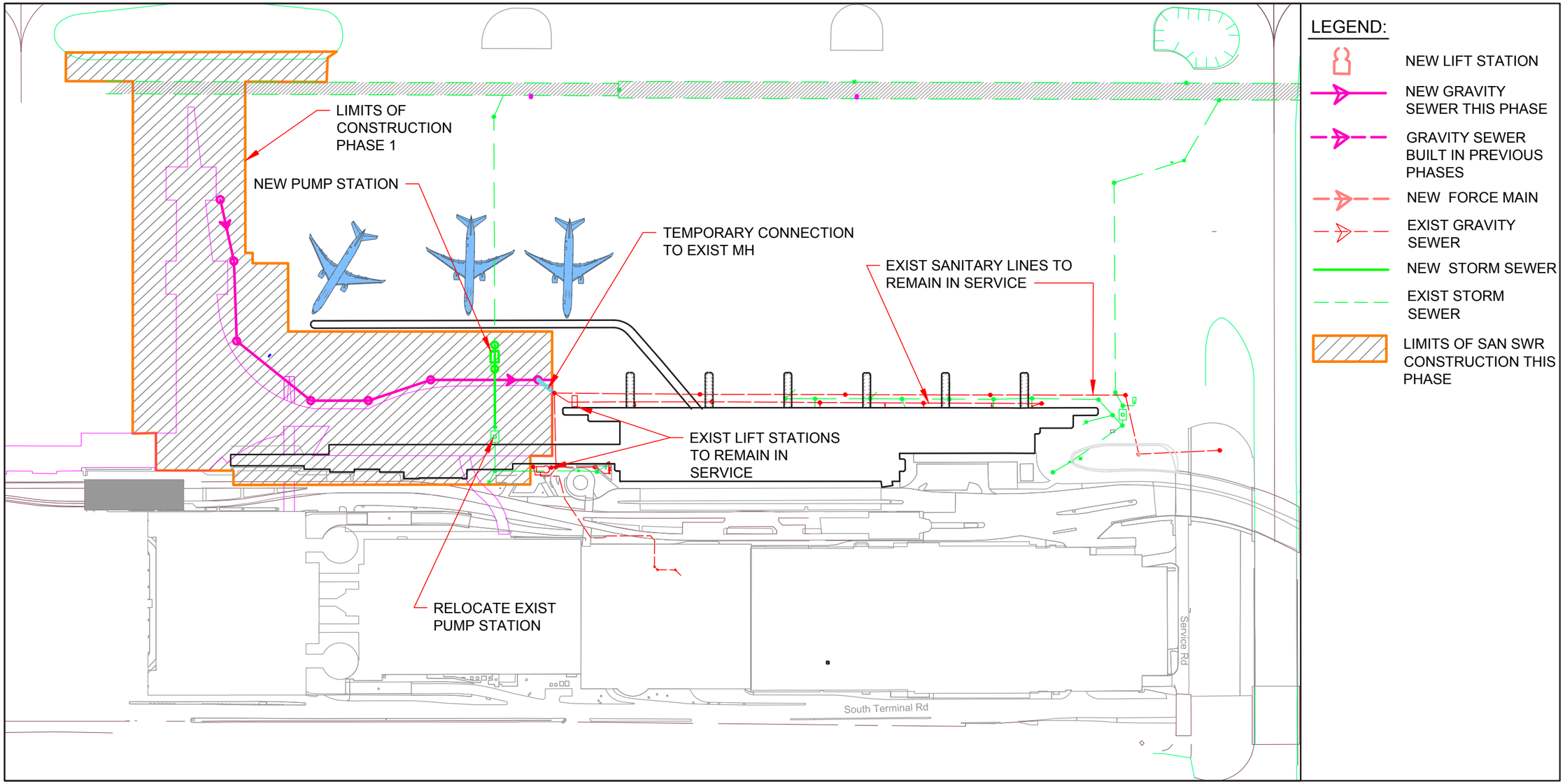
Phase 2 involves the construction of the new Terminal D1. **Figure 7.2.10** shows the four 16 inch diameter fuel mains extending east, adjacent to the taxiway. The existing 16 inch diameter fuel mains are demolished through the construction zone. In addition, the hydrant fuel lines surrounding the existing Terminal C are demolished.

New 12 inch diameter hydrant fuel lines are planned for Terminal D1. The hydrant fuel lines are routed at a distance of 125 ft from the building face. The hydrant fuel lines are an extension from the Terminal B system. To maintain 12 inch pipe size, the hydrant lines are tied into the main lines in an isolation valve vault located on the north side of Pier D1. This completes the hydrant loop around the two Piers B and D1. Two fuel hydrant pits are provided for each aircraft parking position.

7.2.5 Landside

During Phase 2 of construction the Terminal D parking helix will be demolished and removed to allow construction of the new Terminal D landside. Once the helix is demolished the western portion of the new Terminal D curbside and connection to the North Terminal Roadway will be constructed. During Phase 2 construction, operations will be maintained on the existing Terminal D access roadway and prior to beginning Phase 3 construction a two lane connector will be constructed between the west end of the existing Terminal D curbside and the newly constructed curbside (see **Figure 7.2.11**).

Proposed Sanitary Sewer - Phase 2



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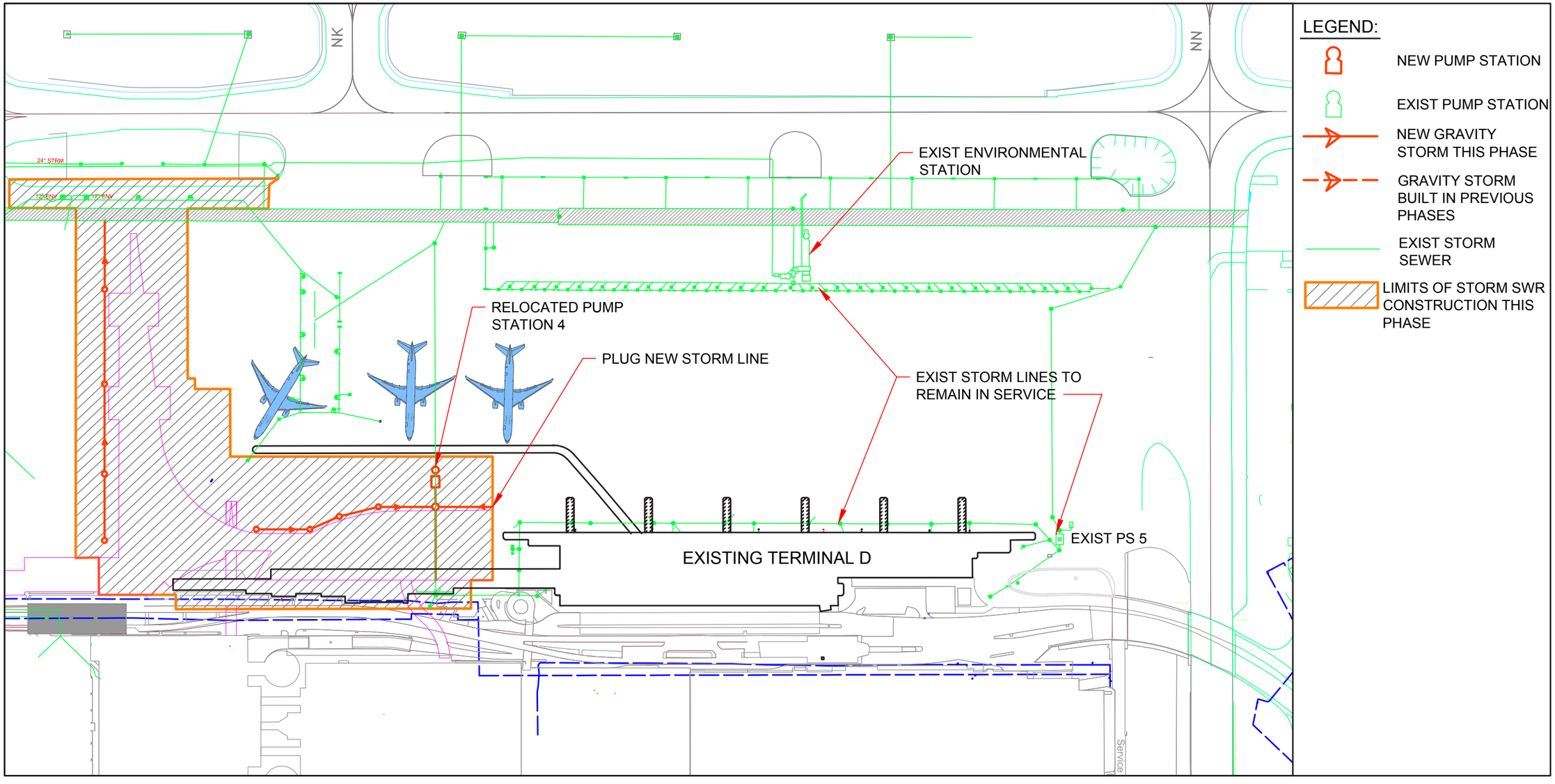
Proposed Storm Sewer - Phase 2



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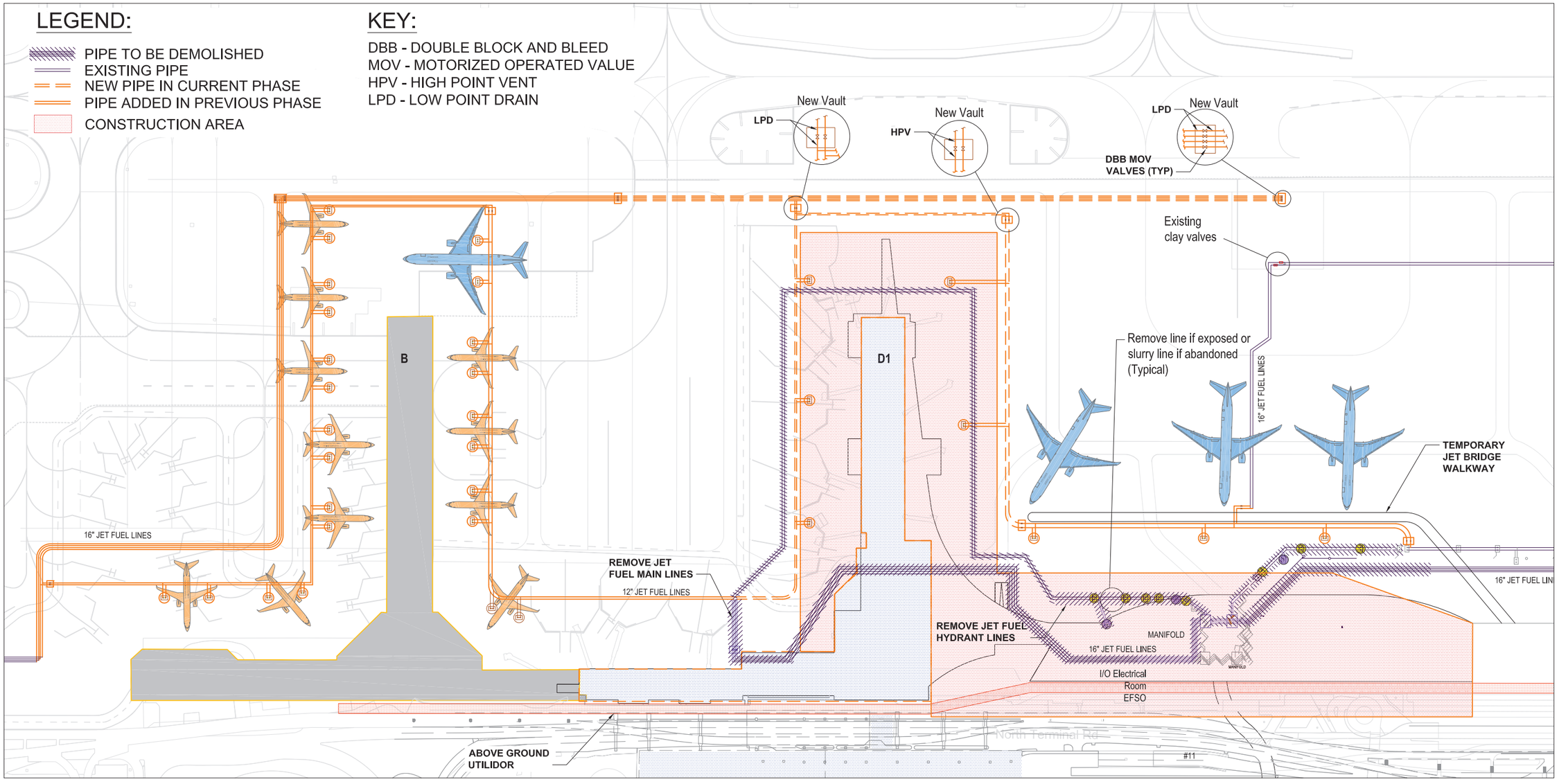
Proposed Hydrant Fueling - Phase 2



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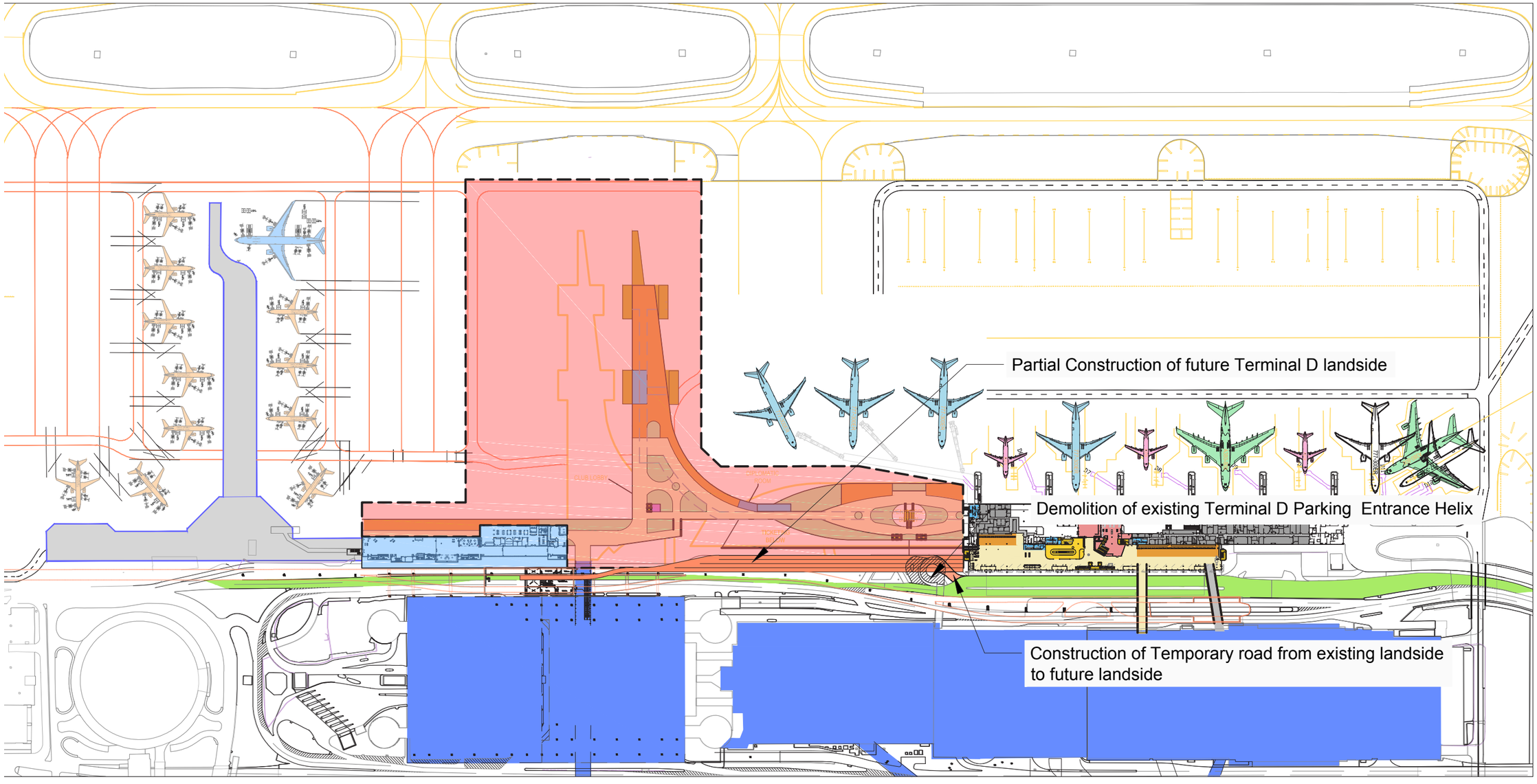
Landside - Rebuild (Phase 2)



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7.3 PROGRAM PHASING: Phase Three

Phase 3 includes additional demolition of portions of the existing Terminal D as well as the construction of the D2 Pier. There are three subphases of Phase 3, and each is described in more detail in the sections below. See **Figure 7.3.1**.

At the completion of Phase 2, passenger operations have now begun in the new MLIT Terminal Processor including check-in and passenger security and the new central concessions core is open. Gate operations are in use on the D1 Pier as well as on the frontal gates. In total eight wide-body international gates are now operating from these new facilities along with gates D10, D11, and D12 in existing Terminal D. The new Sterile Corridor on the upper level of the facility is in use tying into the existing Terminal D Sterile Corridor via a temporary vertical circulation core.

At this point the passenger processing functions of Terminal D, such as check-in and security screening, have been decommissioned; however, portions of Terminal D remain in use throughout Phase 3. Gates D10, D11, and D12 remain in use on the eastern portion of Terminal D, and the existing baggage screening and makeup operations continue to be in use. Portions of the building must also remain open in order to accommodate the international sterile corridor connection to the FIS as well as to accommodate passenger traffic to/from the new MLIT terminal processor and existing Gates D10, D11, and D12.

1. Occupy and begin operations of the new D1 Pier and western 2/3s of the new MLIT Central Core, as well as the west half of the new landside roadway and utilities;
2. Construction of new D2 Pier and northeast portion of MLIT central core.
3. Demolition and reconstruction of concrete apron pavements and underground utilities located in the west side area of new D2 Pier.

7.3.1 Terminal Building

Phase 3A completes temporary modifications to, and additional partial demolition of, existing Terminal D in preparation for the construction of the new D2 Pier.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Prepare a temporary public circulation corridor through existing Terminal D that connects the new MLIT to existing gates D10, D11, and D12 in order to enable the demolition of the portion of the northern face of Terminal D required to construct the D2 Pier. This will include a vertical elevation difference of 5′ (116′ at MLIT and 121′ at existing Terminal D)
  - Prepare a temporary sterile circulation corridor between the new MLIT and the bridge to the FIS facility that enables the demolition of a portion of the northern face of Terminal D required to construct the D2 Pier. This will include a vertical elevation difference of 23′ (134′ at MLIT and 111′ at existing Terminal D)
  - Demolish the northern structural bay of the existing Terminal D between the new MLIT and the location of the east side of the proposed D2 pier.

Phase 3B is the second major construction phase of the MLIT program. This phase constructs the new D2 Pier and the northeast portion of the MLIT Central Core.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Construct the new D2 Pier and northeast portion of the MLIT central core.
  - Construct the apron on the west side of the D2 Pier.
  - Construct a new crossover from the baggage takeaway belts in the check-in lobby to the new baggage screening system and outbound baggage makeup functions under the new D2 Pier.

Phase 3C incrementally activates the new D2 Pier. The gates on the west side of the pier open first, while gates on the east side require additional apron phasing to continue to maximize the gate count.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Activate the west side gates of the new D2 Pier.
  - Activate the new inline baggage screening and outbound baggage makeup system.
  - Demolish and reconstruct the final apron and underground utilities on the east side of the D2 Pier.
  - Activate the east side gates of the new D2 Pier.

7.3.1.1 Ticketing/Check-In Plan (Level 88)

The new Ticketing Hall opens at the start of Phase 3 and the existing eastern Ticketing Hall/SSCP is closed.

Airline ticketing operations will move into the new facility and bags will be processed through the new baggage screening and sortation system. The baggage facilities in the existing east landside Terminal D and the baggage sortation area will be decommissioned.

7.3.1.2 Chilled Water System

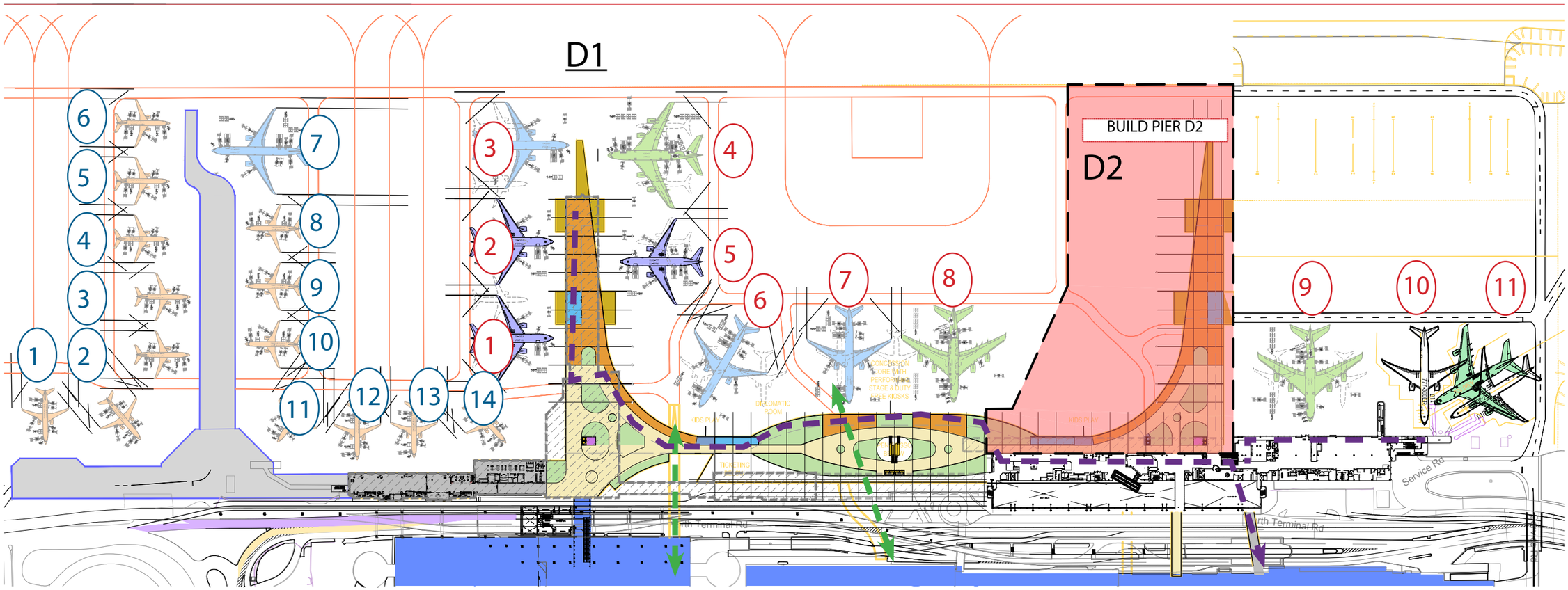
During the demolition of the central concourse of the existing D Concourse (Phase 3C), all the chilled water piping serving this area of the phasing will be disconnected. The ticketing and east side of Terminal D will remain in operation with chilled water and hot water service from the existing Terminal D main mechanical room.

In Phase 3D, chilled water lines from the booster pumps in MRT-001 will be extended to serve air handling units in the new Pier D2 MRA-004, MRR-002, MRA-005, and MRA-006. Chilled water lines will be extended toward the south side of Pier D2 and capped for continuation of the distribution in the next phase. The design firm will determine the size of the lines according to the demand of the areas. See **Figure 7.3.2**.

7.3.1.3 Hot Water System

During the demolition of the central concourse of the existing D Concourse (Phase 3C), all the hot water piping serving this area of the phasing will be disconnected. The ticketing and east side of Terminal D will remain in operation with chilled water and hot water service from the existing Terminal D main mechanical room.

Phase 3



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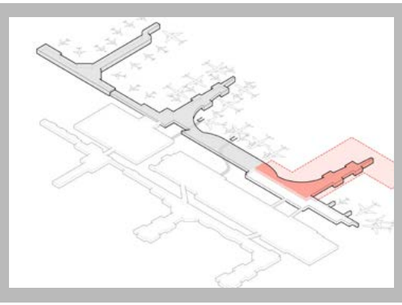


PHASE 3 HIGHLIGHTS:

- PHASE 3A - OPEN NEW D1 PIER, CENTRAL CORE & WEST LANDSIDE
- PHASE 3B - REWORK STERILE CORRIDOR THRU EXISTING D
- PHASE 3C - DEMO CENTRAL PORTION OF EXISTING D CONCOURSE
- PHASE 3D - BUILD NEW D- PIER AND EAST CENTRAL CORE COMPLETION

STERILE CORRIDOR

EXISTING TUNNEL OPEN

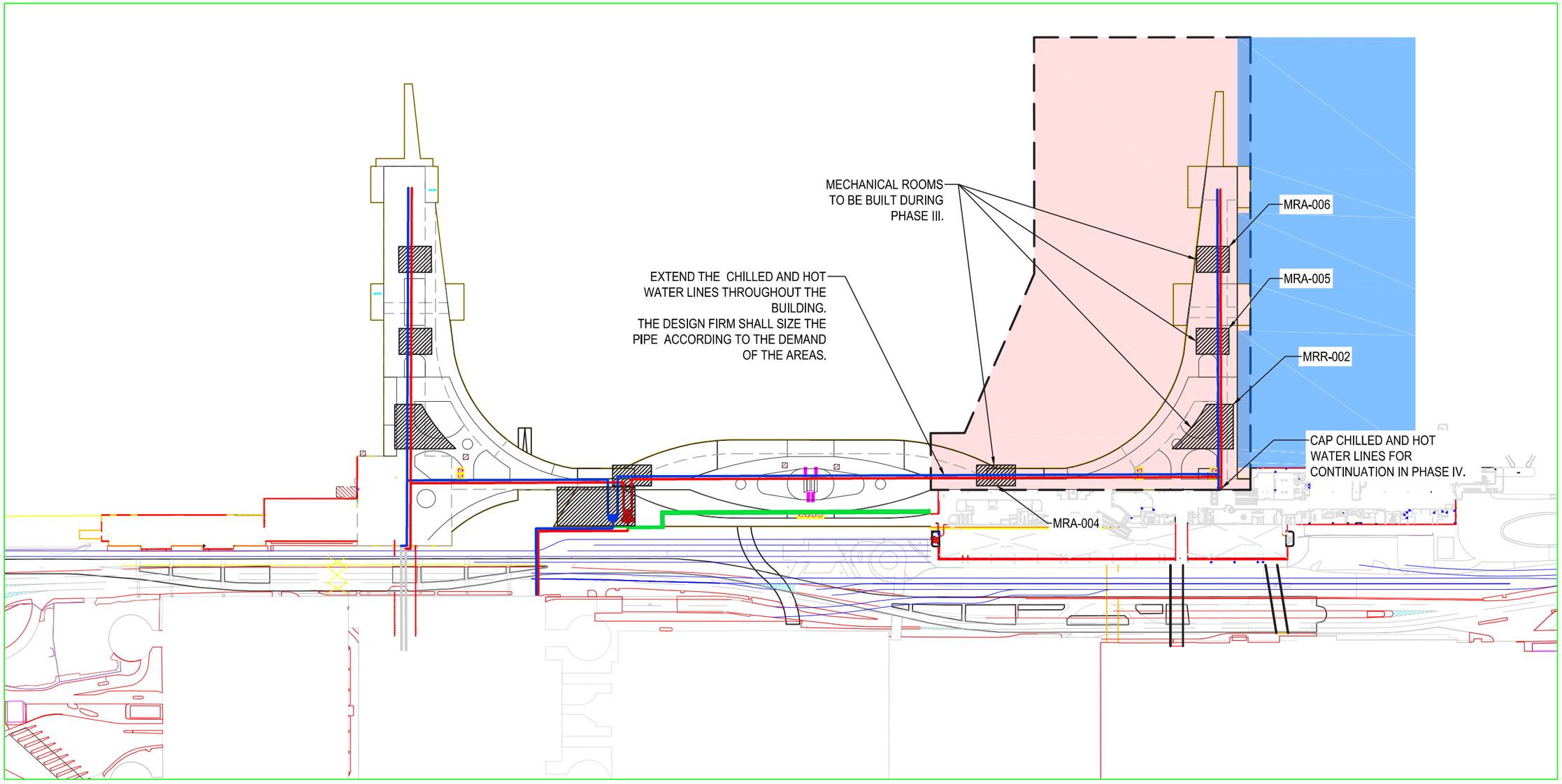
EX TUNNEL CONSTRAINED

GATES

INTL GATES - 11

DOMESTIC - 14

Chilled and Hot Water Pipe Routing - Phase 3 (A, B, C & D)



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In Phase 3D, secondary hot water lines from MRT-001 will be extended to serve air handling units in the new Pier D2 MRA-004, MRR-002, MRA-005, and MRA-006. Secondary hot water lines will be extended toward the south side of Pier D2 and capped for continuation of the distribution in the next phase. The design firm will determine the size of the lines according to the demand of the areas. See **Figure 7.3.2**.

7.3.1.4 HVAC

The existing air duct distribution, HVAC units that serve the north central side of Terminal D shall be disconnected to start building the new Pier D2.

During Phase 3C the following mechanical rooms will be built:

- MRA-004: Located in the Apron Level, this room will be housing HVAC units that will serve the area east of the central side of the Apron and Departure Levels.
- MRA-005: Located in the Apron Level, this room will be housing HVAC units that will serve the area south and southeast of D2 on the Apron and Departure Levels.
- MRA-006: Located in the Apron Level, this room will be housing HVAC units that will serve the north side and part of the south side of D2 on the Apron and Departure Levels.
- MRR-002: Located on the east side of the roof, this room will be housing HVAC units that will serve the new Pier D2 and the east side of the Central Core of the Club Level. See **Figure 7.3.2**.

7.3.1.5 Domestic Water System

During this phase the domestic water lines of the Central Concourse of the existing Terminal D will be demolished.

As the rebuild of this area begins, the new domestic water lines will be extended toward the northeast and the east to serve the new Pier D2. These lines will be routed toward the east to extend the service to the areas that will be built in the next phase. Domestic water heaters will be installed in areas requiring them. See **Figure 7.3.3**.

7.3.1.6 Sanitary Waste and Vent System

In this phase the sanitary collector lines of the Central Concourse of the existing Terminal D will be demolished.

Once the rebuilding of the area in the current phase starts, the 8 inch sanitary sewer lines installed in the previous phase will be extended toward the new Pier D2 adding approximately five 6 inch drop lines over these lines on each level. The new 8 inch lines will be capped for continuing the distribution as the rebuild in the phase begins. See **Figure 7.3.3**.

7.3.1.7 Electrical System

The systems covered in this specific portion of the report will address the electrical distribution between the main switchgear and substations.

An estimated 10,000 kVA will be required for the new D2 Pier. It is recommended to place two substations along the D2 Pier, providing better load distribution. It will be located in respective electrical room. See **Figure 7.3.4**.

The northeast portion of MLIT Central Core will be fed from the substation located in the electrical room ERA 004, on the west side of the Central Core.

The design firm shall analyze the panels that are fed from substation SWBD A1 and SWBD A2. See **Figures 7.3.5** and **7.3.6**.

During this phase the natural gas lines of the Central Concourse of the existing Terminal D will be demolished.

7.3.1.8 Natural Gas

During this phase the natural gas lines of the central concourse of the existing Terminal D will be demolished.

Once the rebuild of this area begins, a new natural gas meter of 20,000 CFH will be installed. From this meter a new 4 inch natural gas line will be brought to serve the new Pier D2 and the east side of the new terminal as the phasing progresses. See **Figure 7.3.3**.

- Install new gas branch line, from CNP 2 inch main line, to the south end of the D2 Pier.
- See **Figure 7.3.7**

7.3.2 SITE UTILITIES

In order to support the additional utility demands due to the construction of the new D2 Pier and the East Central Core, additional utility distribution infrastructure will need to be integrated into the construction.

7.3.2.1 12.5 kV Site Power

As the new terminal continues to expand with the addition of D2 Pier, the load on the new service will continue to expand, and the existing 12.5 kV CenterPoint service to the existing Terminal D, will be maintained, with only those feeders to panels that feed existing portions of the terminal being demolished and removed. This drop-in load will have to be calculated by the designer, and coordinated with CenterPoint. See **Figure 7.3.8.**

7.3.2.2 Site Communication/IT

New IDFs installed in this phase shall be connected back to the new MDF in a traditional hub and spoke arrangement. Demolition and removal of existing equipment shall be coordinated with HAS, as much of the existing equipment has been recently upgraded and may have significant salvage value to the airport.
See **Figure 7.3.9**.

7.3.2.3 Water System

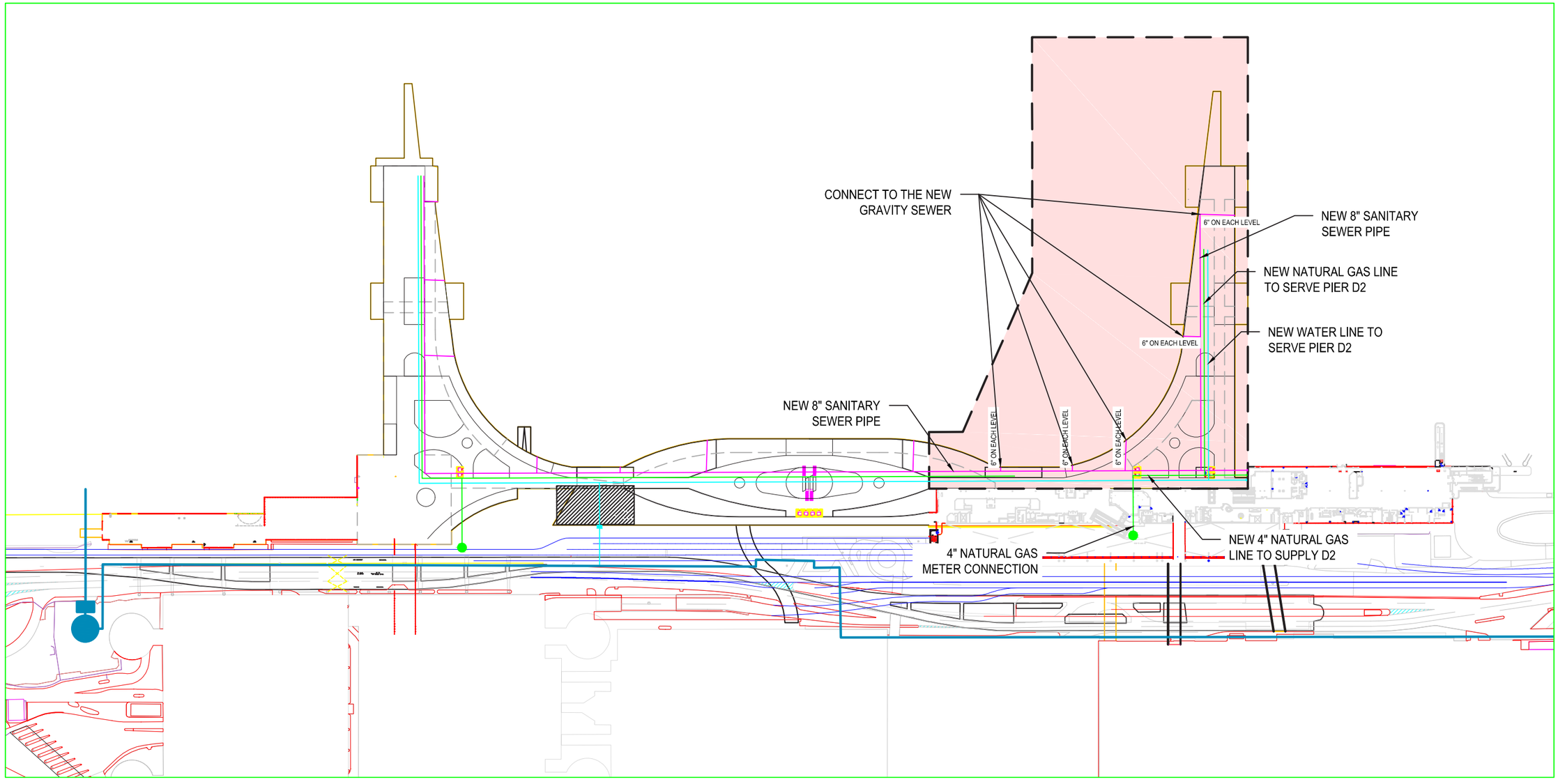
- Extend utility corridor in area of concern.
- Create temporary pipe loop in utility corridor at end of construction zone.
- Install domestic water connection to Terminal D2 from DW/FP pipe loop.
- See **Figure 7.3.10**

7.3.2.4 Sanitary Sewer System

Sequencing of the new sanitary sewer system construction will closely follow that of the terminal and piers with some exemptions. The system is recommended to be constructed in four phases. **Figure 7.3.11** through **Figure 7.3.12** shows recommended for Phase 3. It should be noted that existing Terminal D lift stations that will remain in service during Phase 1 and Phase 2, have been upgraded recently and have the capacity to handle the existing Terminal D and the new Pier D1 sanitary sewer loads.

Construction of the new sanitary sewer lift station and force main, due to selected location and nature of its use, could be constructed independently and ahead of planned Phase 2A. Similarly, the new triturator, recommended to be constructed east of Taxiway NN, could be constructed independently and ahead of Phase 1 or during the Phase 1 construction.

Plumbing Pipe Routing - Phase 3 (A, B, C & D)



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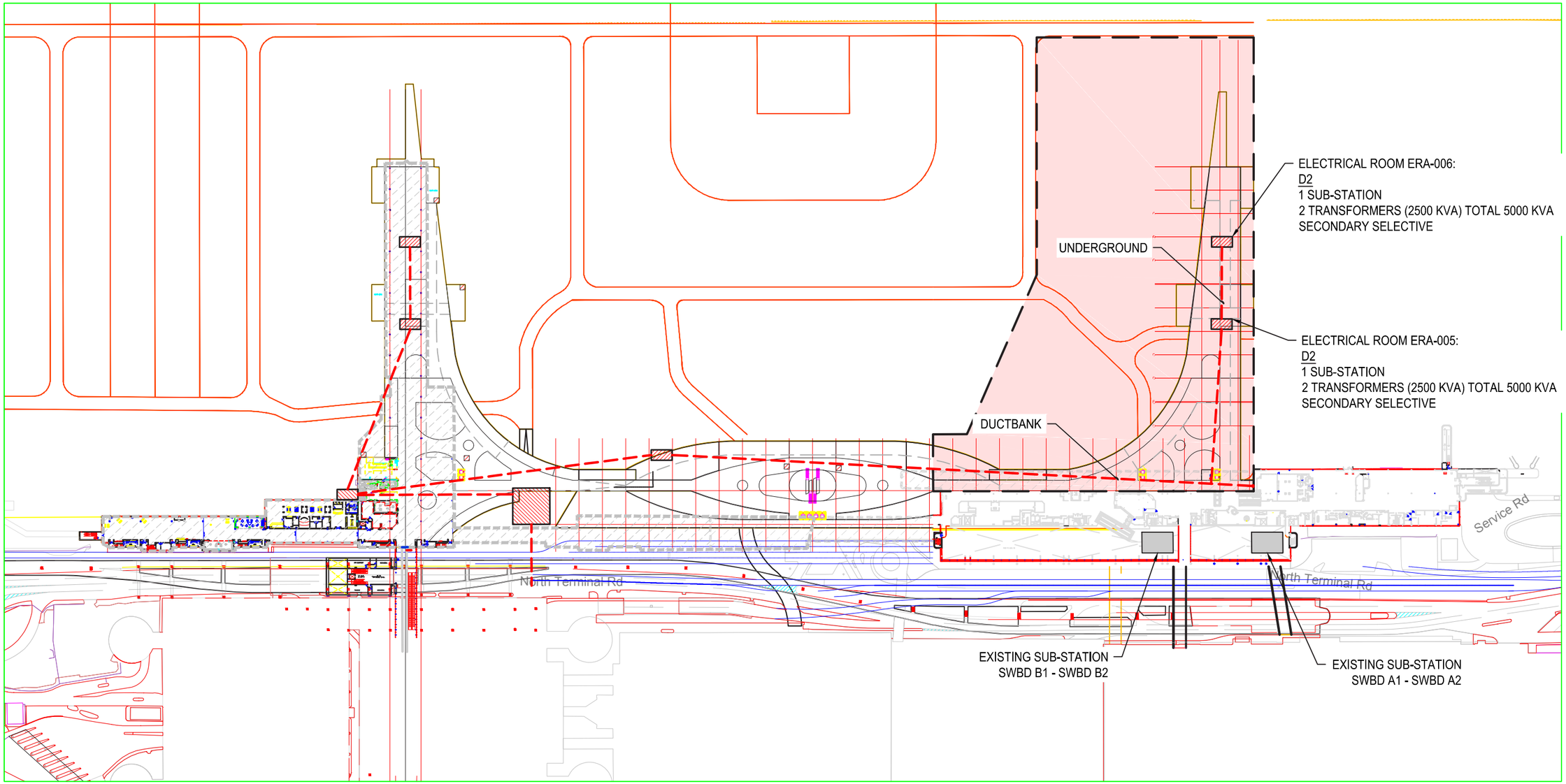
Plumbing Pipe Routing - Phase 3 (A, B, C & D) Fig 7.3.3

Power Distribution - Phase 3 (A, B, C & D)



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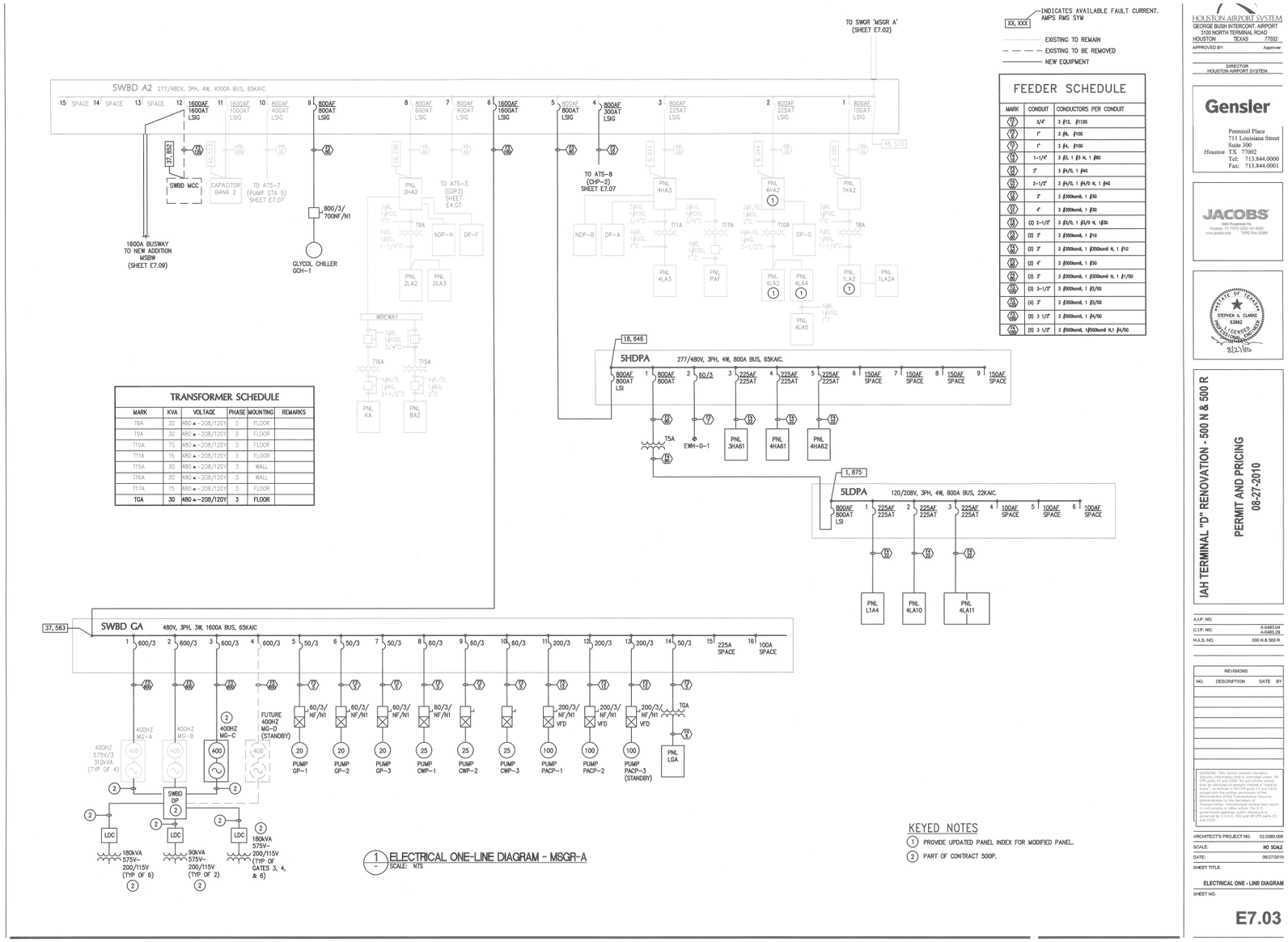
Electrical One-Line Diagram - MSGR-A



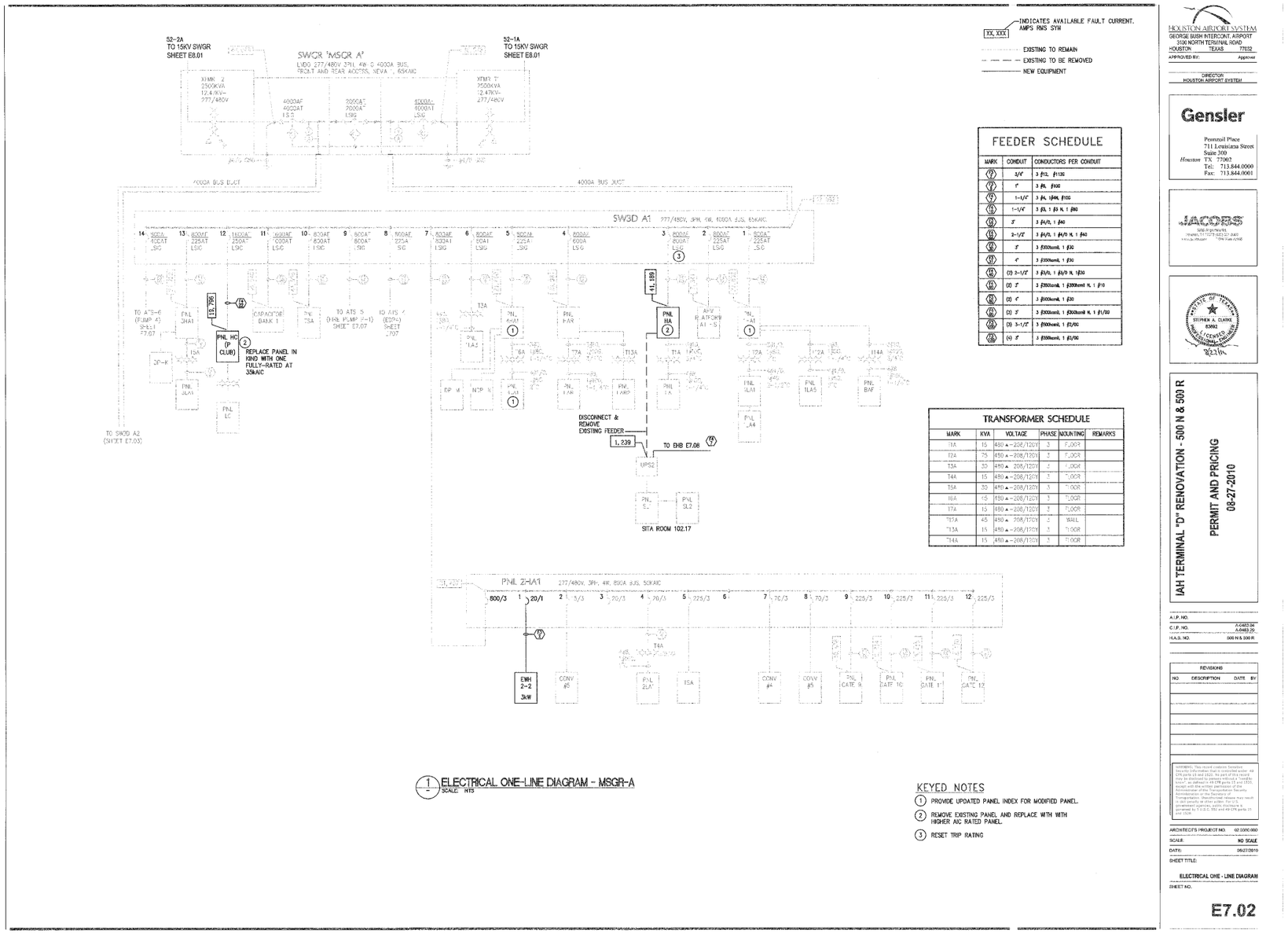
FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
F1	3/4"	3 #12, #12G
F2	1"	3 #8, #10G
F3	1"	3 #4, #10G
F4	1-1/4"	3 #3, 1 #3 N, 1 #8G
F5	3"	3 #4/0, 1 #4G
F6	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
F7	3"	3 #300kcmil, 1 #3G
F8	4"	3 #350kcmil, 1 #3G
F9	(2) 2-1/2"	3 #3/0, 1 #3/0 N, 1#3G
F10	(2) 3"	3 #350kcmil, 1 #1G
F11	(2) 3"	3 #350kcmil, 1 #300kcmil N, 1 #1G
F12	(2) 4"	3 #500kcmil, 1 #3G
F13	(3) 3"	3 #500kcmil, 1 #300kcmil N, 1 #1/0G
F14	(3) 3-1/2"	3 #500kcmil, 1 #2/0G
F15	(4) 3"	3 #350kcmil, 1 #3/0G
F16	(5) 3-1/2"	3 #500kcmil, 1 #4/0G
F17	(5) 3 1/2"	3 #500kcmil, 1#500kcmil N,1 #4/0G

TRANSFORMER SCHEDULE

MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T8A	30	480 Δ - 208/120Y	3	FLOOR	
T9A	30	480 Δ - 208/120Y	3	FLOOR	
T10A	75	480 Δ - 208/120Y	3	FLOOR	
T11A	15	480 Δ - 208/120Y	3	FLOOR	
T15A	30	480 Δ - 208/120Y	3	WALL	
T16A	30	480 Δ - 208/120Y	3	WALL	
T17A	15	480 Δ - 208/120Y	3	FLOOR	
TGA	30	480 Δ - 208/120Y	3	FLOOR	

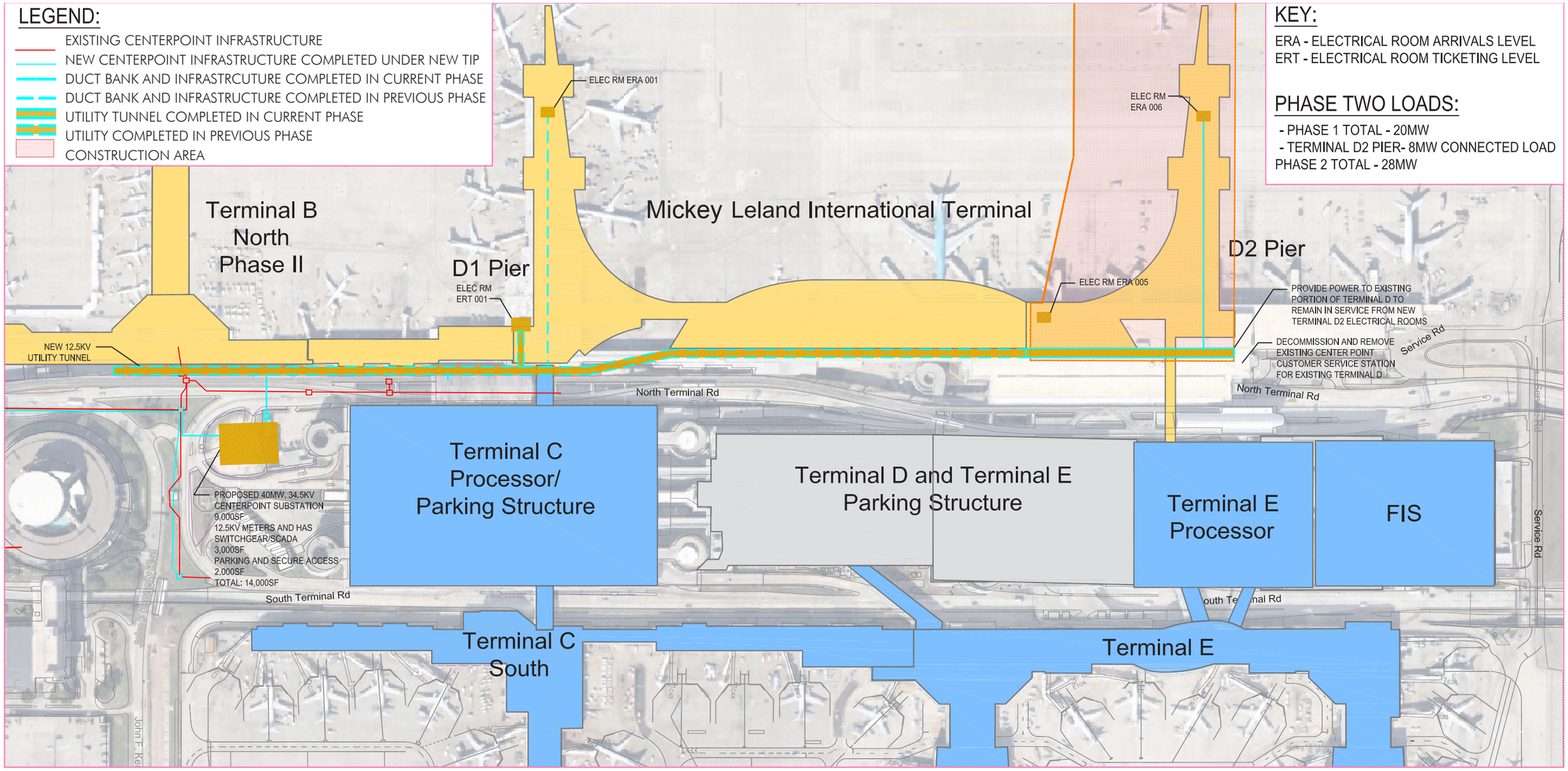
Electrical One-Line Diagram - MSGR-A



Proposed Natural Gas - Phase 2

0′ 100′ 200′

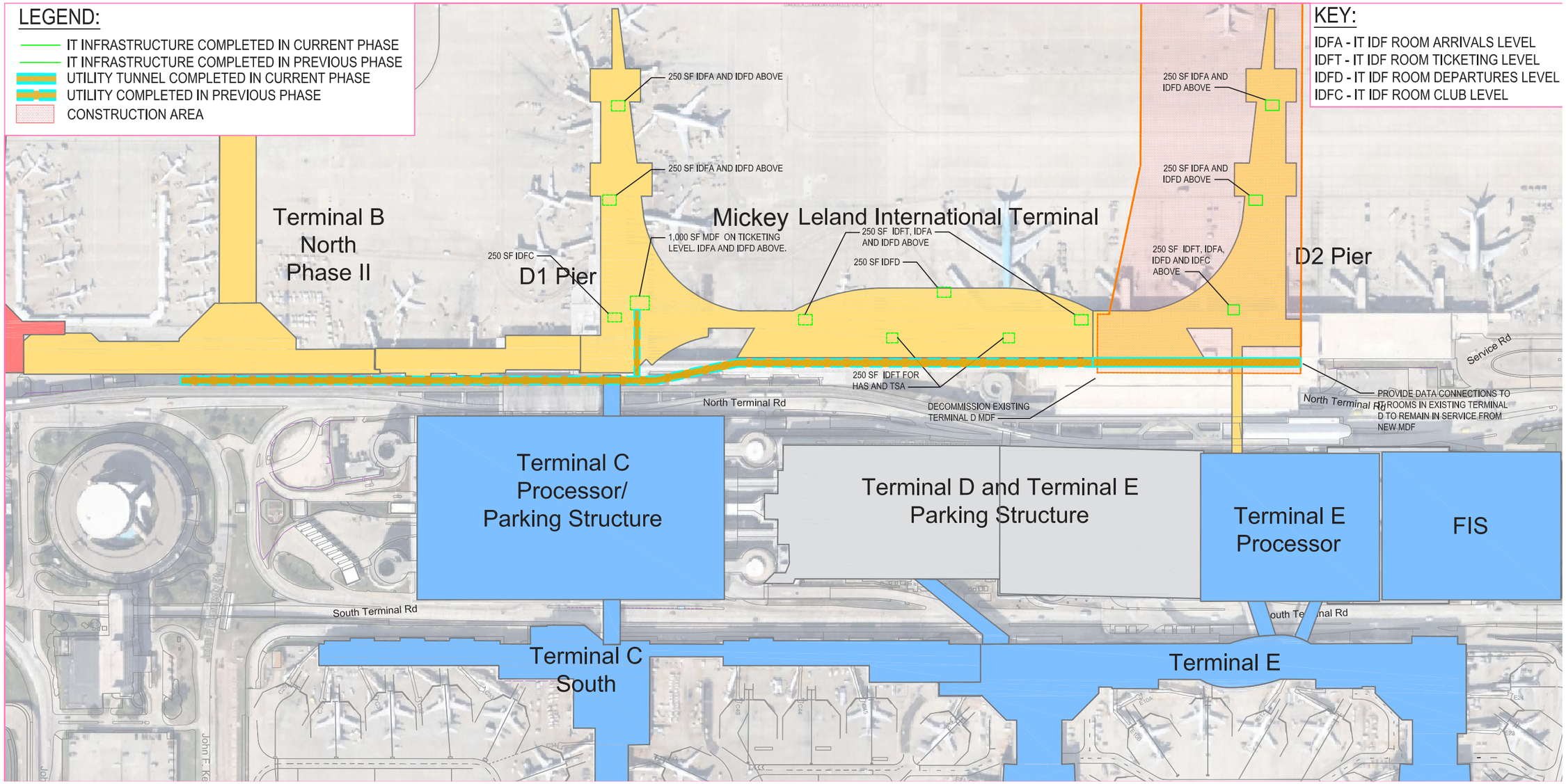
Phase 3 - Option 1 12.5 kV Distribution



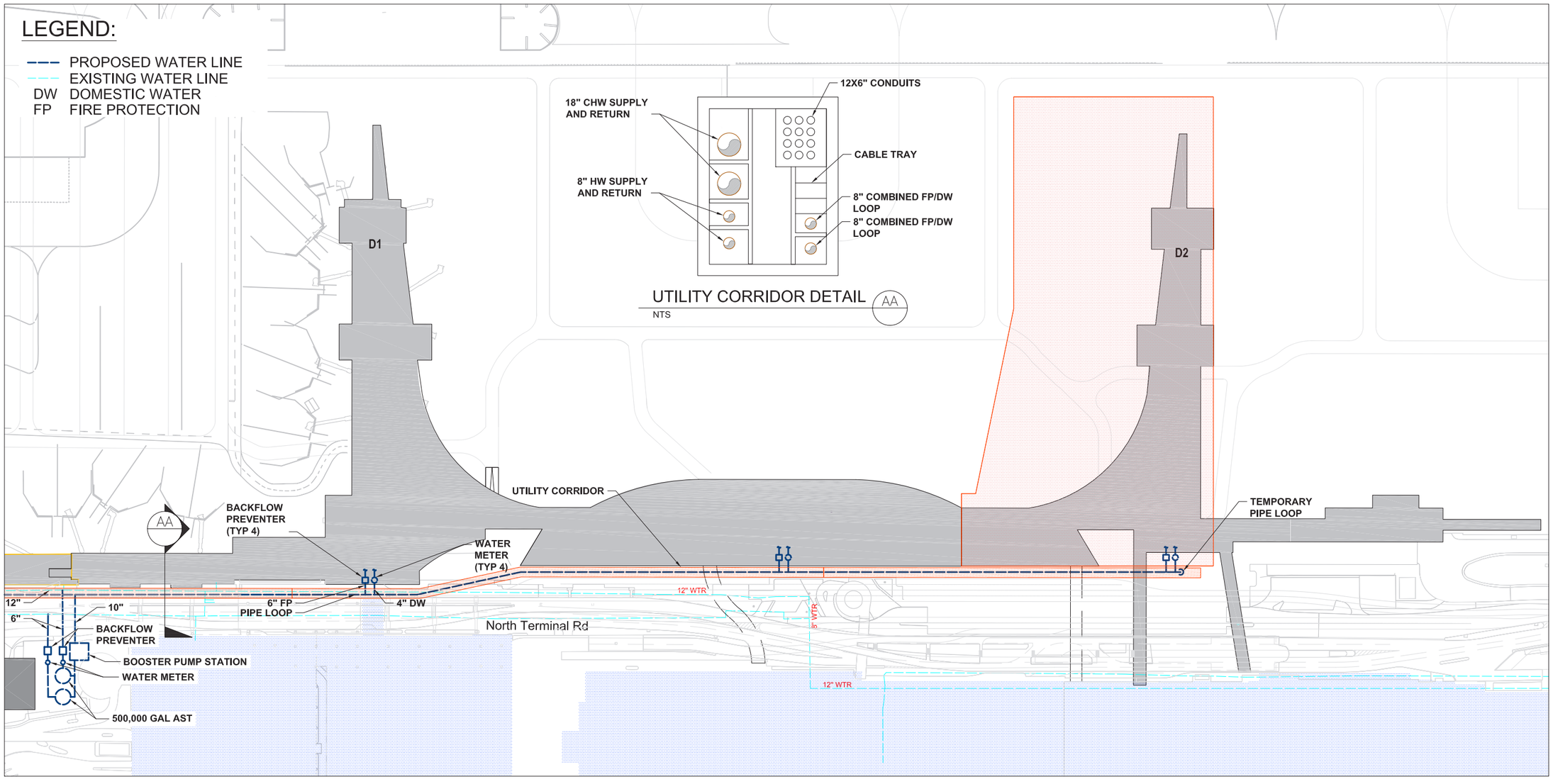
0′ 100 250′

Phase 3 - Option 1 12.5 kV Distribution Fig 7.3.8

Phase 3 IT Distribution

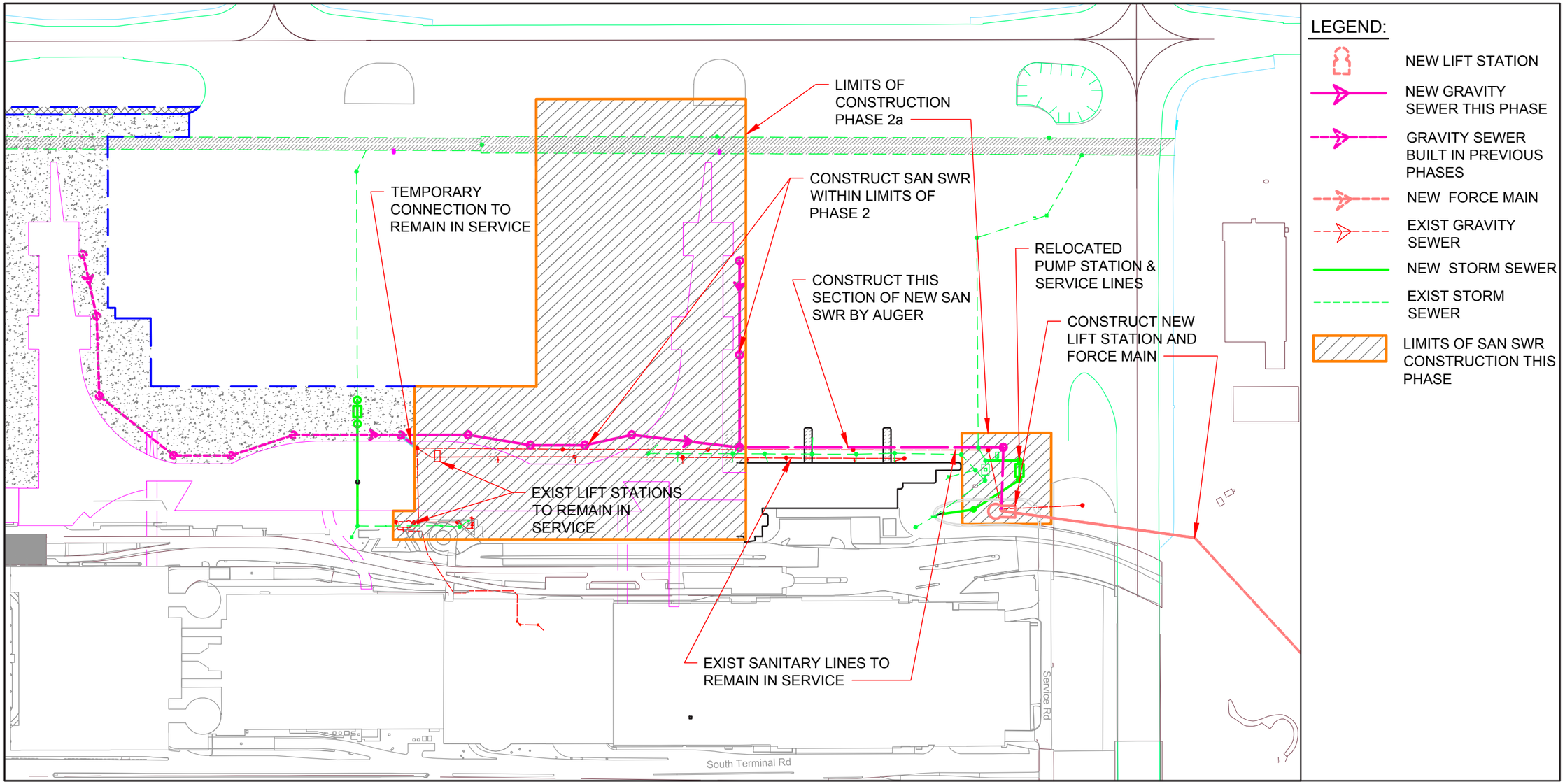


Proposed Domestic Water/Fire Protection - Phase 3



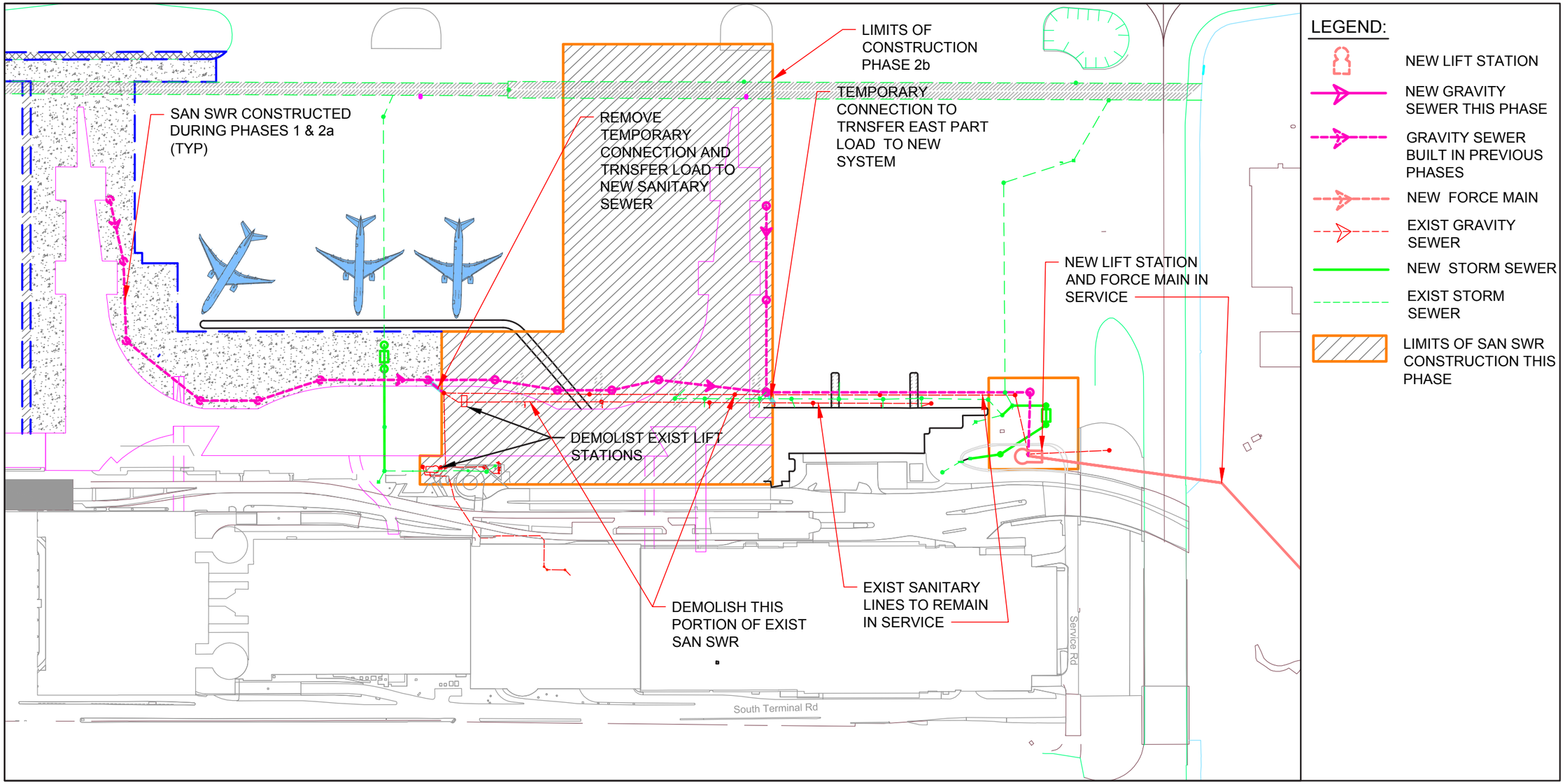
0′ 100 250′

Proposed Sanitary Sewer - Phase 3



0′ 100′ 250′ 500′

Proposed Sanitary Sewer - Phase 3



0′ 100′ 250′ 500′

7.3.2.5 Apron Grading and Drainage

The proposed drainage system is composed of three subsystems serving three different parts of the facility. Accordingly, construction of each drainage subsystem needs to follow the construction of the facilities it serves. See **Figures 7.3.13**.

- Pump Stations No. 4 and No. 5: These pump stations lift the road side drainage storm water and discharge it into the storm sewer box culverts located just north of the North Ramp. Relocation of Pump Station No. 4 is recommended during Phase 1 and relocation of Pump Station No. 5 is recommended during Phase 3.

- Roof Drainage System: The proposed construction sequences are Phase 1 through Phase 3, following the construction of the new terminal and new piers. The proposed roof drainage is composed of five (5) independent segments that will ease their construction without being dependent on other Phases.

- Apron Surface Runoff Collection System: As shown on the Proposed Storm Sewer **Figure 7.3.13**, use of the existing collection system has been maximized. In addition, the network has been broken down into three independent segments to ease construction phasing. However, the drainage network construction sequence needs to follow the apron paving phasing.

7.3.2.6 Hydrant Fueling

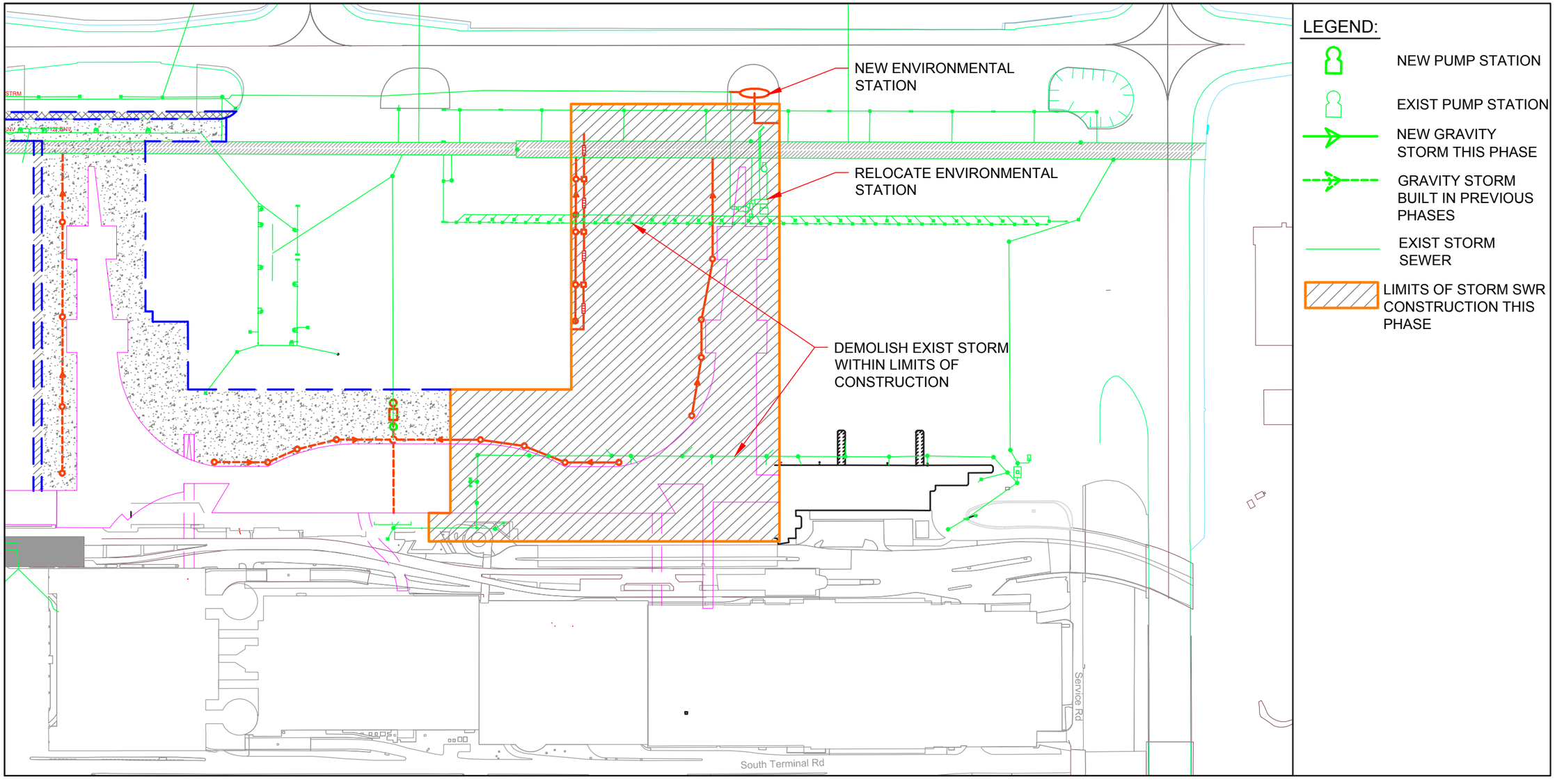
Phase 3 involves the construction of the new D2 Pier. **Figure 7.3.14** shows the four, 16 inch diameter fuel mains continuing east, adjacent to the taxiway, until they connect to the existing cargo fuel lines, located east of taxiway SF. The existing 16 inch diameter fuel mains are demolished through the construction zone. In addition, the hydrant fuel lines in the construction zone are demolished. This includes the west portion of the hydrant lines serving the hardstand positions. The east portion of the hardstand lines are planned to tie into the fuel mains for continued service.

New 12 inch diameter hydrant fuel lines are routed along the west side of Pier D2. The hydrant fuel lines are routed at a distance of 125 ft from the building face. The hydrant fuel lines connect to the main lines northwest of Terminal D2. The hydrant lines also tie into the east end of the 12 inch fuel lines that previously served the temporary jet bridge walkway that is east of Terminal D1. Two fuel hydrant pits are provided for each aircraft parking position.

7.3.3 LANDSIDE

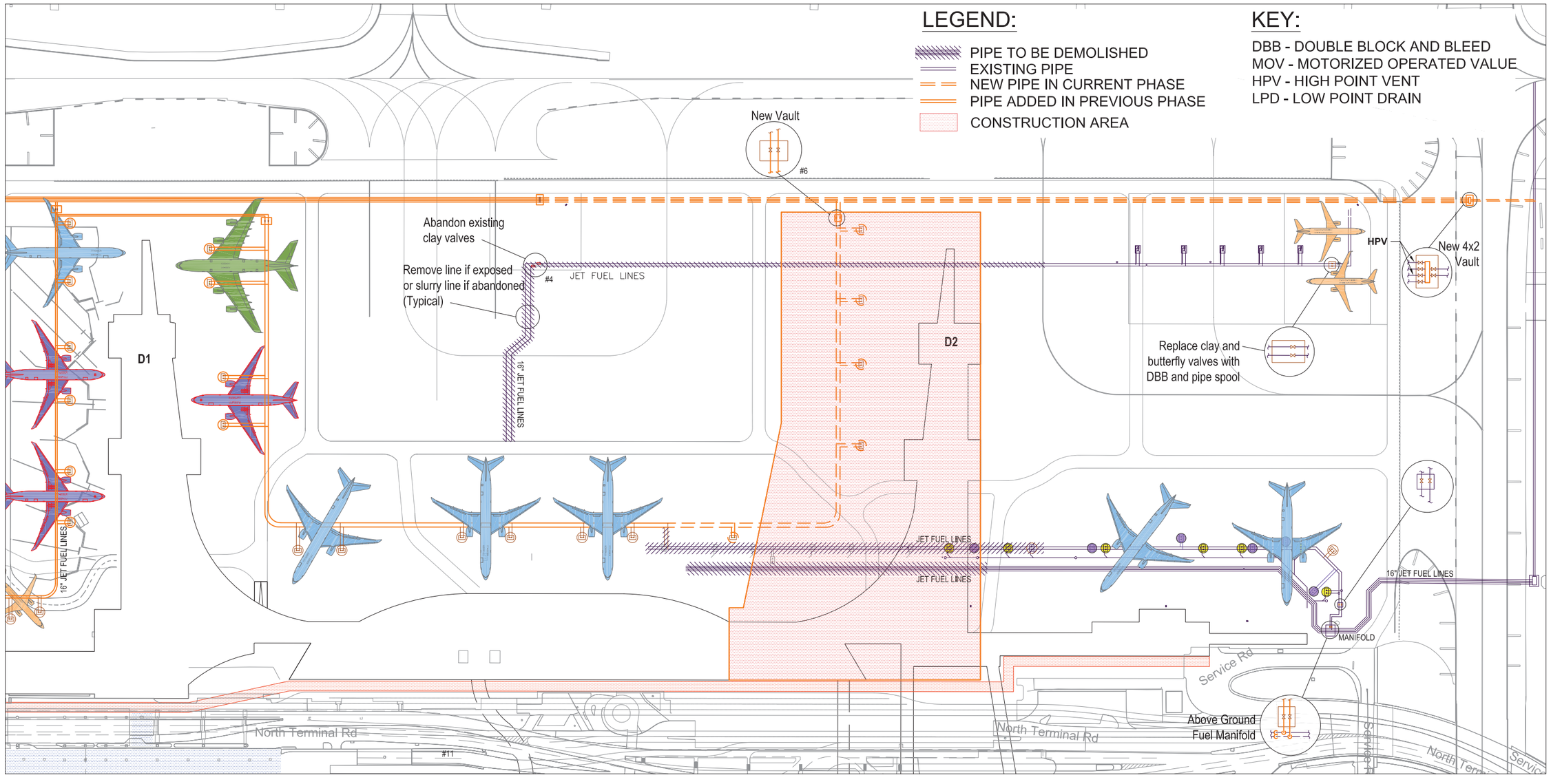
During Phase 3 of construction the western portion of the new Terminal D curbside will be open to serve Terminal D west operations. Access to the new curbside will be provided from the existing Terminal D curbside and access roadway (see **Figure 7.3.15**).

Proposed Storm Sewer - Phase 3

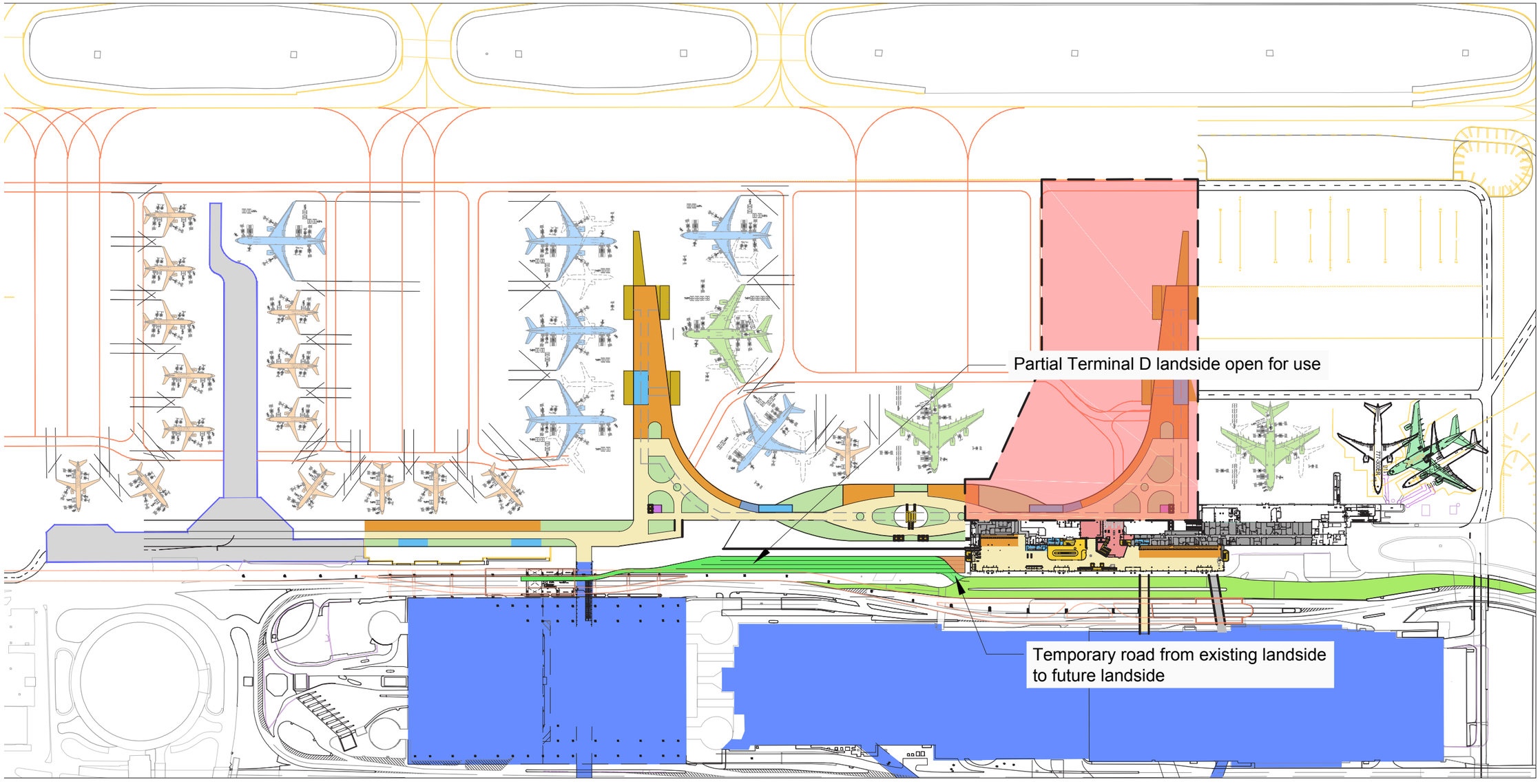


0′ 100′ 250′ 500′

Proposed Hydrant Fueling - Phase 3



Landside - Rebuild (Phase 3)



0′ 275′

7.4 PROGRAM PHASING: Phase Four

Phase 4 includes final demolition of the remaining portions of Terminal D and the completion of the MLIT and East Pier gates (see **Figure 7.4.1** and **Figure 7.4.2**). There are six subphases of Phase 4, and each is described in more detail in the sections below.

At the completion of Phase 3, passenger operations have now begun in the new D2 Pier. There are now 13 wide-body gates in operation in the new MLIT and the remaining portions of Terminal D can incrementally be demolished and replaced in order to complete the MLIT and the East Pier.

1. Occupy and begin operations of the new D2 Pier and northeast portion of the MLIT Central Core.
3. Demolition of the east half of the existing Terminal D and Terminal D east baggage handling facilities;
4. Demolition and reconstruction of the east half of the landside roadway and utilities.
5. Construction of temporary sterile connector walkway.
6. Demolition of existing terminal, east/west concourse, and construction of the MLIT east/west concourse.
7. Refurbishment of existing sterile connector bridge to the FIS facility.
8. Occupy and begin operations of the completed east half of the MLIT, east half of landside roadway, utilities, and the new MLIT east/west concourse.
9. Final completion of the MLIT Development Program.

7.4.1 TERMINAL BUILDING

Phase 4A demolishes the remaining portion of the east Terminal D processor and landside curb front in preparation for completion of the MLIT terminal processor and landside.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Demolish the remainder of the Terminal D processor up to the existing sterile corridor bridge.
  - Demolish the remaining existing Terminal D curb front.

Phase 4B completes the remaining portion of the MLIT processor and the landside facilities.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Construct the remainder of the MLIT processor.
  - Construct the remainder of the MLIT curb front.
  - Construct a temporary connection between the new MLIT sterile corridor and the sterile corridor bridge that crosses the roadway to enable the demolition of the remainder of the existing Terminal D and the future MLIT East Pier. This will require further study during Design Phases to properly mitigate the vertical elevation differences and study the validity of the existing bridge.

Phase 4C activates the final portion of the MLIT processor and the new landside facilities. In this phase passengers will utilize a temporary sterile corridor connection from the MLIT to the existing sterile corridor bridge.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Activate the remaining portion of the MLIT processor and the east portion of the landside facilities.
  - Begin to utilize the temporary sterile corridor connection between the new MLIT and the sterile corridor bridge that crosses the roadway.

Phase 4D demolishes the easternmost last remaining portion of the existing Terminal D in preparation for construction of the MLIT East Pier.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Demolish the remaining easternmost portion of the existing Terminal D and the east baggage handling facilities.
  - Demolish the remaining existing apron and underground utilities.

Phase 4E constructs the MLIT East Pier and associated apron.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Construct the MLIT East Pier.
  - Construct the associate apron and underground utilities associated with the East Pier.
  - Restore the existing sterile connector bridge linking the MLIT to the existing FIS facility.

Phase 4F activates the MLIT East Pier, thus culminating the development program. At the completion of this phase the MLIT Terminal will be operating in its entirety with a total of 15 wide-body aircraft gates in use.

Key activities during this phase:

- Terminal Building Architecture and Airside
  - Activate the East Pier of the MLIT.

7.4.1.1 Ticketing/Check-In Plan (Level 88)

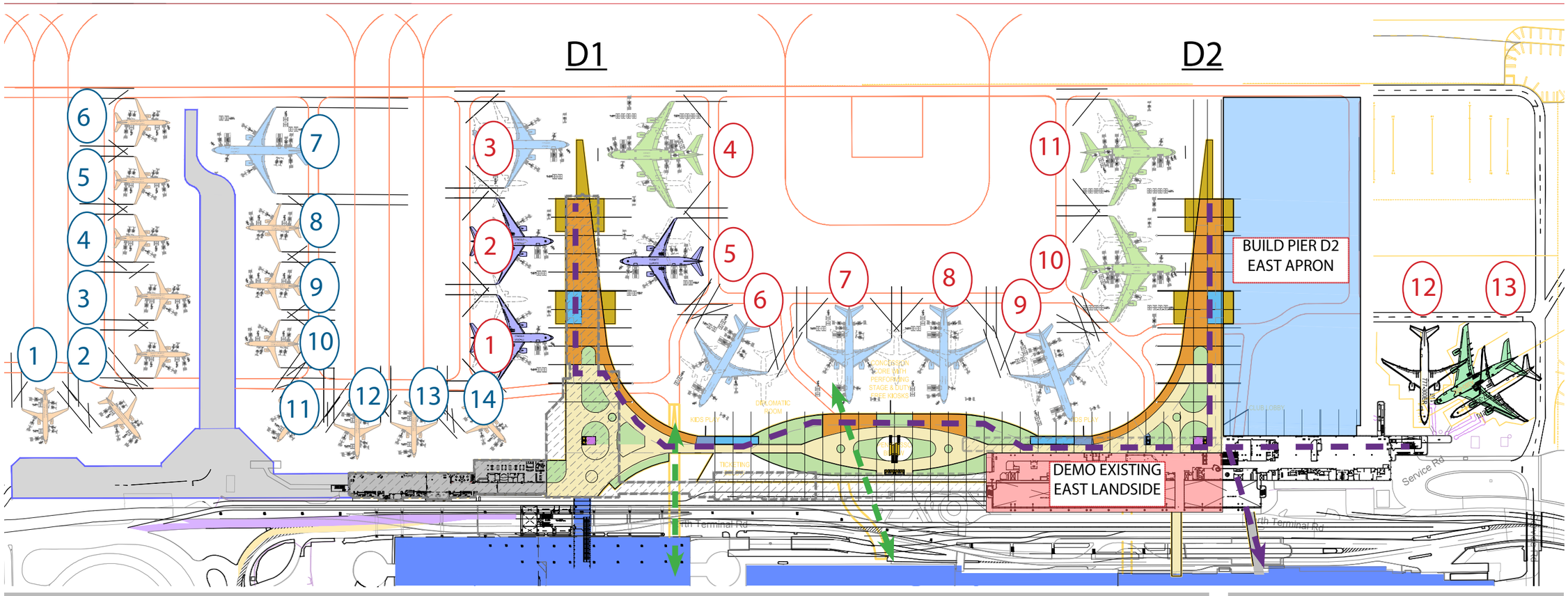
The Western Ticketing Hall remains the only ticketing hall, as in Phase 3, however, one less wide-body gate is available. The new eastern terminal section is under construction including an additional curb lane, wider sidewalk, and a bigger ticket hall to match the new Western Ticket Hall.

7.4.1.2 Chilled Water System

During this phase the existing landside ticketing in the existing Terminal D will be demolished. . All the duct distribution and HVAC units serving this area shall be disconnected. Since the current main mechanical room in the Basement Level of Terminal D will be demolished in this phase, it is necessary to install temporary service lines of chilled water (extending the lines from those that were capped in Phase III) and connect them to the existing ones that are feeding the units at the east side of the existing Terminal D since this area will not be developed until the next phase.

Once the area mentioned above is demolished, the chilled water lines that were connected to the main lines

Phase 4 (A-C)



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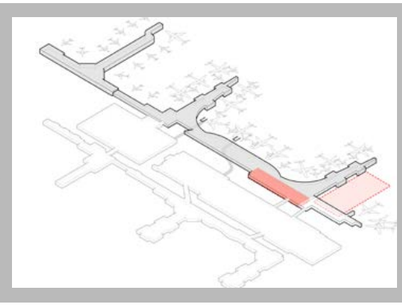


PHASE 4 HIGHLIGHTS:

- PHASE 4A - OPEN EAST CENTRAL CORE AND NEW PIER D2
- PHASE 4B - REBUILD/OPEN D-PIER EAST APRON (*MORE GATES BECOME AVAILABLE EARLY)
- PHASE 4C - DEMO EXISTING EAST LANDSIDE TICKETING
- PHASE 4D - OPEN NEW WEST LANDSIDE

STERILE CORRIDOR

EXISTING TUNNEL OPEN

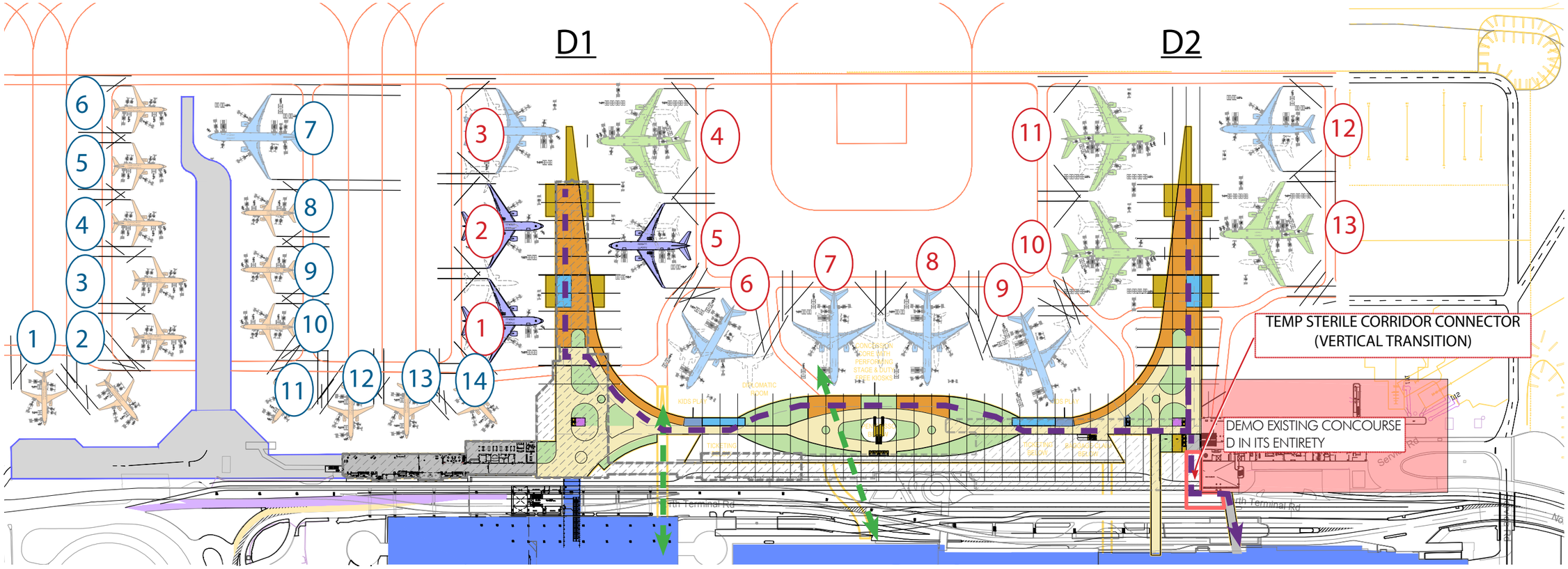
EX TUNNEL CONSTRAINED

GATES

INTL GATES - 13-15*

DOMESTIC - 14

Phase 4 (D-H)



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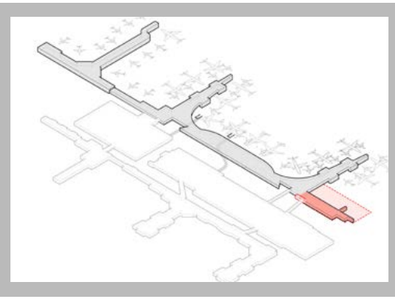


PHASE 4 HIGHLIGHTS:

- PHASE 4D - BUILD TEMPORARY STERILE CONNECTOR WALKWAY
- PHASE 4E- OPEN NEW EAST TICKETING LANDSIDE AND CURBSIDE
- PHASE 4F - DEMO REMAINING EXISTING D CONCOURSE
- PHASE 4G - REBUILD/RENOVATE FIS BRIDGE
- PHASE 4H - REBUILD APRON & REMAINING GATES

STERILE CORRIDOR

EXISTING TUNNEL OPEN

EX TUNNEL CONSTRAINED

GATES

INTL GATES - 13

DOMESTIC - 14

coming from the CUP in Phase II will be extended to be connected to the existing chilled water lines that are serving the existing Terminal D. This connection is intended to create a new redundant chilled water system. In addition, during this phase the chilled water lines will be extended to serve the new room MRT-002 and then left chilled water lines capped toward the east side for continuation of their distribution in the next phase. The design firm will determine the size of the lines according to the demand of the areas. See **Figure 7.4.3**.

Since the remaining existing Terminal D concourse will be demolished in Phase 4F, the temporary chilled water lines that were installed during Phase 4C, along with all the duct distribution and HVAC units, will be demolished as well.

During Phases 4G and 4H the remaining of the new terminal will be built. The chilled water pipelines that were capped in Phase 4 will be connected to new ones that will serve the new room MRT-003 located at the east side of the new Mickey Leland international Terminal. The design company will determine the size of the lines according to the demand of the areas. See **Figure 7.4.4**.

7.4.1.3 Hot Water System

In Phase 4C the existing landside of ticketing at Terminal D will be demolished. All the hot water piping, pumps, and heat exchangers located in this area will be removed. It will be necessary to install temporary hot water lines to serve the east side of the terminal since this will not be redeveloped until Phase 4H.

In Phase 4D the secondary hot water lines from MRT-001 that were installed in Phase 3D will be extended into new mechanical room MRT-002. A branch of this line will provide temporary service to the east side of Terminal D. Another branch will be provided for serving the east side gates' renovation in Phase 4H. The design firm will determine the size of the lines according to the demand of the areas.

Once the high temperature hot water piping from the CUP to the existing Terminal D mechanical room is disconnected, it will be connected to the 8 inch hot water line provided in Phase 2C to implement a redundant high temperature hot water supply to the heat exchangers in MRT-001.

In Phase 4H all hot water piping serving the east side gates and the temporary hot water line installed in Phase 4C will be removed. New hot water piping from MRT-002 will be extended to serve loads in this area. See **Figure 7.4.2**.

Since the remaining existing Terminal D Concourse will be demolished in Phase 4F, the temporary hot water lines that were installed during Phase 4C will be demolished as well.

During the Phases 4G and 4H it will be built the remaining of the new terminal. The hot water lines that were capped in Phase 4 will be connected to new ones that will serve the new room MRT-003 located at the east side of the new Mickey Leland International Terminal. The design company will determine the size of the lines according to the demand of the areas. See **Figure 7.4.4**.

7.4.1.4 HVAC

The existing air duct distribution and HVAC units that serve the existing landside ticketing in Terminal D will be disconnected during Phase 4C to start the rebuilding of the area.

During this phase the following mechanical room will be built:

MRT-002: Located in the Ticketing Level, this room will house HVAC units that will serve the east side of the Ticketing and Baggage Levels. See **Figure 7.4.3**.

In the current Phase 4F the remaining existing D Concourse will be demolished; thus, all the duct distribution and HVAC units serving this area will be demolished as well.

During this phase the following mechanical room will be built:

- MRT-003: Located in the Ticketing Level, this room will house HVAC units that will serve the very end of the east side of the Ticketing and Baggage Levels. See **Figure 7.4.4**.

7.4.1.5 Domestic Water System

During this phase the domestic water lines of the existing landside ticketing in the existing Terminal D will be demolished.

As the rebuild of this area begins, the new domestic water lines will be extended toward the south side of D2 Pier as required in the area to be built. Domestic water heaters will be installed in areas as required. See **Figure 7.4.5**.

Also during this phase the domestic water lines in the remaining existing D Concourse will be demolished.

As the rebuild of this area begins, the new domestic water lines will be extended toward the east side of the new terminal as required in the area to be built. Domestic water heaters will be installed in areas as required. See **Figure 7.4.6**.

7.4.1.6 Sanitary Waste and Vent System

In this phase the sanitary collector lines of the existing landside of ticketing in the existing Terminal D will be demolished.

Once the rebuilding of the area in the current phase begins, the 8 inch sanitary sewer lines installed in the previous phase will be extended toward the south of the new D2 Pier as the areas require. . See **Figure 7.4.5**.

In this phase the sanitary collection lines of the remaining existing D Concourse will be demolished.

Once the rebuilding of the area in the current phase begins, the 8 inch sanitary sewer lines installed in Phase 3 will be extended toward the east adding approximately six, 6 inch drop lines over these lines on each level to be connected to the new gravity sewer line around the building. See **Figure 7.4.6**.

7.4.1.7 Electrical System

The systems covered in this specific portion of the report will address the electrical distribution between the main switchgear and substations.

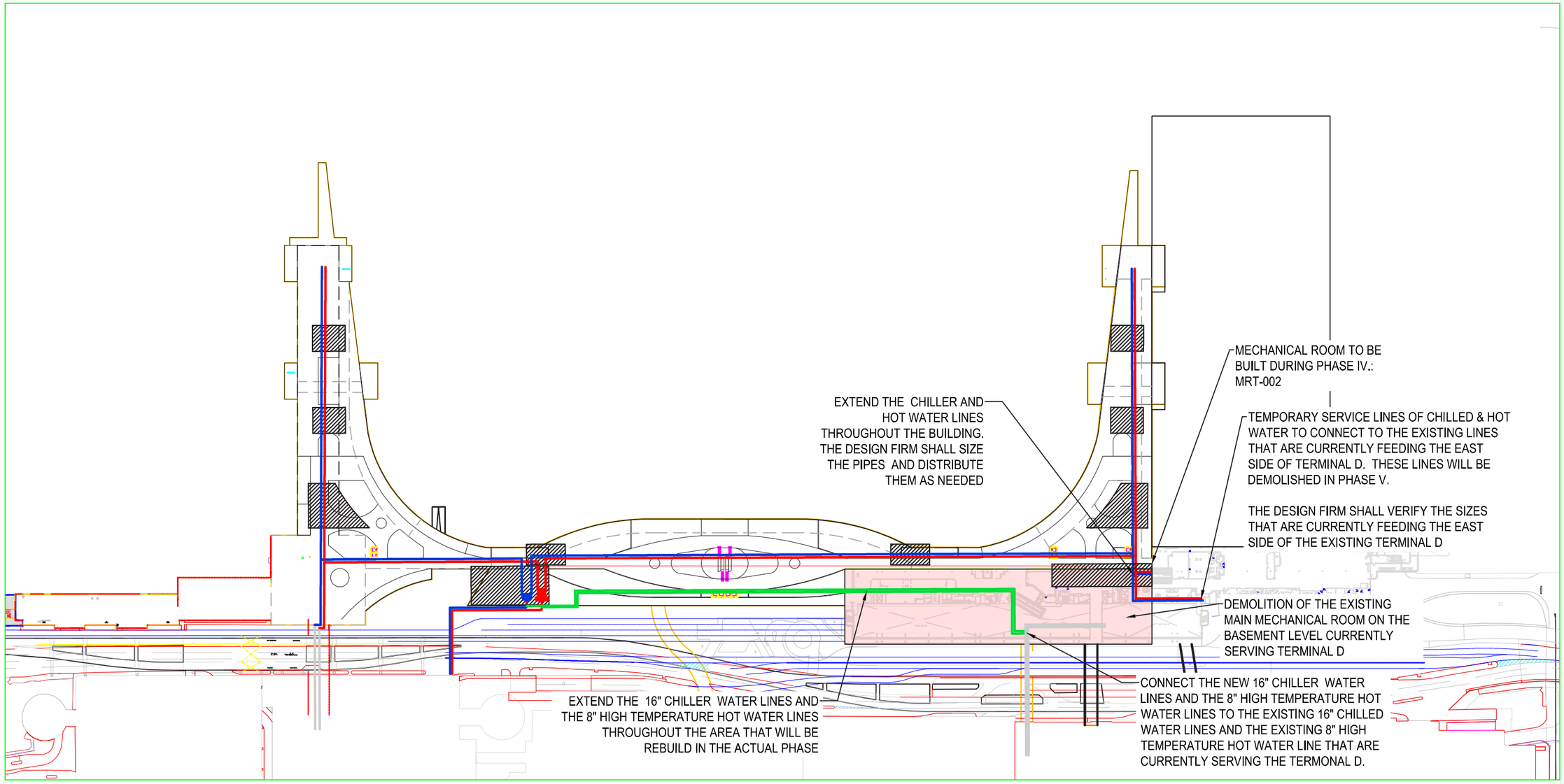
An estimated 10,000 kVA will be required for the new Terminal D. It is recommended that two substations be placed, providing better load distribution. They will be located in the electrical room. See **Figure 7.4.7**.

Prior to demolishing the existing east landside, the design firm shall analyze the panels that are fed from substation SWBD B1 and SWBD B2. See **Figure 7.4.8** and **Figure 7.4.9**.

Prior to demolishing the existing Terminal D, the design firm shall analyze the panels that are fed from Substation SWBD A1 and SWBD A2. Prior to demolishing the Terminal D east baggage handling facilities, the design firm shall analyze the panel that is fed from Substation SWBD A1 and SWBD A2. See **Figure 7.4.10** and **Figure 7.4.11**.

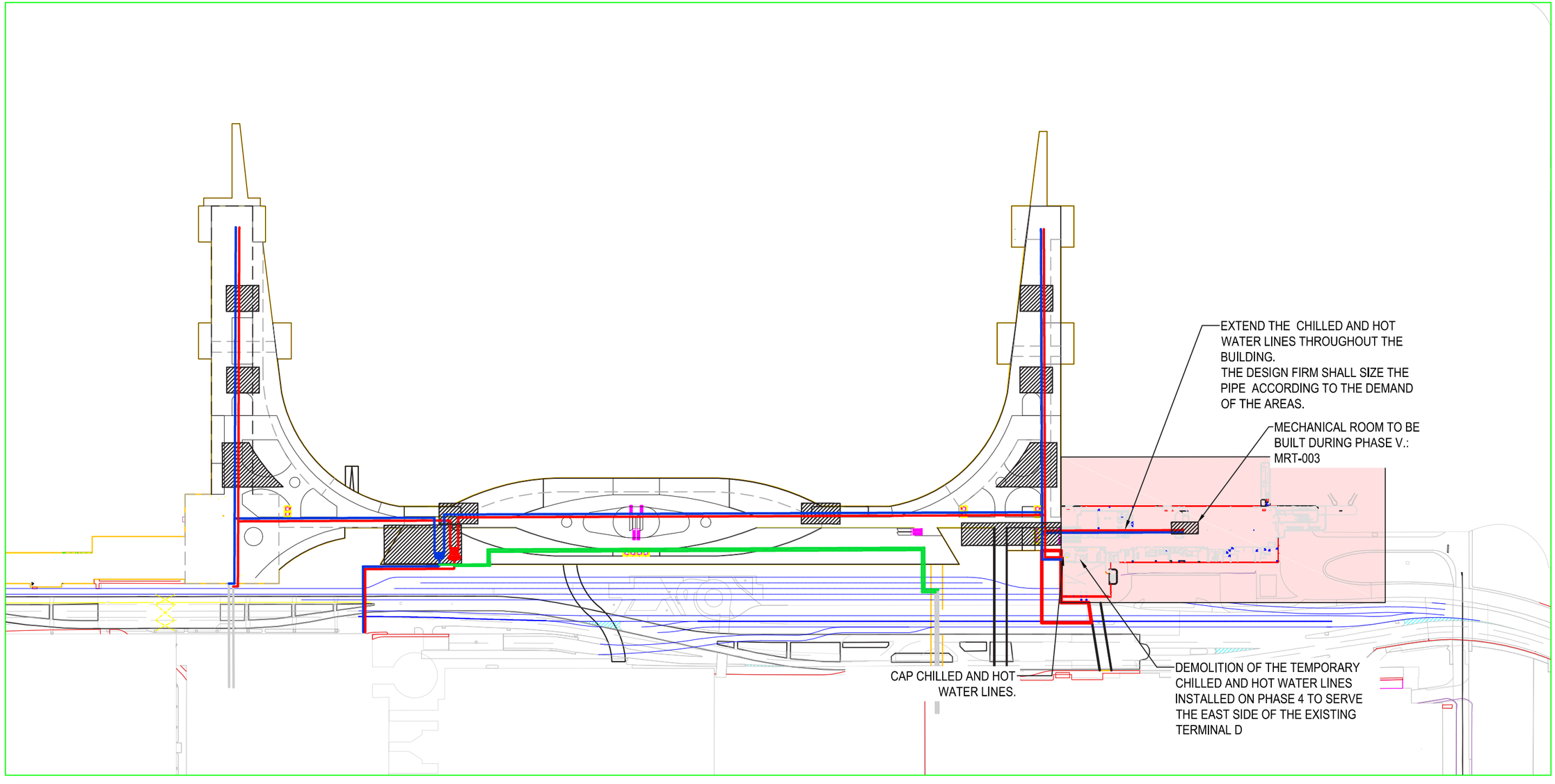
In Phase 1 we propose installing a new 12.5 kV CenterPoint feeder which will feed power to one transformer and distribution switchgear, located above ground on the existing housekeeping pad which provides temporary

Chilled and Hot Water Pipe Routing - Phase 4 (A, B, C & D)



0′ 100′ 200′

Chilled and Hot Water Pipe Routing - Phase 4 (D, E, F, G & H)



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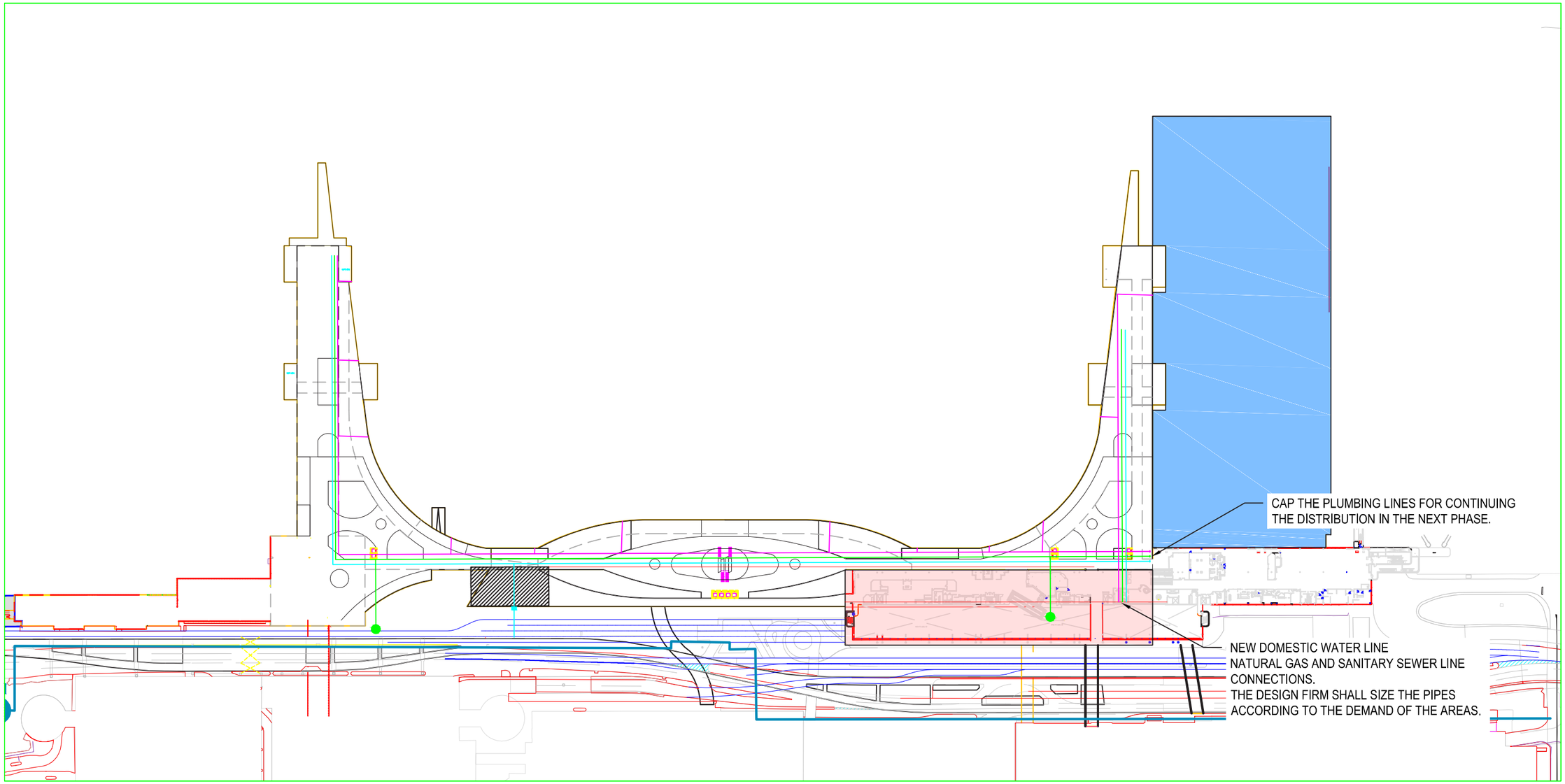
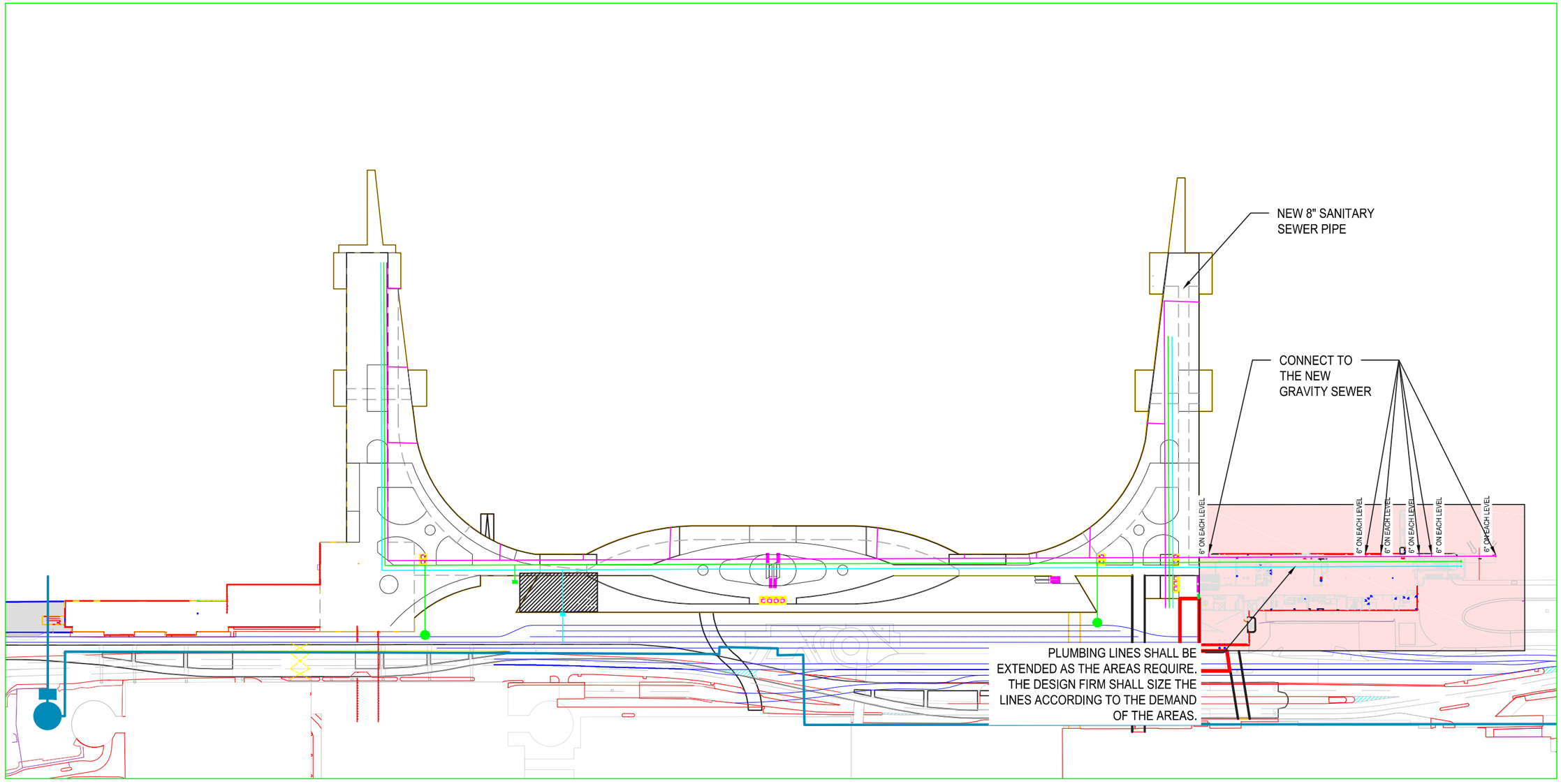
Plumbing Pipe Routing - Phase 4 (A, B, C & D)



0′ 100′ 200′

Plumbing Pipe Routing - Phase 4 (D, E, F, G & H)



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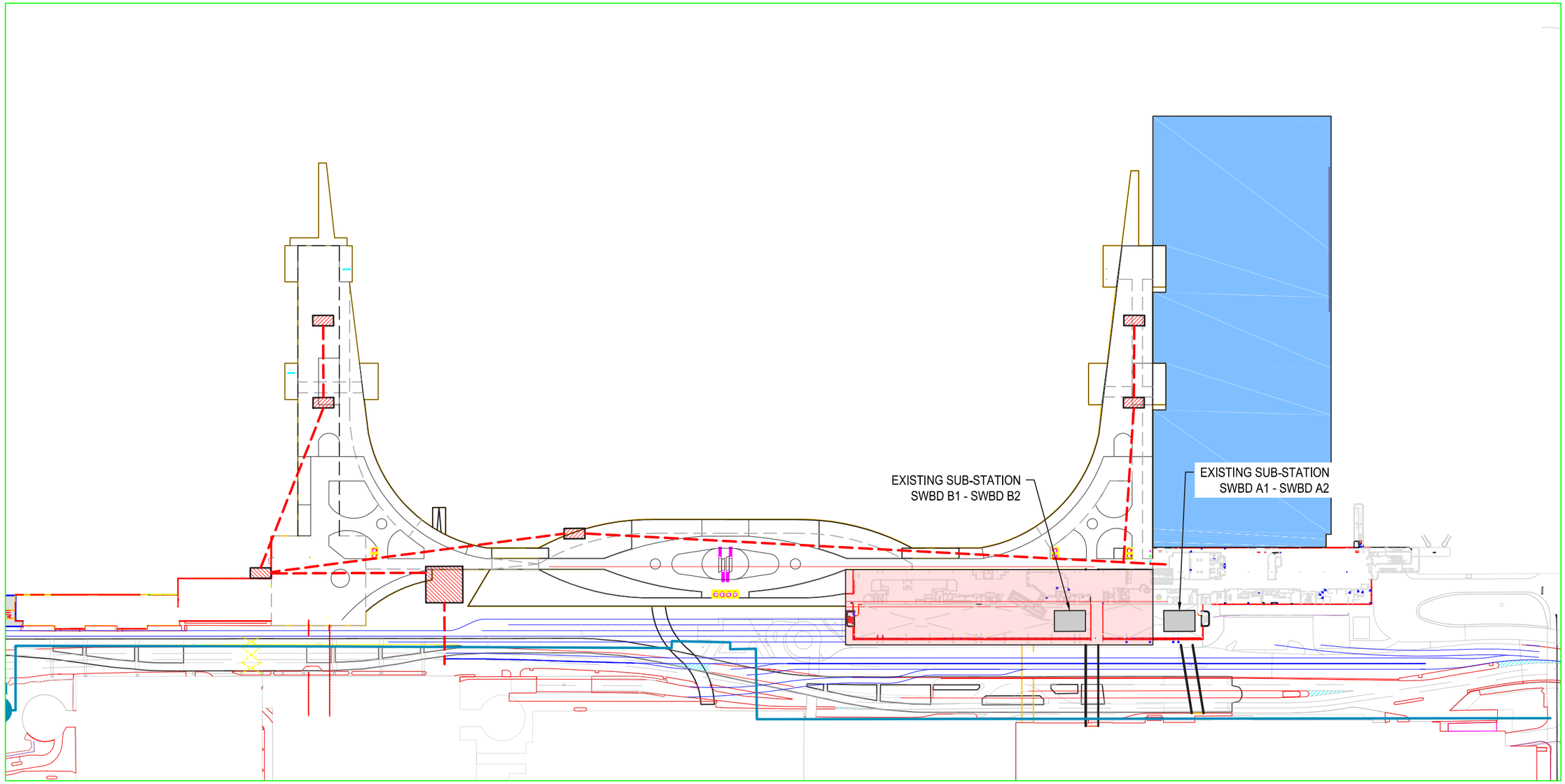
Power Distribution - Phase 4 (A, B, C & D)



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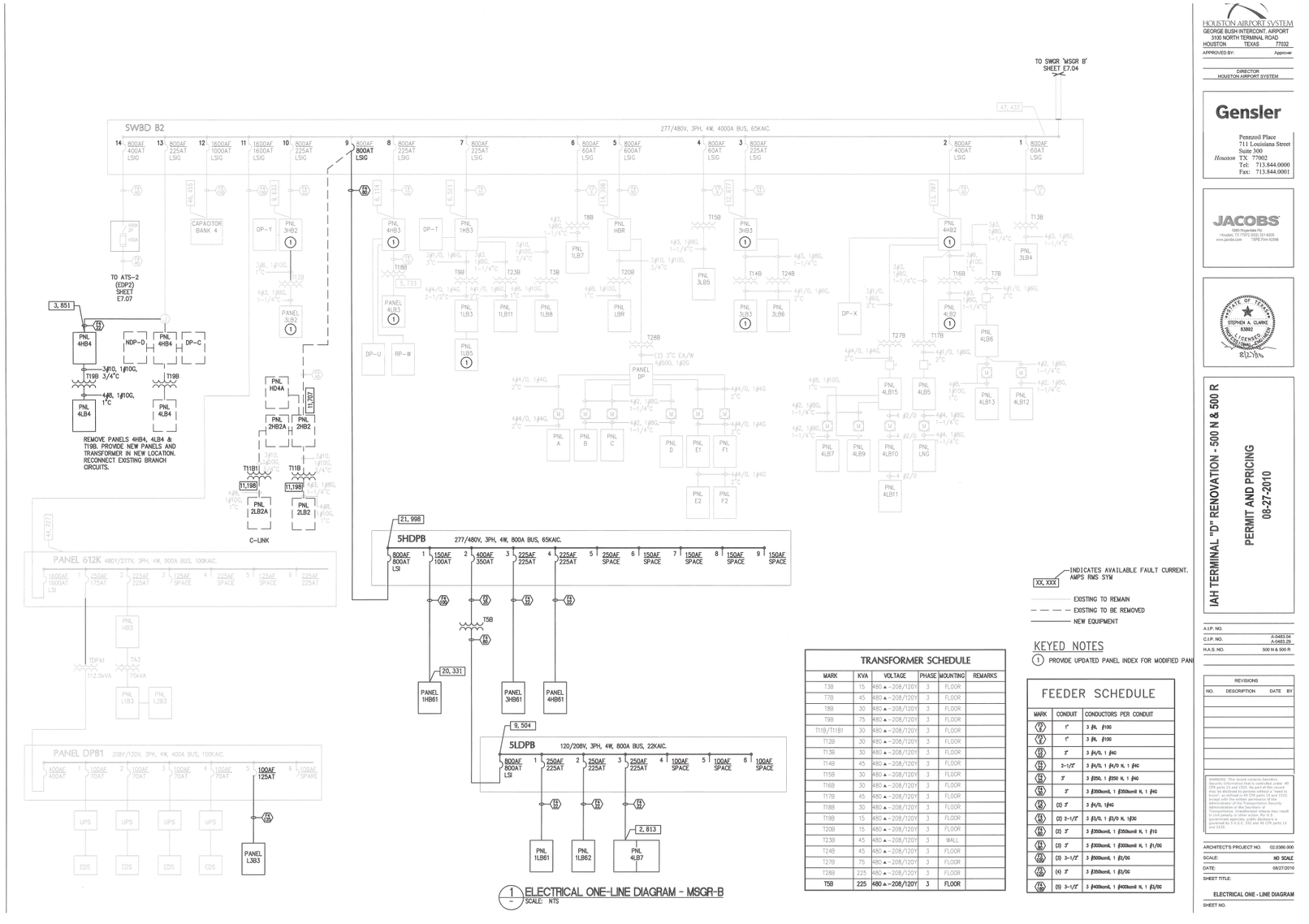
Electrical One-Line Diagram - MSGR-B



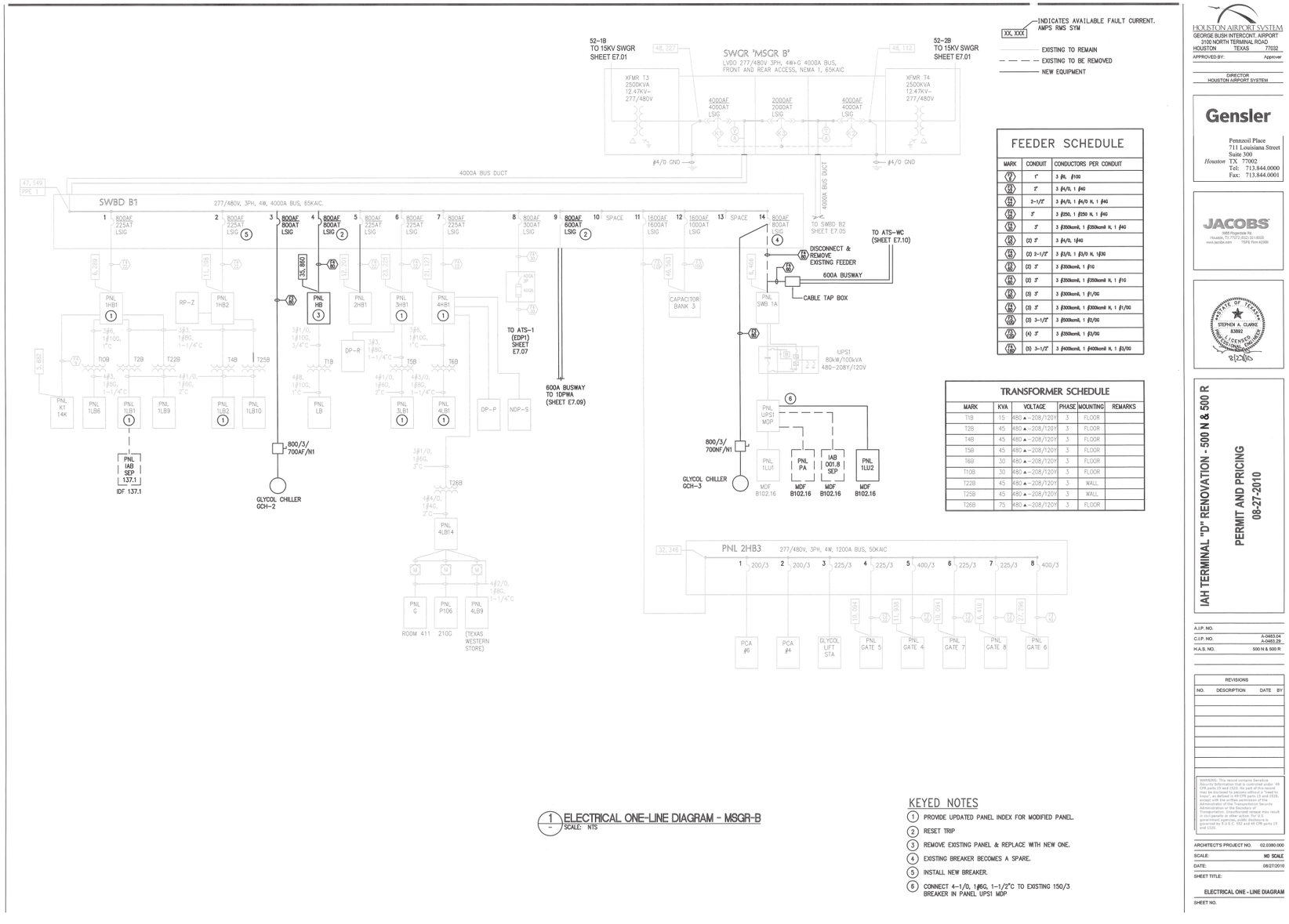
TRANSFORMER SCHEDULE

MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T3B	15	480 Δ – 208/120Y	3	FLOOR	
T7B	45	480 Δ – 208/120Y	3	FLOOR	
T8B	30	480 Δ – 208/120Y	3	FLOOR	
T9B	75	480 Δ – 208/120Y	3	FLOOR	
T11B/T11B1	30	480 Δ – 208/120Y	3	FLOOR	
T12B	30	480 Δ – 208/120Y	3	FLOOR	
T13B	30	480 Δ – 208/120Y	3	FLOOR	
T14B	45	480 Δ – 208/120Y	3	FLOOR	
T15B	30	480 Δ – 208/120Y	3	FLOOR	
T16B	30	480 Δ – 208/120Y	3	FLOOR	
T17B	45	480 Δ – 208/120Y	3	FLOOR	
T18B	30	480 Δ – 208/120Y	3	FLOOR	
T19B	15	480 Δ – 208/120Y	3	FLOOR	
T20B	15	480 Δ – 208/120Y	3	FLOOR	
T23B	45	480 Δ – 208/120Y	3	WALL	
T24B	45	480 Δ – 208/120Y	3	FLOOR	
T27B	75	480 Δ – 208/120Y	3	FLOOR	
T28B	225	480 Δ – 208/120Y	3	FLOOR	
T5B	225	480 Δ – 208/120Y	3	FLOOR	

FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
(12)	1"	3 #6, #10G
(12)	1"	3 #6, #10G
(13)	2"	3 #4/0, 1 #4G
(14)	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
(15)	3"	3 #250, 1 #250 N, 1 #4G
(16)	3"	3 #350kcmil, 1 #350kcmil N, 1 #4G
(17)	(2) 3"	3 #4/0, 1#4G
(18)	(2) 2-1/2"	3 #3/0, 1 #3/0 N, 1#3G
(19)	(2) 3"	3 #350kcmil, 1 #350kcmil N, 1 #1G
(20)	(3) 3"	3 #300kcmil, 1 #300kcmil N, 1 #1/0G
(21)	(3) 3-1/2"	3 #500kcmil, 1 #3/0G
(22)	(4) 3"	3 #350kcmil, 1 #3/0G
(23)	(5) 3-1/2"	3 #400kcmil, 1 #400kcmil N, 1 #3/0G

Electrical One-Line Diagram - MSGR-B



FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
1	1"	3 #6, #10G
2	2"	3 #4/0, 1 #4G
3	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
4	3"	3 #250, 1 #250 N, 1 #4G
5	3"	3 #300kcmil, 1 #300kcmil N, 1 #4G
6	(2) 3"	3 #4/0, 1#4G
7	(2) 2-1/2"	3 #3/0, 1 #3/0 N, 1#3G
8	(2) 3"	3 #300kcmil, 1 #1G
9	(2) 3"	3 #300kcmil, 1 #300kcmil N, 1 #1G
10	(3) 3"	3 #300kcmil, 1 #1/0G
11	(3) 3"	3 #300kcmil, 1 #300kcmil N, 1 #1/0G
12	(3) 3-1/2"	3 #500kcmil, 1 #2/0G
13	(4) 3"	3 #350kcmil, 1 #3/0G
14	(5) 3-1/2"	3 #400kcmil, 1 #400kcmil N, 1 #3/0G

TRANSFORMER SCHEDULE

MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T1B	15	480 Δ-208/120Y	3	FLOOR	
T2B	45	480 Δ-208/120Y	3	FLOOR	
T4B	45	480 Δ-208/120Y	3	FLOOR	
T5B	45	480 Δ-208/120Y	3	FLOOR	
T6B	30	480 Δ-208/120Y	3	FLOOR	
T10B	30	480 Δ-208/120Y	3	FLOOR	
T22B	45	480 Δ-208/120Y	3	WALL	
T25B	45	480 Δ-208/120Y	3	WALL	
T26B	75	480 Δ-208/120Y	3	FLOOR	

1 ELECTRICAL ONE-LINE DIAGRAM - MSGR-B
SCALE: NTS

KEYED NOTES

1. PROVIDE UPDATED PANEL INDEX FOR MODIFIED PANEL.
2. RESET TRIP
3. REMOVE EXISTING PANEL & REPLACE WITH NEW ONE.
4. EXISTING BREAKER BECOMES A SPARE.
5. INSTALL NEW BREAKER.
6. CONNECT 4-1/0, 1#6G, 1-1/2"C TO EXISTING 150/3 BREAKER IN PANEL UPS1 MDP

HOUSTON AIRPORT SYSTEM
GEORGE BUSH INTERCONT. AIRPORT
3100 NORTH TERMINAL ROAD
HOUSTON TEXAS 77032
APPROVED BY: Approver
DIRECTOR
HOUSTON AIRPORT SYSTEM

Gensler
Pennzoil Place
711 Louisiana Street
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IAH TERMINAL "D" RENOVATION - 500 N & 500 R
PERMIT AND PRICING
08-27-2010

A.I.P. NO.
C.I.P. NO. A-0483.04 A-0483.29
H.A.S. NO. 500 N & 500 R

REVISIONS
NO. DESCRIPTION DATE BY

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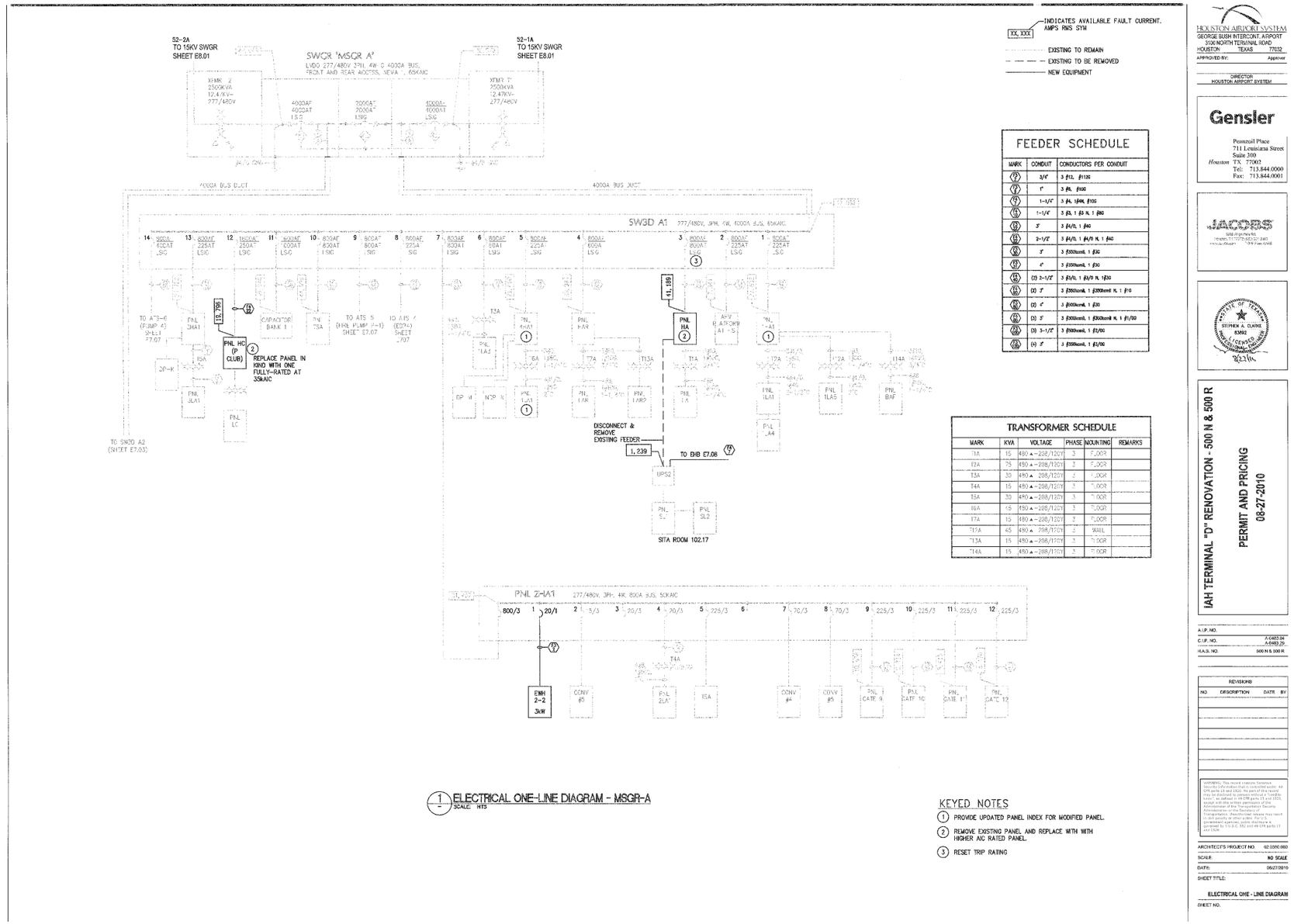
ARCHITECT'S PROJECT NO. 02.0380.000
SCALE: NO SCALE
DATE: 08/27/2010
SHEET TITLE:
ELECTRICAL ONE - LINE DIAGRAM
SHEET NO.

Electrical One-Line Diagram - MSGR-A



FEEDER SCHEDULE		
MARK	CONDUIT	CONDUCTORS PER CONDUIT
12	3/4"	3 #12, #12G
12	1"	3 #8, #10G
12	1-1/4"	3 #4, 1#4N, #10G
12	1-1/4"	3 #3, 1 #3 N, 1 #8G
12	3"	3 #4/0, 1 #4G
12	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
12	3"	3 #350kcmil, 1 #3G
12	4"	3 #350kcmil, 1 #3G
12	(2) 2-1/2"	3 #4/0, 1 #4/0 N, 1#3G
12	(2) 3"	3 #350kcmil, 1 #350kcmil N, 1 #1G
12	(2) 4"	3 #500kcmil, 1 #3G
12	(3) 3"	3 #500kcmil, 1 #500kcmil N, 1 #1/0G
12	(3) 3-1/2"	3 #500kcmil, 1 #1/0G
12	(4) 3"	3 #500kcmil, 1 #1/0G

TRANSFORMER SCHEDULE					
MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T1A	15	480 Δ - 208/120Y	3	FLOOR	
T2A	75	480 Δ - 208/120Y	3	FLOOR	
T3A	30	480 Δ - 208/120Y	3	FLOOR	
T4A	15	480 Δ - 208/120Y	3	FLOOR	
T5A	30	480 Δ - 208/120Y	3	FLOOR	
T6A	15	480 Δ - 208/120Y	3	FLOOR	
T7A	15	480 Δ - 208/120Y	3	FLOOR	
T12A	45	480 Δ - 208/120Y	3	WALL	
T13A	15	480 Δ - 208/120Y	3	FLOOR	
T14A	15	480 Δ - 208/120Y	3	FLOOR	

1 ELECTRICAL ONE-LINE DIAGRAM - MSGR-A
SCALE: NTS

KEYED NOTES

1. PROVIDE UPDATED PANEL INDEX FOR MODIFIED PANEL.
2. REMOVE EXISTING PANEL AND REPLACE WITH WITH HIGHER AIC RATED PANEL.
3. RESET TRIP RATING

HOUSTON AIRPORT SYSTEM
GEORGE BUSH INTERCONT. AIRPORT
3100 NORTH TERMINAL ROAD
HOUSTON TEXAS 77032
APPROVED BY: Approver
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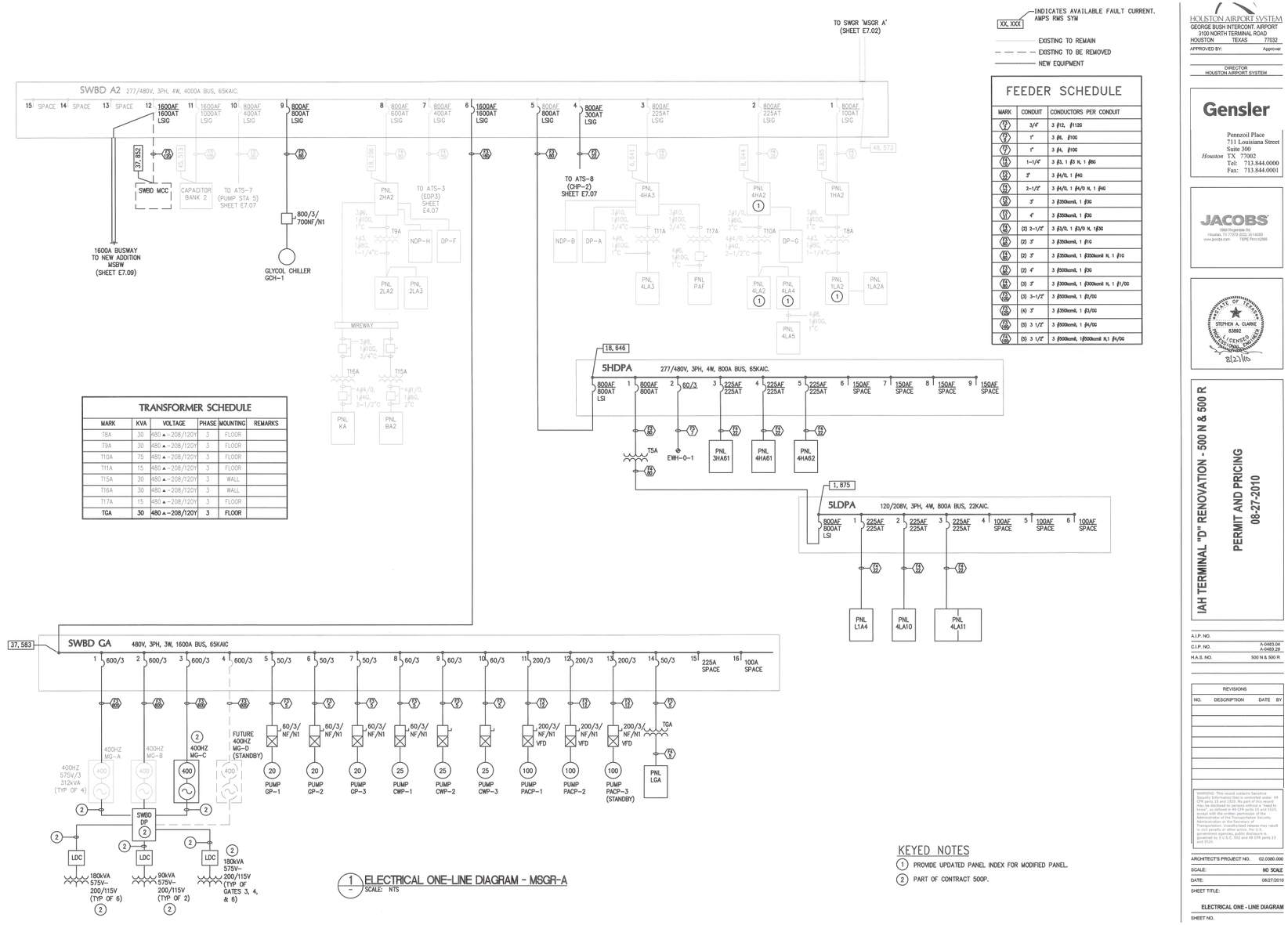
ARCHITECT'S PROJECT NO. 02.0380.060
SCALE: NO SCALE
DATE: 06/27/2010
SHEET TITLE:
ELECTRICAL ONE - LINE DIAGRAM
SHEET NO.

Electrical One-Line Diagram - MSGR-A



1 ELECTRICAL ONE-LINE DIAGRAM - MSGR-A
SCALE: NTS

TRANSFORMER SCHEDULE

MARK	KVA	VOLTAGE	PHASE	MOUNTING	REMARKS
T8A	30	480 Δ - 208/120Y	3	FLOOR	
T9A	30	480 Δ - 208/120Y	3	FLOOR	
T10A	75	480 Δ - 208/120Y	3	FLOOR	
T11A	15	480 Δ - 208/120Y	3	FLOOR	
T15A	30	480 Δ - 208/120Y	3	WALL	
T16A	30	480 Δ - 208/120Y	3	WALL	
T17A	15	480 Δ - 208/120Y	3	FLOOR	
TGA	30	480 Δ - 208/120Y	3	FLOOR	

FEEDER SCHEDULE

MARK	CONDUIT	CONDUCTORS PER CONDUIT
7	3/4"	3 #12, #12G
7	1"	3 #8, #10G
7	1"	3 #4, #10G
14	1-1/4"	3 #3, 1 #3 N, 1 #8G
13	3"	3 #4/0, 1 #4G
13	2-1/2"	3 #4/0, 1 #4/0 N, 1 #4G
13	3"	3 #350kcmil, 1 #3G
13	4"	3 #350kcmil, 1 #3G
13	(2) 2-1/2"	3 #3/0, 1 #3/0 N, 1#3G
13	(2) 3"	3 #350kcmil, 1 #1G
13	(2) 3"	3 #350kcmil, 1 #350kcmil N, 1 #1G
13	(2) 4"	3 #500kcmil, 1 #3G
13	(3) 3"	3 #300kcmil, 1 #300kcmil N, 1 #1/0G
13	(3) 3-1/2"	3 #500kcmil, 1 #2/0G
13	(4) 3"	3 #350kcmil, 1 #3/0G
13	(5) 3 1/2"	3 #500kcmil, 1 #4/0G
13	(5) 3 1/2"	3 #500kcmil, 1#500kcmil N,1 #4/0G

KEYED NOTES

1. PROVIDE UPDATED PANEL INDEX FOR MODIFIED PANEL.
2. PART OF CONTRACT 500P.

HOUSTON AIRPORT SYSTEM
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HOUSTON TEXAS 77032
APPROVED BY: Approver

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H.A.S. NO. 500 N & 500 R

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ARCHITECT'S PROJECT NO. 02.0380.000
SCALE: NO SCALE
DATE: 08/27/2010
SHEET TITLE:
ELECTRICAL ONE - LINE DIAGRAM
SHEET NO.

power to ticketing and outbound baggage. At this time, the design firm will analyze the load that is fed from the temporary substation to the demolition site and rebuild from the new substation.

We propose a new substation in room ERT 004. (See **Figure 7.4.12**).

7.4.1.8 Natural Gas

During this phase the natural gas lines of the existing landside ticketing in the existing Terminal D will be demolished.

Once the rebuild of this area begins, the natural gas lines will be extended toward the south side of D2 Pier as the area to be built requires. (See **Figure 7.4.5**).

During this phase the natural gas lines of the remaining existing D Concourse will be demolished.

Once the rebuild of this area begins, the natural gas lines will be extended toward the east side of the Mickey Leland International Terminal as the area to be built requires. (See **Figure 7.4.6**).

- Replace existing CNP gas meter with a new one and maintain existing branch line from CNP 2 inch main line.

7.4.1.9 Fire Suppression

- Install fire protection water connection to Terminal D east extension from DW/FP pipe loop.
- See **Figure 7.4.13**

7.4.2 SITE UTILITIES

In order to support the additional utility demands, due to the completion of the MLIT east apron, additional utility distribution infrastructure will need to be integrated within the construction.

7.4.2.1 12.5 kV Site Power

As the new terminal continues to expand, the load on the new service will continue to expand, and the existing 12.5 kV CenterPoint service to the existing Terminal D, will be maintained, with only those feeders to panels that feed existing portions of the terminal being demolished and removed. This drop-in load will have to be calculated by the designer, and coordinated with CenterPoint.

As the demolition limits get closer to the main electrical room in the basement of the existing Terminal D, additional re-routes will have to be provided in order to maintain short-term temporary power from the existing substation to the loads on the far east end of the existing Terminal D. These re-routes and temporary feeders will have to be coordinated by the design team as the limits of demolition are determined. (See **Figure 7.4.14**).

The existing 12.5 kV CenterPoint substation and service to the existing Terminal D, are to be decommissioned and removed at the end of phase 3, and the beginning of phase 4. Coordinate with CenterPoint for removal of their equipment prior to any demolition work. Contractor shall ensure that all CenterPoint feeders and equipment have either been removed or de-energized prior to commencing with any demolition work. A minimum of 3 months should be allocated to the removal and decommissioning of all CenterPoint equipment.

Provisions for future power to the east will be built into not only the proposed utility corridor, but also into the 12.5 kV substation and feeders. This will ensure that when the need arises for a new MLIT Pier D3, or an FIS expansion, tying into the electrical infrastructure will cause no disruptions to the existing loads, and require no additional infrastructure upgrades.

7.4.2.2 Site Communication/IT

Once all fiber optic (FO) and PBX cutovers have been completed, and the entire system is in operation and has been commissioned and tested in the new MDF in its new location at the base of Pier D1, the existing Terminal D basement MDF and associated IDFs, within the limits of demolition, can be demolished. New IDFs installed shall be connected back to the new MDF in a traditional hub and spoke arrangement. Demolition and removal of existing equipment will be coordinated with HAS, as much of the existing equipment has been recently upgraded and may have significant salvage value to the airport. (See **Figure 7.4.15**).

New IDFs installed in this phase will be connected back to the new MDF in a traditional hub and spoke arrangement. Demolition and removal of existing equipment will need to be coordinated with HAS, as much of the existing equipment has been recently upgraded and may have significant salvage value to the airport.

Provisions for future IT, FO trunk lines to the east will be built into not only the proposed utility corridor, but also the MLIT MDF, ensuring that when the need arises for a new MLIT Pier D3, or an FIS expansion, tying into the IT infrastructure will cause no disruptions to the existing loads, and require no additional infrastructure upgrades.

7.4.2.3 Water System

- Extend utility corridor to the east end of Terminal D.
- Create pipe loop at the end of the utility corridor.
- Install domestic water connection to Terminal D east extension from DW/FP pipe loop.

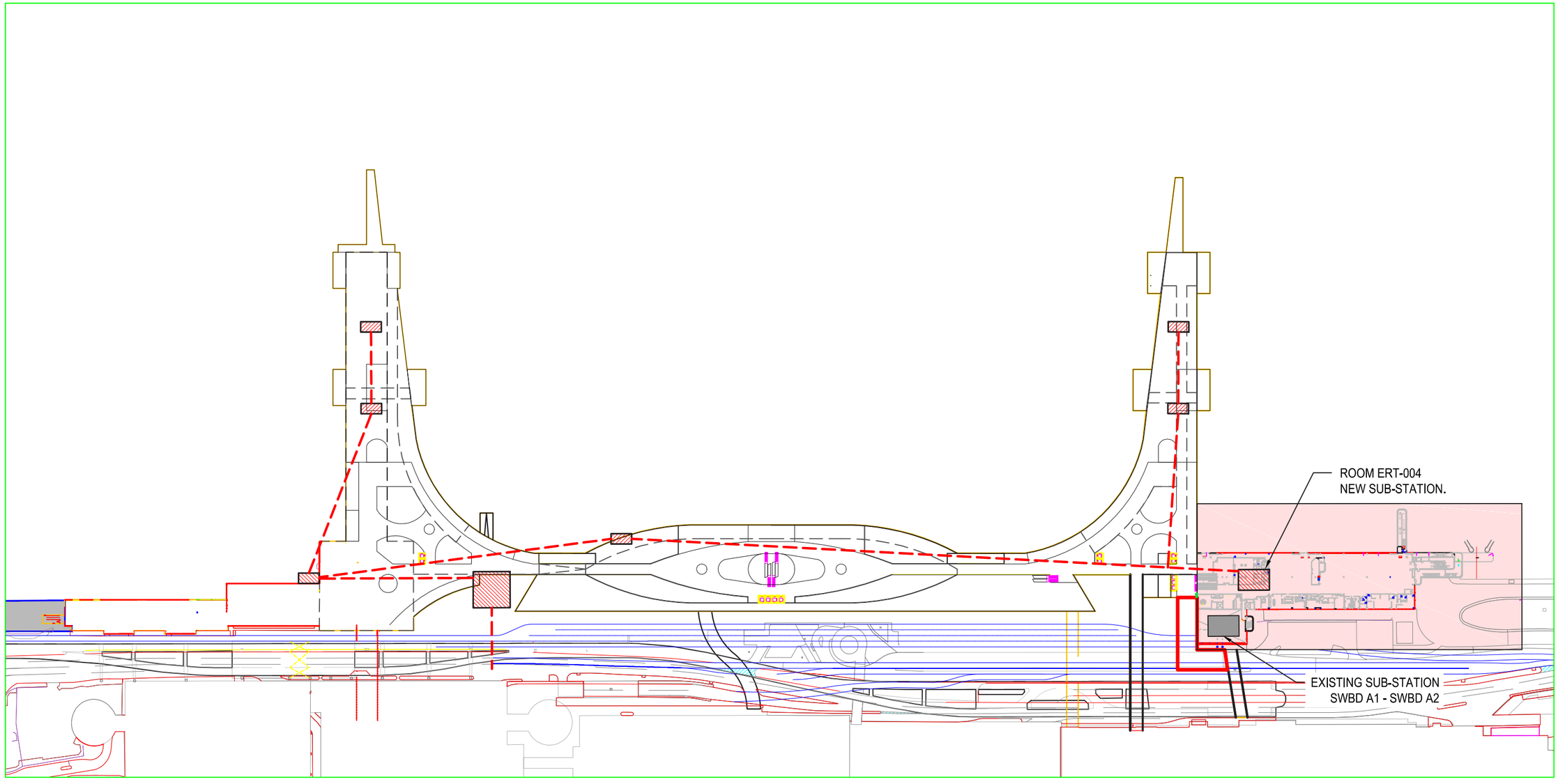
See **Figure 7.4.13.**

7.4.2.4 Sanitary Sewer System

Sequencing for the new sanitary sewer system construction will closely follow that of the terminal and piers with some exemptions. The system is recommended to be constructed in four phases. **Figures 7.4.16** shows recommended limits for Phase 4. It should be noted that existing Terminal D lift stations that will remain in service during Phase 1 and Phase 2, have been upgraded recently and have the capacity to handle the existing Terminal D and the new D1 Pier sanitary sewer loads.

Construction of the new sanitary sewer lift station and force main, due to selected location and nature of its' use, could be constructed independently and ahead of planned Phase 2A. Similarly, the new triturator, recommended to be constructed east of taxiway NN, could be constructed independently and ahead of Phase 1 or during the Phase 1 construction.

Power Distribution - Phase 4 (D, E, F, G & H)



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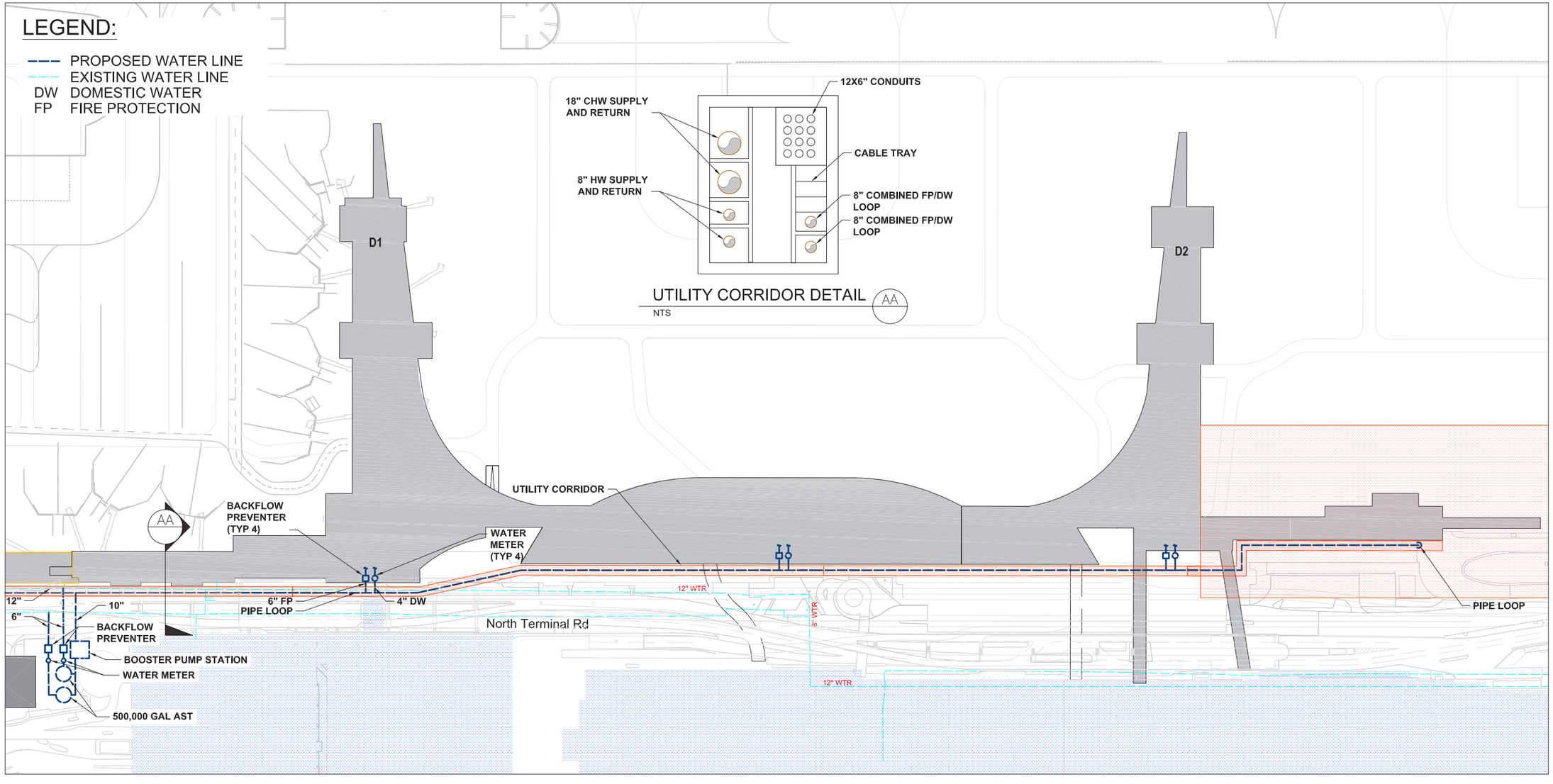
Proposed Domestic Water/Fire Protection - Phase 4



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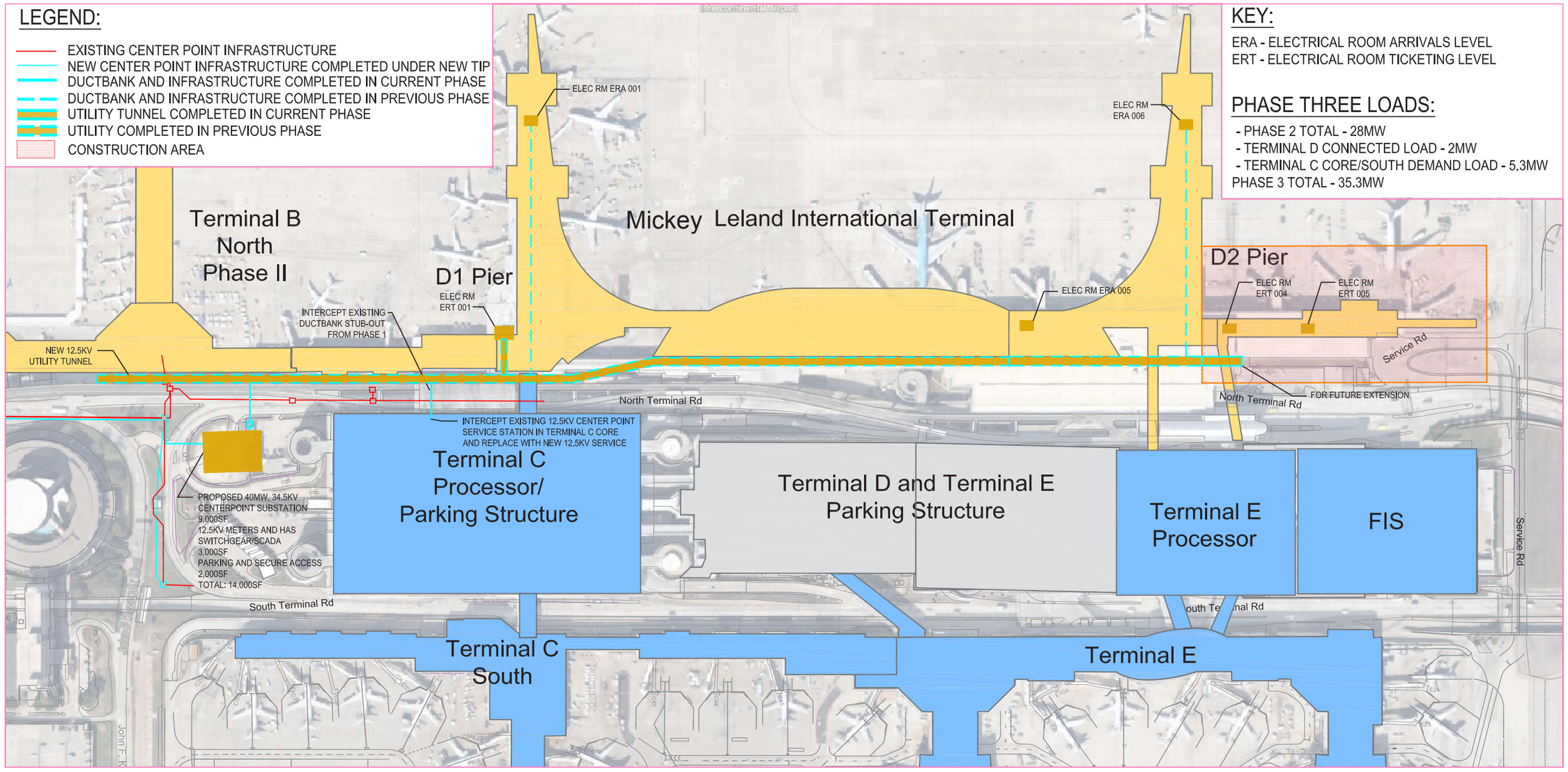
Phase 4 - Option 1 12.5 kV Distribution



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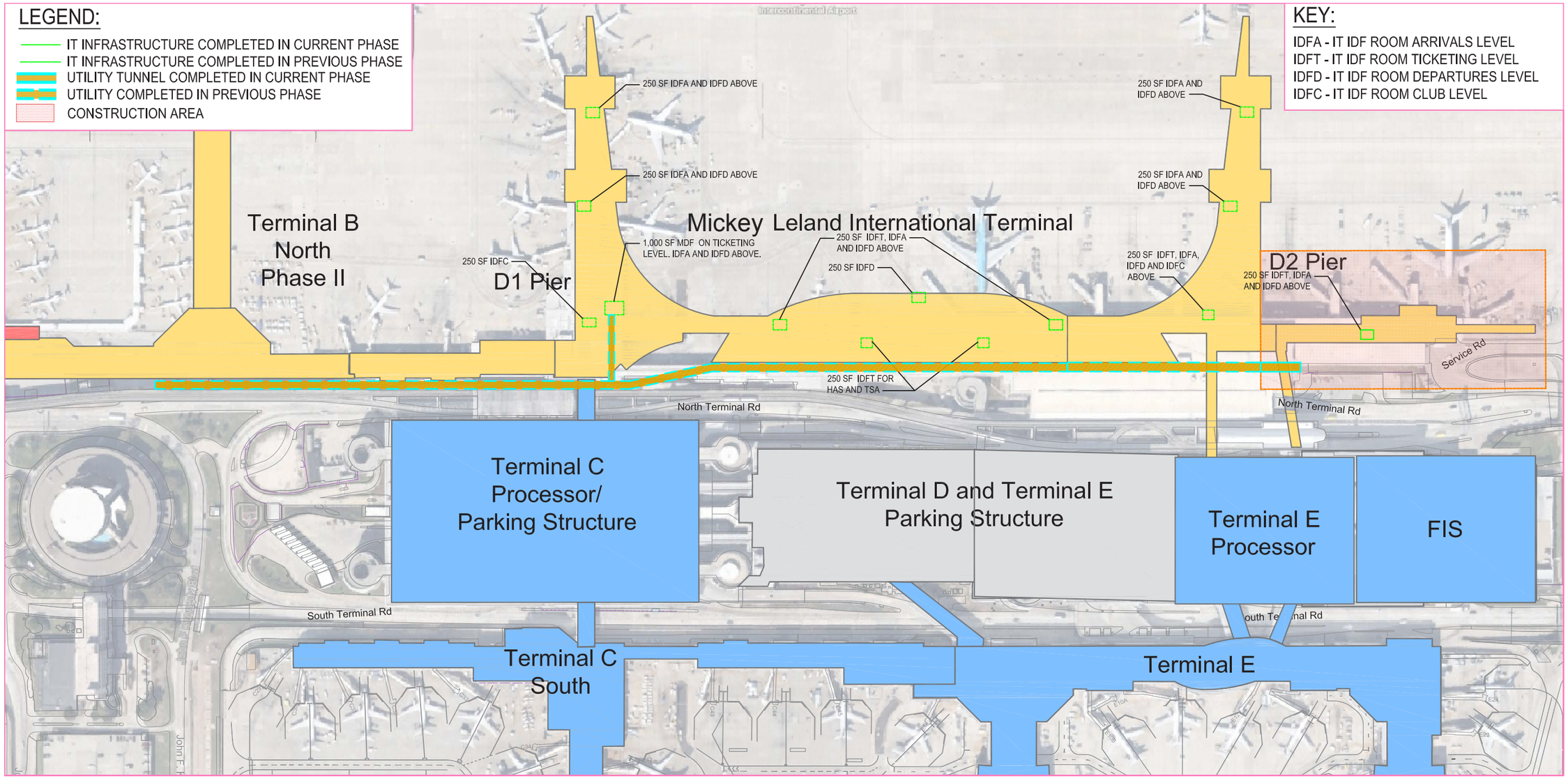
Phase 4 IT Distribution



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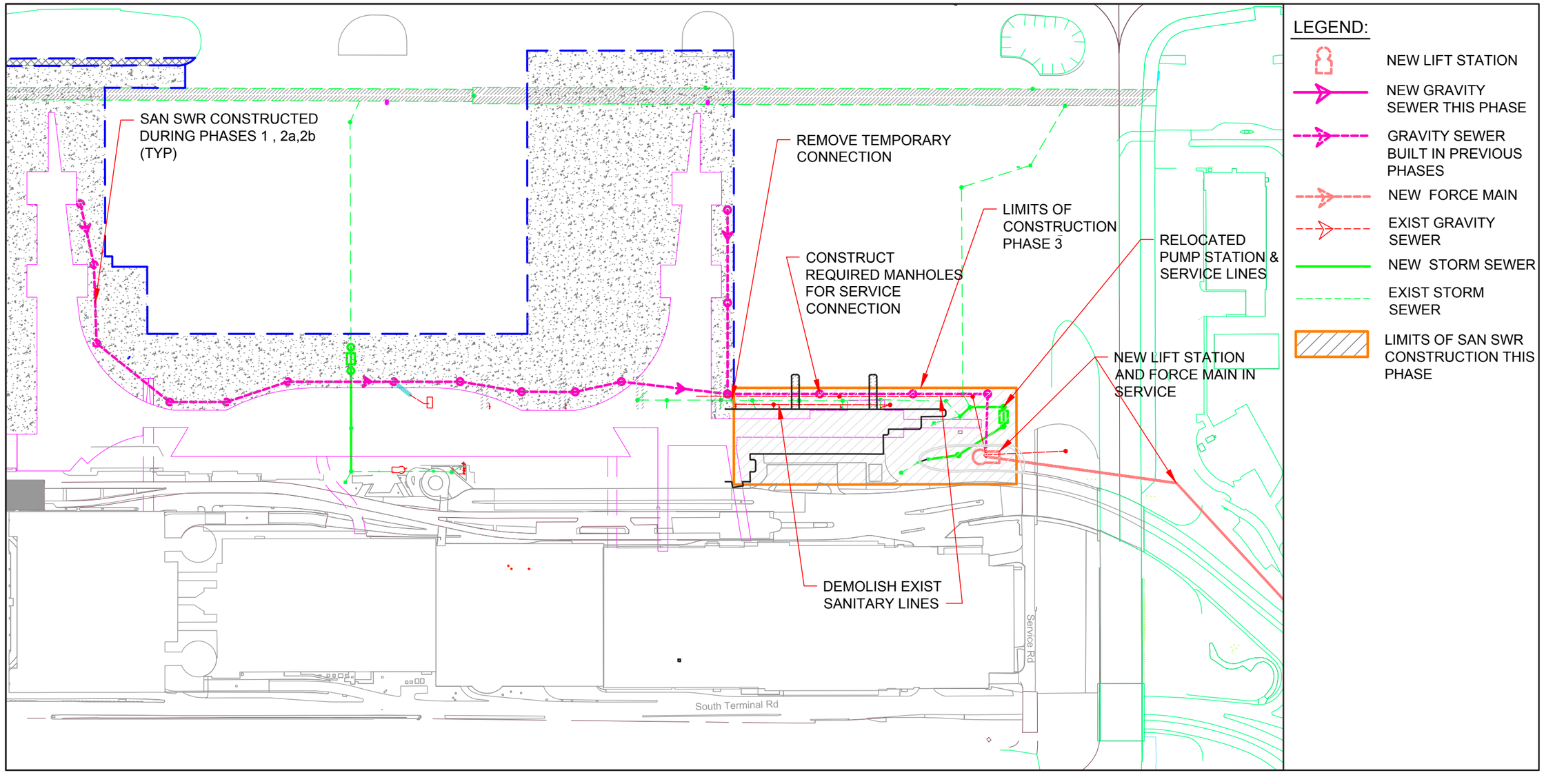
Proposed Sanitary Sewer - Phase 4



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7.4.2.5 Apron Grading and Drainage

The proposed drainage system is composed of three subsystems serving three different parts of the facility. Accordingly, construction of each drainage subsystem needs to follow the construction of the facilities it serves. See **Figures 7.4.17**.

- Pump Stations No. 4 and No. 5: These pump stations lift the road side drainage storm water and discharge it into the storm sewer box culverts located just north of the north ramp. Relocation of Pump Station No. 4 is recommended during Phase 1 and relocation of Pump Station No. 5 is recommended during Phase 3.

- Roof Drainage System: The proposed construction sequences are Phase 1 through Phase 3, following the construction of the new terminal and new piers. The proposed roof drainage is composed of five independent segments that will ease their construction without being dependent on other phases. **Figure 7.4.17** depicts recommended limits for Phase 4.

- Apron Surface Runoff Collection System: As shown on the Proposed Storm Sewer, use of the existing collection system has been maximized. Additionally, the network has been broken down into three independent segments to ease construction phasing. However, the drainage network construction sequence needs to follow the apron paving phasing.

The airside water demand is limited to the storm sewer environmental protection system. Though portions of the existing storm sewer, due to apron grading change will be removed and a new line installed, the total water demand will not change and the majority of the existing waterlines could be reconnected and reused. Phasing shall follow the phasing for new storm sewers and apron pavement phasing.

7.4.2.6 Hydrant Fueling

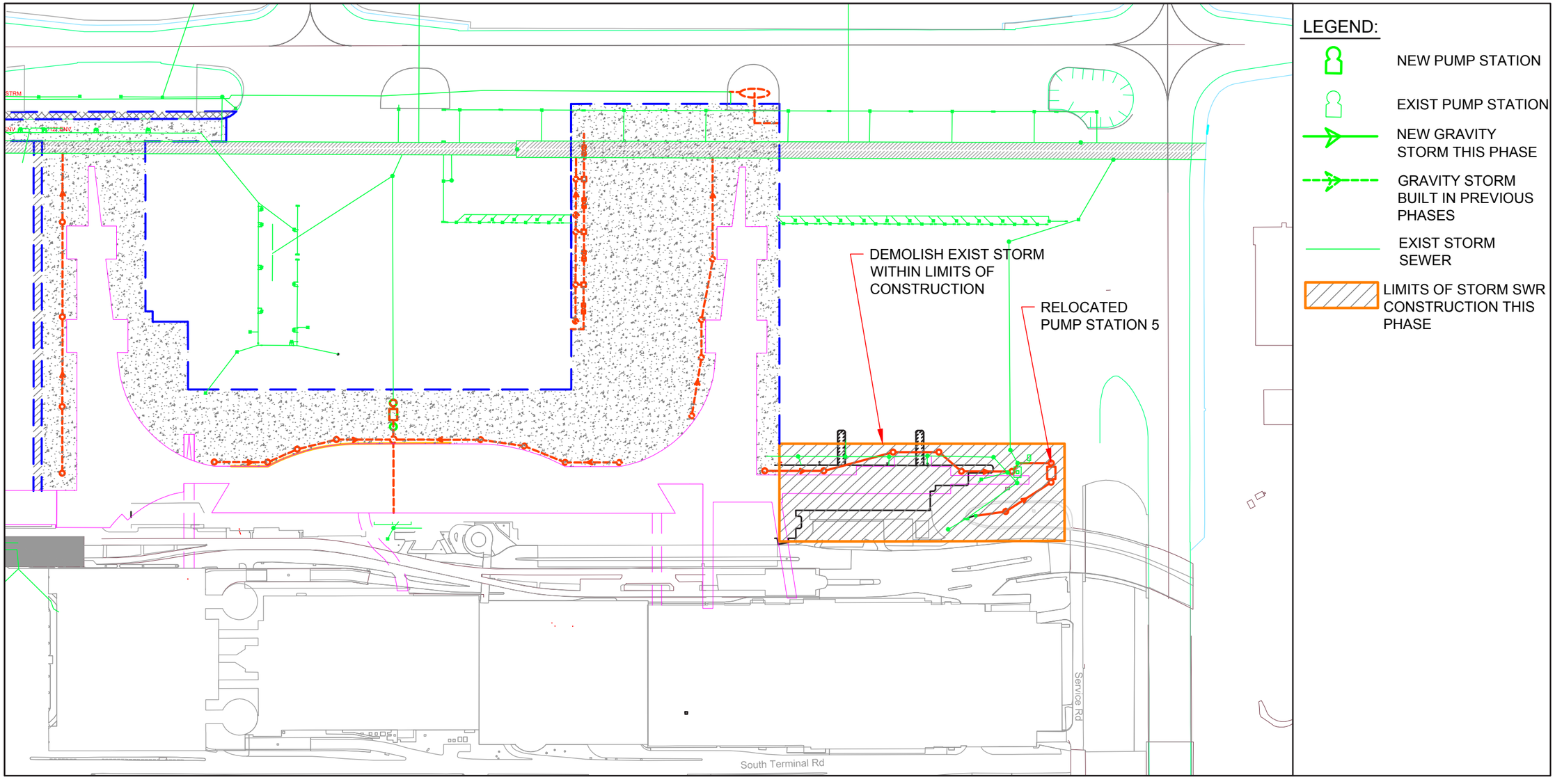
Phase 4B involves construction of the paving east of Pier D2. **Figure 7.4.18** shows two new 12 inch diameter hydrant fuel lines running along the east side of Pier D2. They connect to the fuel mains northeast of Pier D2 and terminate into the existing Terminal D hydrant fuel lines. Two fuel hydrant pits are provided for each aircraft parking position.

Phase 4H involves demolition of the existing Terminal D East Concourse and related area. **Figure 7.4.19** shows the demolition of the existing fuel mains running east. Two new hydrant fuel lines are installed and run parallel to the east end of Terminal D. New fuel hydrant pits are installed for the remaining aircraft parking positions.

7.4.3 LANDSIDE

After existing Terminal D is demolished during Phase 4 of construction the eastern portion of the new Terminal D curbside will be constructed along with a new entry roadway. The new entry roadway will tie into the existing roadway west of the taxiway bridge. During this phase Terminal D traffic will continue to use the existing terminal D roadway, which is south of the new roadway construction, to access the Terminal D west curbside where all Terminal D curbside activity will occur (see **Figure 7.4.20** and **7.4.21**). During this phase no curbside drop-off or pick-up activity will occur along the existing curbside. The existing roadway will be limited to two lanes to access the western portion of new Terminal D.

Proposed Storm Sewer - Phase 4



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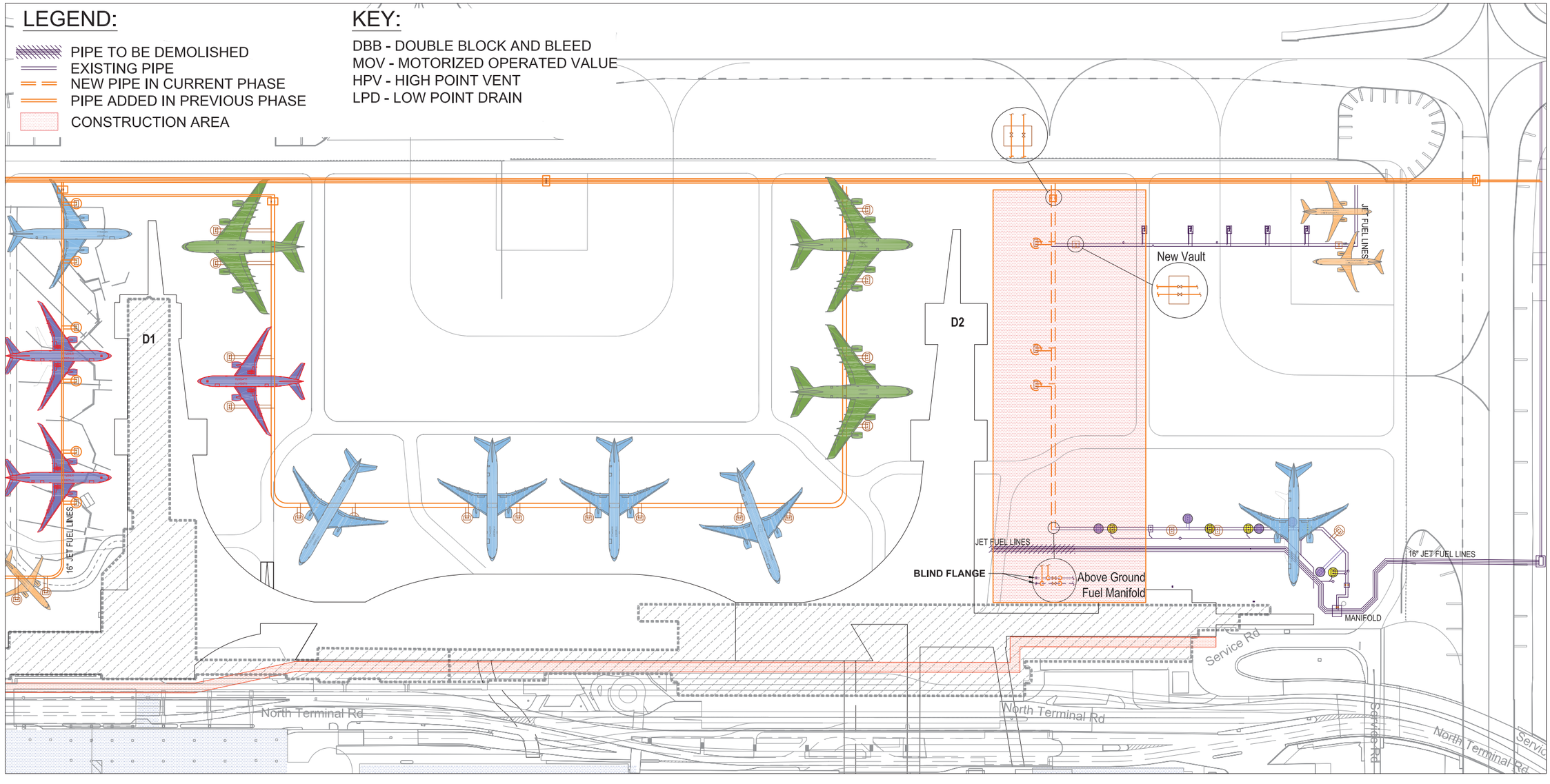
Proposed Hydrant Fueling - Phase 4B



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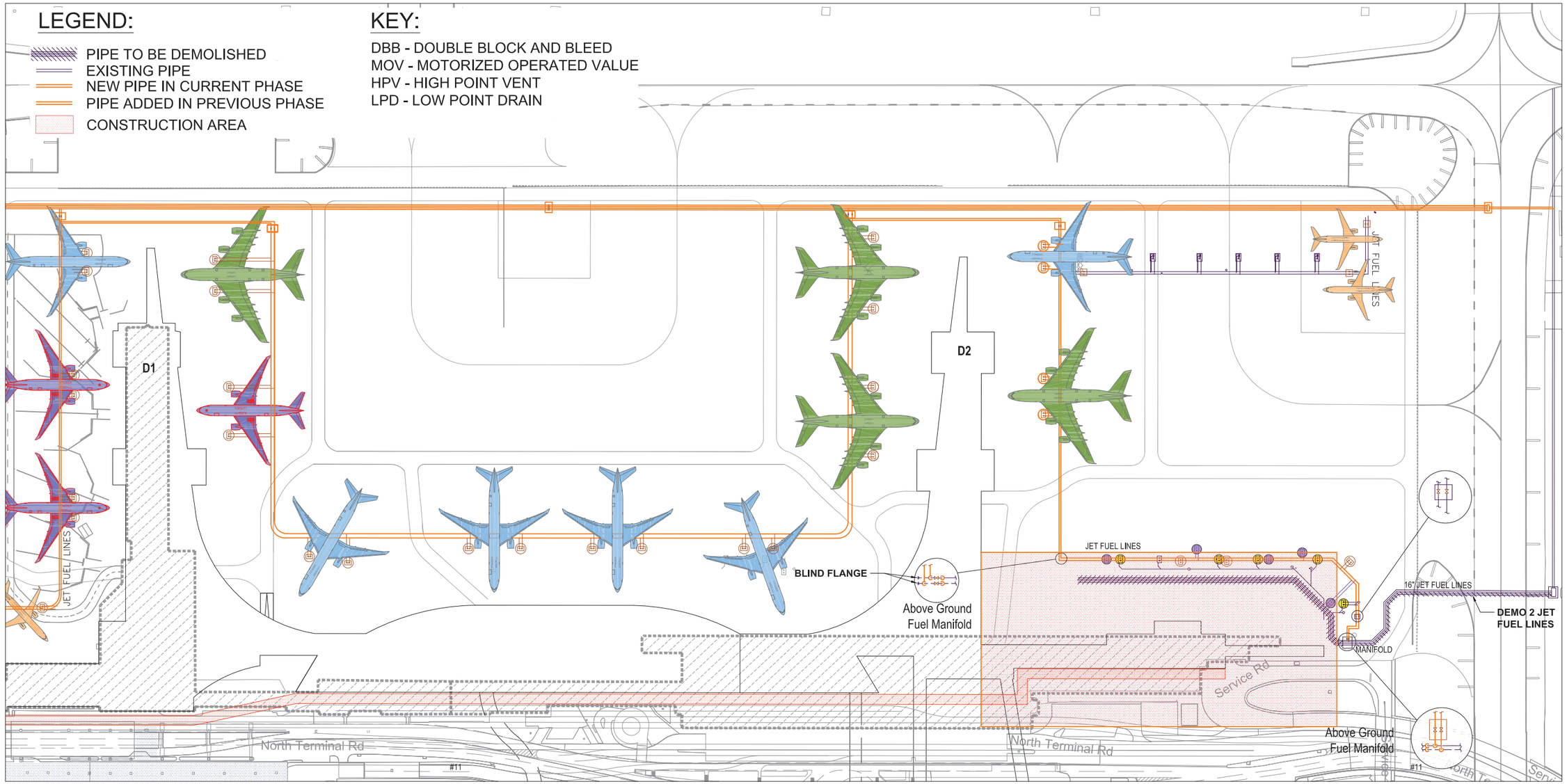
Proposed Hydrant Fueling - Phase 4F



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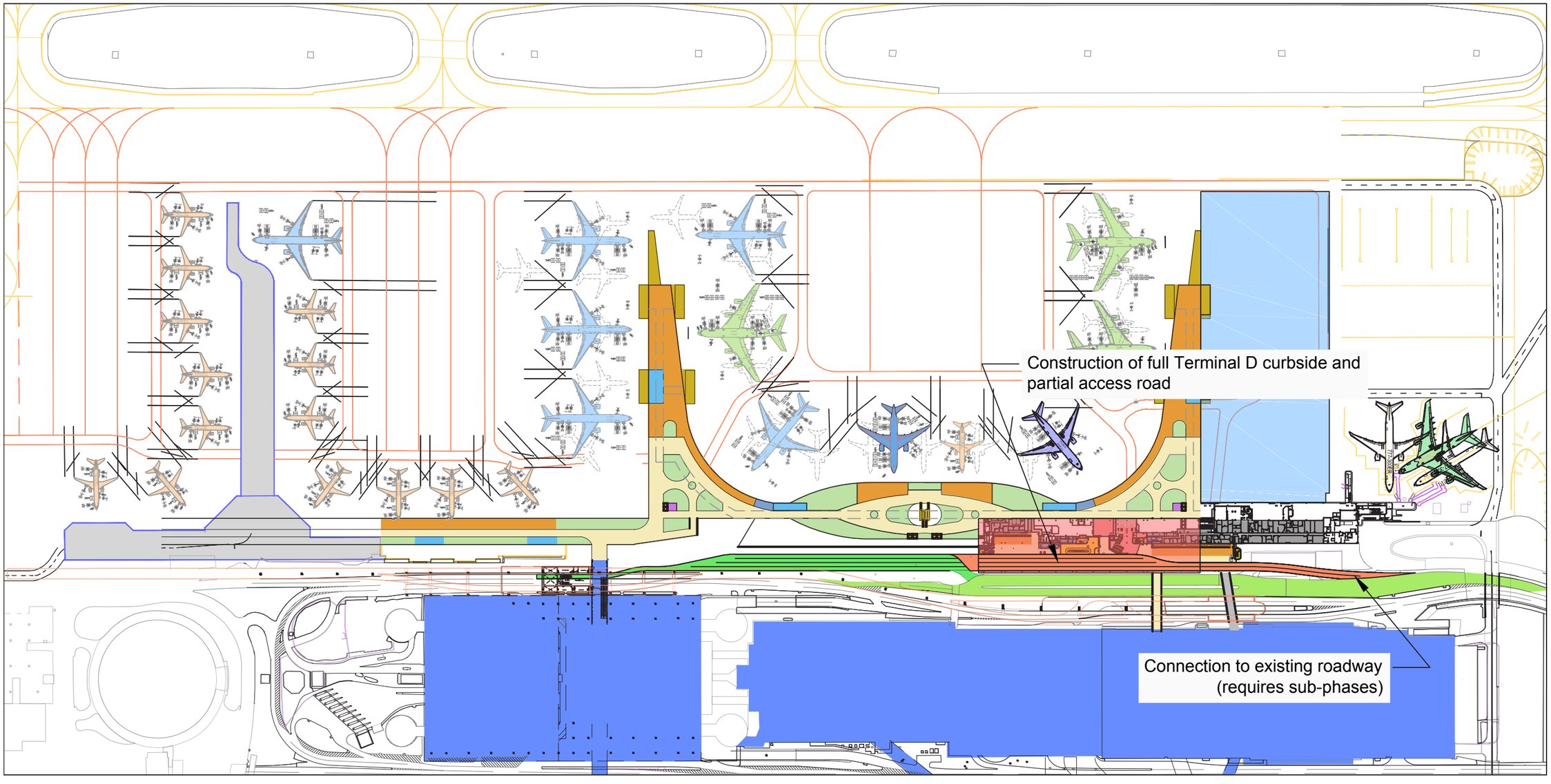
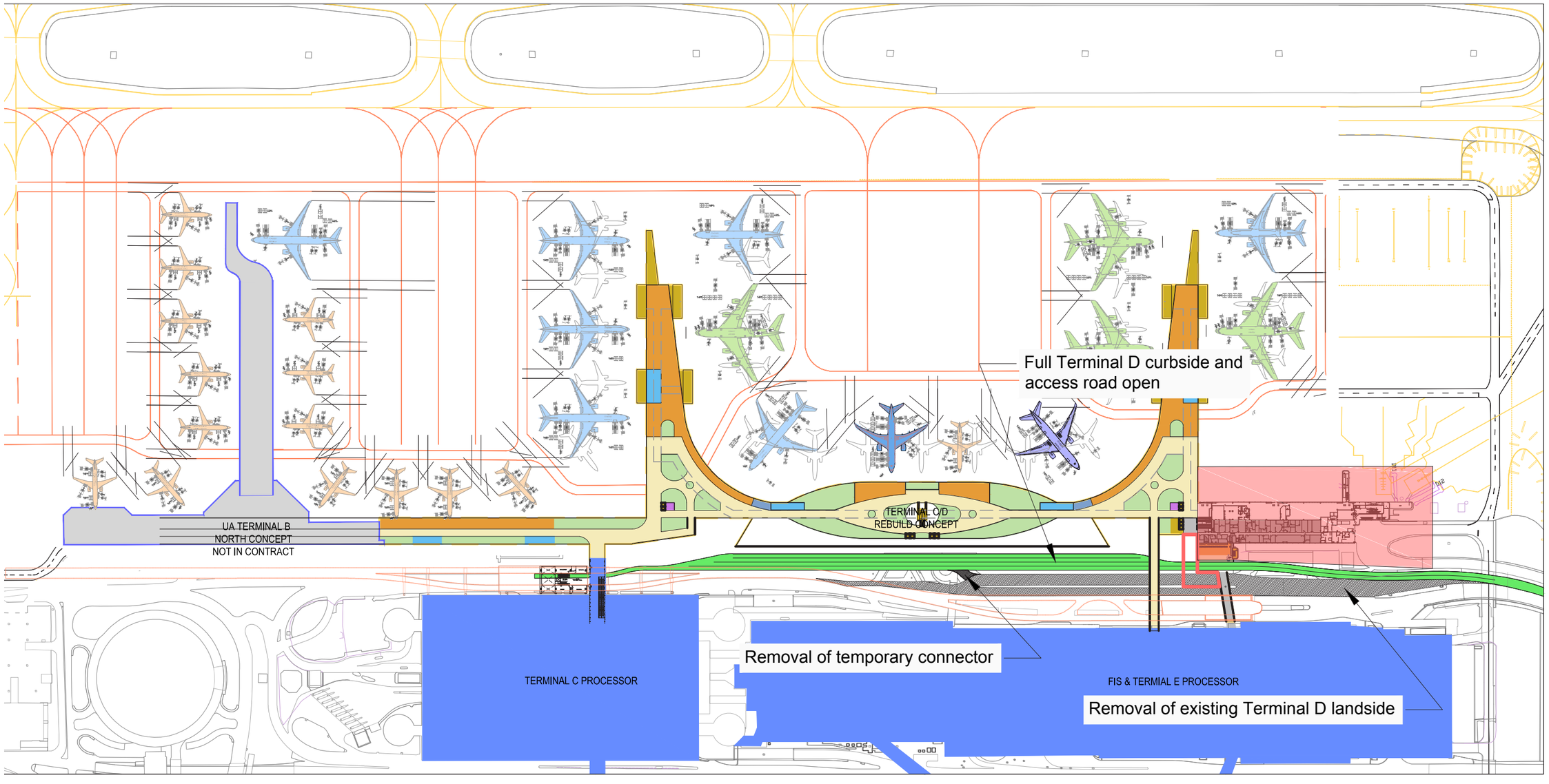
Landside - Rebuilt (Phase 4 A, B, C, & D)



0′ 275′

Landside - Rebuilt (Phase 4 E, F, G, & H)



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Chapter 8

Program Cost Estimates

8.0 Program Cost Estimates

This chapter summarizes the Rough Order of Magnitude (ROM)) costs for the Mickey Leland International Terminal (MLIT) Program. ROM estimates were prepared to compare the Rebuild and Renovation alternatives. The Rebuild alternative floor plans are included in **Chapter 5.** The renovation floorplans were not finalized, but the assumption was made that the same program requirements (square footage) would be used for the Rebuild and Renovate alternatives.

8.1 Basis of Estimate

This exercise looks at two alternatives for the MLIT Program:

Rebuild Alternative - The Rebuild Alternative demolishes the existing C North Pier (D1), C/D connector and D Terminal in their entirety and constructs a completely new facility consisting of a D1 Pier, central processor and D2 Pier. This was determined to be the preferred alternative.

Reuse Alternative - The Reuse Alternative renovates the existing C North Pier (D1), demolishes the existing C/D connector and D Terminal and constructs a new central processor and D2 pier. The renovation demolishes existing building systems and finishes at the C North Pier down to structure and installs a new enclosure system, MEP systems and finishes.

The estimates are based upon the planning drawings for the Rebuild alternative included in **Chapter 5.** Square foot areas for the Rebuild alternative are included in the Facility Requirements Summary in **Chapter 5**. Quantities were taken from these documents, where possible, and parametric methods were used for other systems in conjunction with references from other airport terminal projects at HAS and comparable terminals in the United States previously estimated by HNTB and Faithful+Gould.

8.2 Basis of Pricing

The ROM estimates reflect the fair market value for the construction of this project and should not be construed as a prediction of low bid. The unit costs include labor, material, and equipment costs plus subcontractors' overhead and profit costs. Costs are based upon 2014 US dollars.

8.2.1 PROCUREMENT METHOD

Pricing assumes a procurement process with competitive bidding for every portion of the construction work. This means that the Construction Manager at Risk will receive a minimum of three competitive bids from all subcontractors and materials/equipment suppliers. If fewer bids are solicited or received, it is anticipated that prices will be higher.

8.2.2 WAGE RATES

This estimate is priced on the basis of Union Prevailing Wage rates.

8.2.3 PHASING

It is assumed that phased construction will not be overly constrained by airport operational constraints; the construction team will have reasonable access to the work area.

8.2.4 ACCESS AND SECURITY

The estimate anticipates that site access will be primarily from the Landside and that security requirements will be typical for this scale of project at an active airport facility.

8.3 Mark-Up and Contingency Assumptions

Table 8.1 summarizes the soft costs and contingencies.

Table 8.1 – Soft Costs and Contingencies

CATEGORY	PERCENTAGE
Architecture / Engineering Fees	8%
Program Management Fees	4%
Construction Manager at Risk (CMAR)t Fees	3%
CMAR General Conditions and Overhead	10%
Testing	1%
Inspection	2%
QA / QC Services	1%
Insurance	2%
Bonds	2%
Administrative Fees	1%
Commissioning	2%
Art Program	1.75%
TOTAL SOFT COSTS	36.75%
OWNER CONTROLLED CONTINGENCY	20%

8.4 Statement of Probable Cost of Construction

The ROM estimates are based upon 2014 US Dollars. The consultant team has many years of experience providing cost consulting services in the aviation construction industry. Historically, the deviation between construction estimates and the corresponding bid amounts is minimal, however, the consultant team has no control over the method of determining prices adopted by any individual general contractor, subcontractor or supplier. The consultant team cannot control the cost of labor and materials, the bidding environment or other market conditions, and it is not possible to provide any guarantee that proposals, bids, or actual construction costs will not deviate from this or subsequent cost estimates.

The consultant team has prepared this estimate in accordance with widely accepted principles and practices to reflect the fair market value of the project. This estimate is made on the basis of the experience, qualifications, and the best judgment of professional consultants who have gained an expertise in the aviation construction industry.

8.5 Project Scope Clarifications

The following assumptions have been made in regard to this project:

8.5.1 FOUNDATIONS

Foundations will be drilled piers with pier caps and grade beams. On grade floors will be typical slab-on-grade construction.

8.5.2 BASEMENT CONSTRUCTION

The project includes a limited basement. For purposes of pricing, this is assumed to be a cast-in-place structure.

8.5.3 SUPERSTRUCTURE

For purposes of pricing, the superstructure will be structural steel with cast-in-place concrete floor slabs on metal deck.

8.5.4 EXTERIOR ENCLOSURE

Exterior enclosure is assumed to be a combination of metal panels and concrete masonry (CMU) for the first floor and curtain wall and metal panel for the second and higher floors. It is assumed that there will be limited areas of higher value exterior finishes. Public landside entrances are assumed to include vestibules.

8.5.5 ROOFING

Roofing costs are based on large areas of metal roofing, complex geometry, clerestory windows and skylights. Low slope areas will have single-ply roofing. All areas will be insulated to meet current energy codes and will have integral gutters or roof drains.

8.5.6 INTERIOR CONSTRUCTION

Interior partitions are considered metal framing with drywall, with large areas of interior glass walls.

8.5.7 STAIRS

Stairs are considered metal pan with concrete infill at non-public areas.

8.5.8 INTERIOR FINISHES

Passenger areas are assumed to have terrazzo flooring (or similar material), glass partitions and guardrails, and other wall finishes of durable materials, and high end ceilings. All public area finishes are to meet or exceed current HAS finish standards. Back-of-house areas are assumed to include areas with carpet tile (or similar) flooring, painted gypsum board walls and acoustical ceilings, and other areas with sealed concrete floors, painted CMU walls and painted exposed-structure ceilings.

Concession and clubs spaces have been estimated as shell construction. Future tenants will provide interior design and construction of these spaces under separate leases, agreements and permits.

8.5.9 CONVEYING SYSTEMS

This includes elevators, escalators and moving walks. The costs for these systems are represented parametrically based on similar programs (dollars per square foot).

8.5.10 PLUMBING

The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.11 HVAC

The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.12 FIRE PROTECTION

The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.13 ELECTRICAL

The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.14 SERVICES

This includes fire alarm, telephone/data networks and systems and equipment, access control, EVIDS, CCTV, paging, public address, and master clock systems. The costs for these systems are represented parametrically based on similar programs (dollars per square foot).

8.5.15 EQUIPMENT

This includes Baggage Handling Systems. The costs for these systems are represented parametrically based on similar programs (dollars per square foot).

8.5.16 FURNISHINGS

This includes ticket and gate counters and other fixed furnishings and holdroom seating and other moveable furnishings. The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.17 DEMOLITION

This is costs for the phased demolition of the existing buildings. Site demolition is covered in the Sitework costs. The costs for this division are represented parametrically based on similar programs (dollars per square foot).

8.5.18 AIRSIDE SITEWORK

Sitework costs include demolition of apron paving and related utilities, earthwork, site utilities, lighting and communications, new apron paving, and new and renovated passenger boarding bridges.

8.5.19 LANDSIDE IMPROVEMENTS

Landside improvements include temporary roadways and related work, demolition of existing roadways, sidewalks and utilities, earthwork and new utilities, roadways, sidewalks, fences, walls, barriers, lighting and landscaping. Two alternative scenarios were estimated, including Tying into the Terminal C Roadway and Extending the Roadway to the A/B Exit. Extending the Roadway to the A/B exit being the preferred alternative.

8.5.20 UTILITY ENABLING PROJECTS

Utility enabling projects include electrical, fire and domestic water, chilled/heating water, aviation fuel, environmental lift stations and sanitary sewers. Two alternative scenarios were estimated, with the UTILIDOR alternative being preferred.

8.5.21 OTHER ENABLING PROJECTS

These include:

- Ground Service Equipment for Irregular Operations at the Hardstand – busses, air stairs, ADA lifts, and mobile ground power and preconditioned air units
- Ramp Control Tower at the Terminal C Parking garage (shell space only)
- Temporary Relocations During Construction (multiple phases)
- Hoteling Space for Staff During Construction (multiple phases)
- Additional Enabling Projects which are not yet defined

8.6 Exclusions

This estimate specifically excludes the following items:

- Any non-competitive bid or restrictive contract conditions
- Feasibility and financing costs
- Land acquisition and real estate fees
- Owner furnished items and owner move-in costs
- TSA provided equipment and furnishings
- Items marked on plans as N.I.C. (Not in Contract)
- Furniture and Equipment beyond that listed in the narrative

Table 8.2 summarizes the cost estimate for the Rebuild Alternative for the Terminal, and the UTILIDOR alternative for site utilities.

Table 8.2 – MLIT Program Cost Estimate Summary

CATEGORY	LOW*	HIGH*
New Terminal D, D1 & D2	$438,298,483	$502,400,637
Air Side Sitework	$94,881,902	$108,758,597
Land Side Improvements	$5,172,543	$5,929,039
Utility Enabling Projects	$142,241,383	$163,044,510
Other Enabling Projects	$85,789,534	$98,336,449
MLIT Program Cost	**$766,383,844**	**$878,469,232**

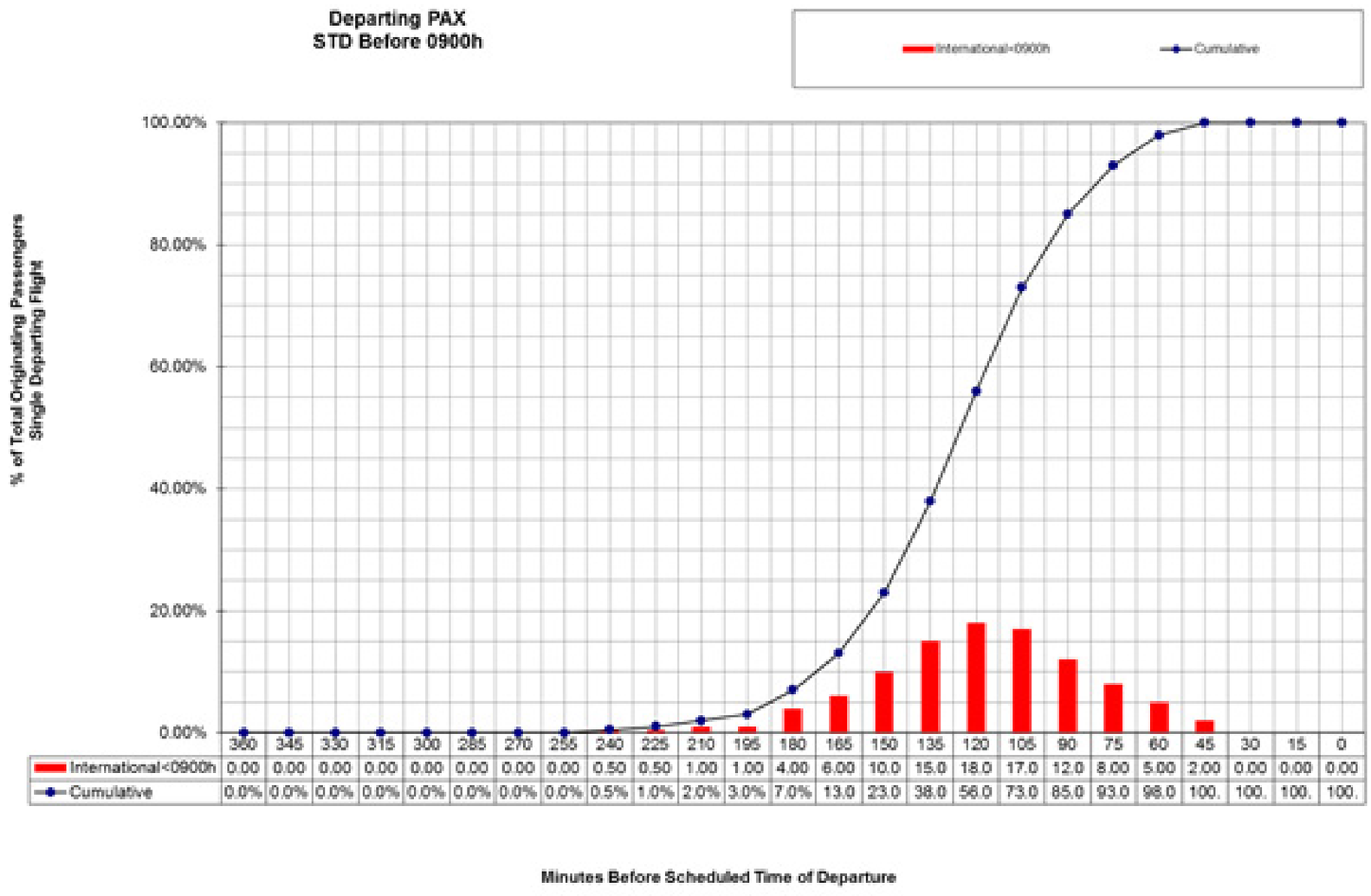
**Including Owner's Soft Costs*

*** The above table reflects the latest draft cost estimates. Finalized revisions will be included in the completed RFQ.*

Appendix A

Passenger Show-Up Profiles

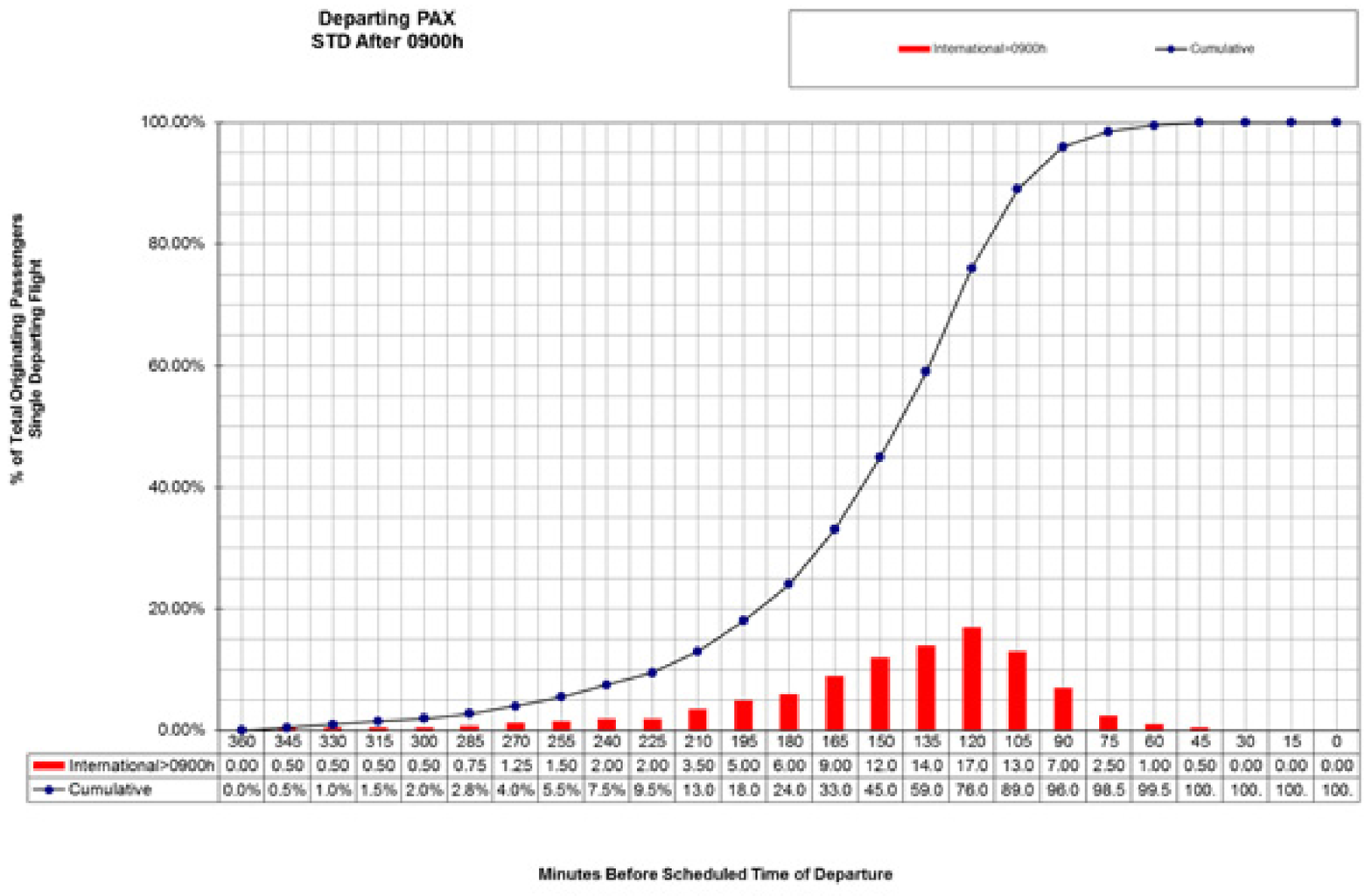
Appendix A.1 - Passenger Show-Up Profiles - Before 9am



	360	345	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0
International<0900h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	1.00	1.00	4.00	6.00	10.0	15.0	18.0	17.0	12.0	8.00	5.00	2.00	0.00	0.00	0.00
Cumulative	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	1.0%	2.0%	3.0%	7.0%	13.0	23.0	38.0	56.0	73.0	85.0	93.0	98.0	100.	100.	100.	100.

Source: 2010 Peak Week Survey Results. Houston Airport Systems and HNTB, February 2011.
Prepared by: Ricondo & Associates, Inc., May 2014.

Appendix A.2 - Passenger Show-Up Profiles - After 9am



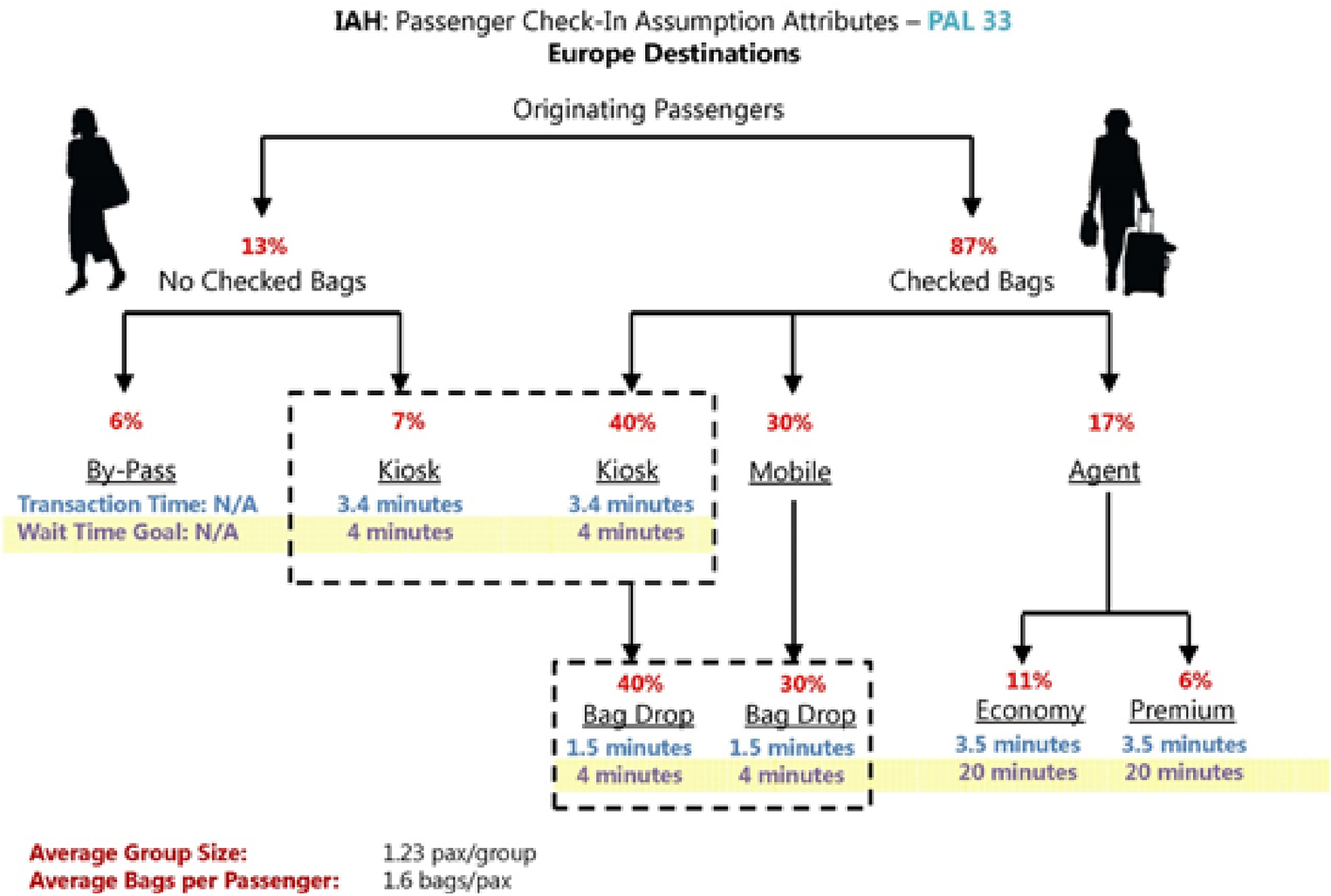
	360	345	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0
International>0900h	0.00	0.50	0.50	0.50	0.50	0.75	1.25	1.50	2.00	2.00	3.50	5.00	6.00	9.00	12.0	14.0	17.0	13.0	7.00	2.50	1.00	0.50	0.00	0.00	0.00
Cumulative	0.0%	0.5%	1.0%	1.5%	2.0%	2.8%	4.0%	5.5%	7.5%	9.5%	13.0	18.0	24.0	33.0	45.0	59.0	76.0	89.0	96.0	98.5	99.5	100.	100.	100.	100.

Source: 2010 Peak Week Survey Results. Houston Airport Systems and HNTB, February 2011.
Prepared by: Ricondo & Associates, Inc., May 2014.

Appendix B

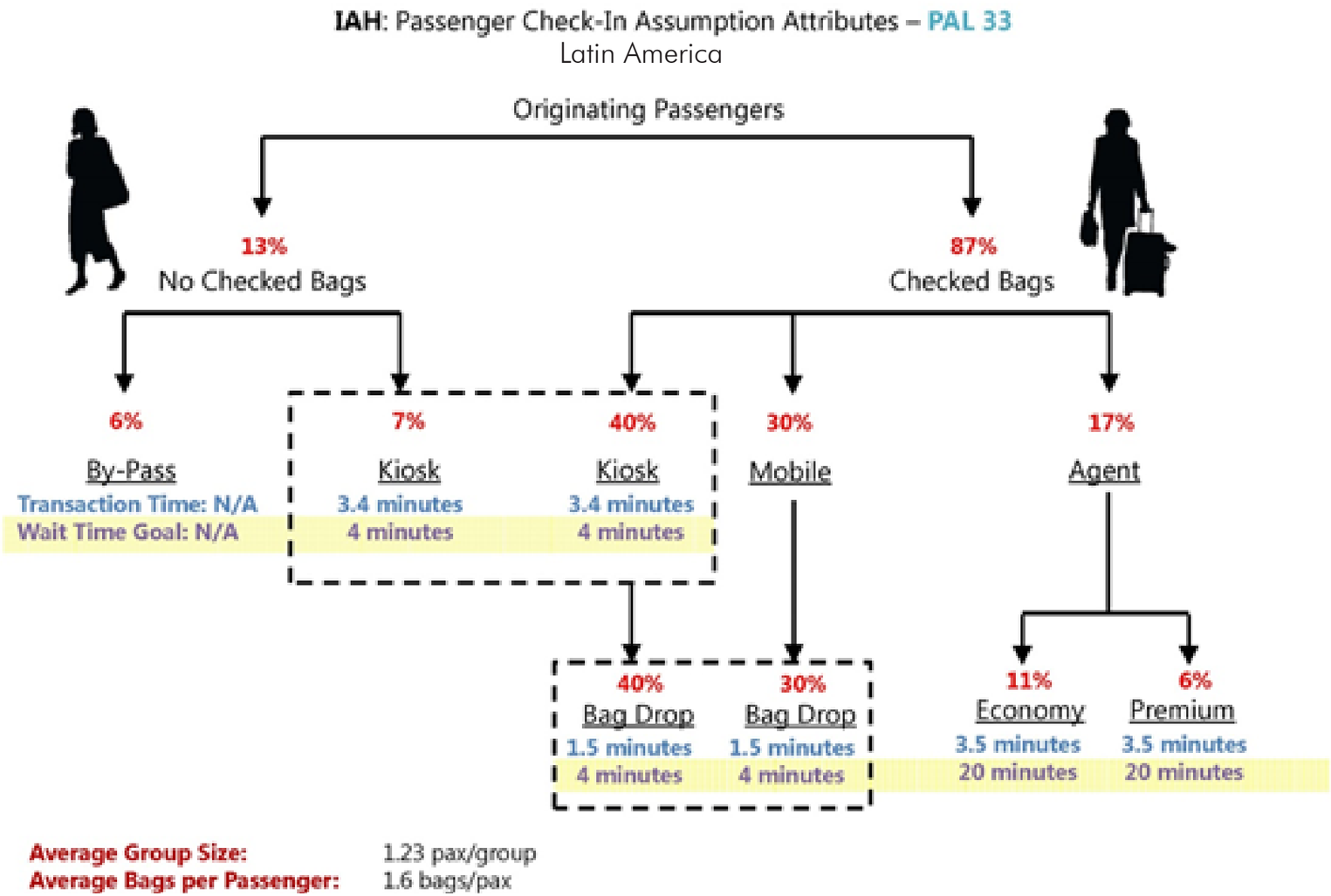
Check-in Attributes

Appendix B.1 - Check-In Attributes - Europe Bound



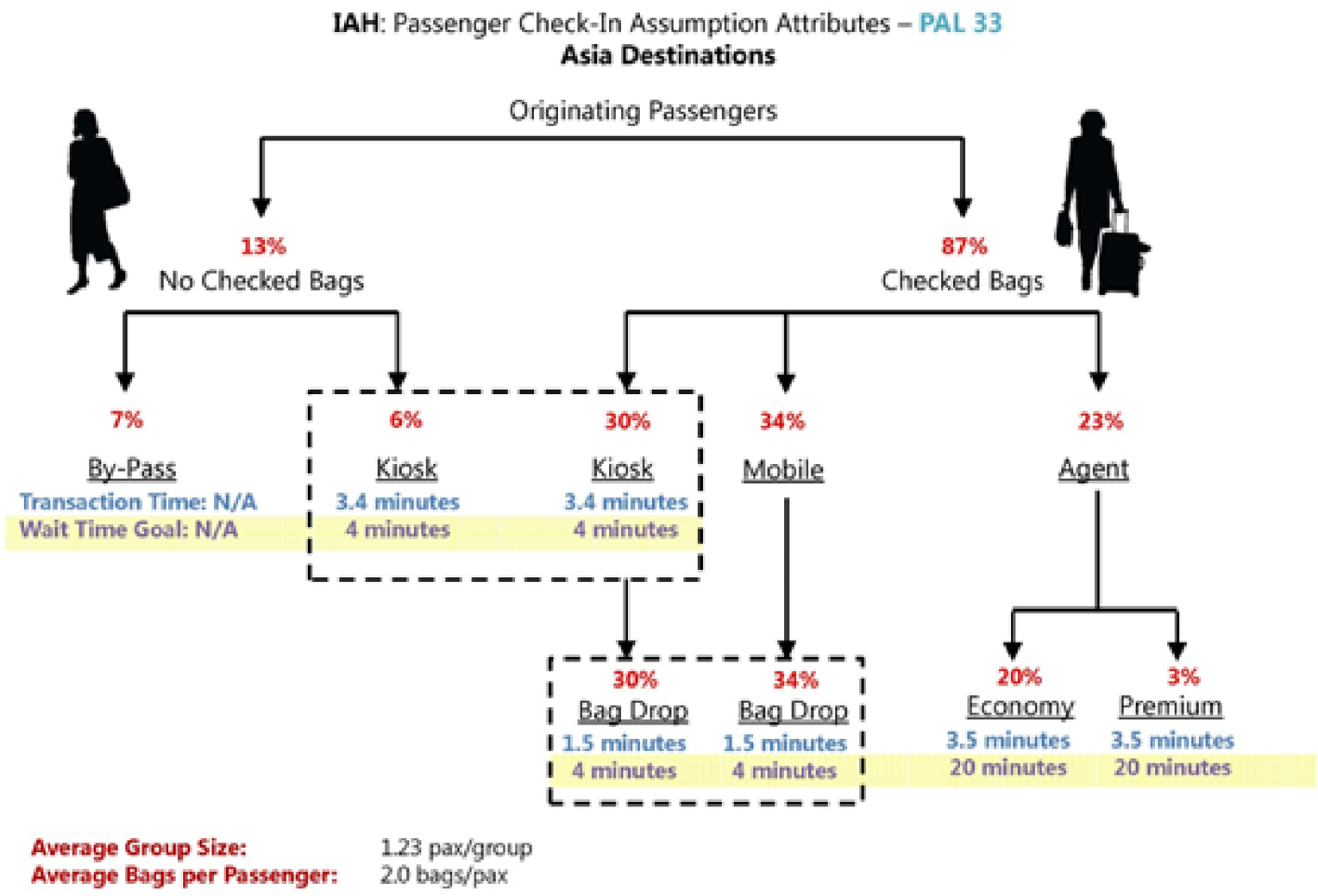
Source:
1/ Air France survey
2/ KLM Royal Dutch Airlines survey
3/ Lufthansa Airlines survey
4/ Ricondo & Associates, Inc., May 2014.
Prepared by: Ricondo & Associates, Inc., May 2014.

Appendix B.2 - Check-In Attributes - Latin America Bound



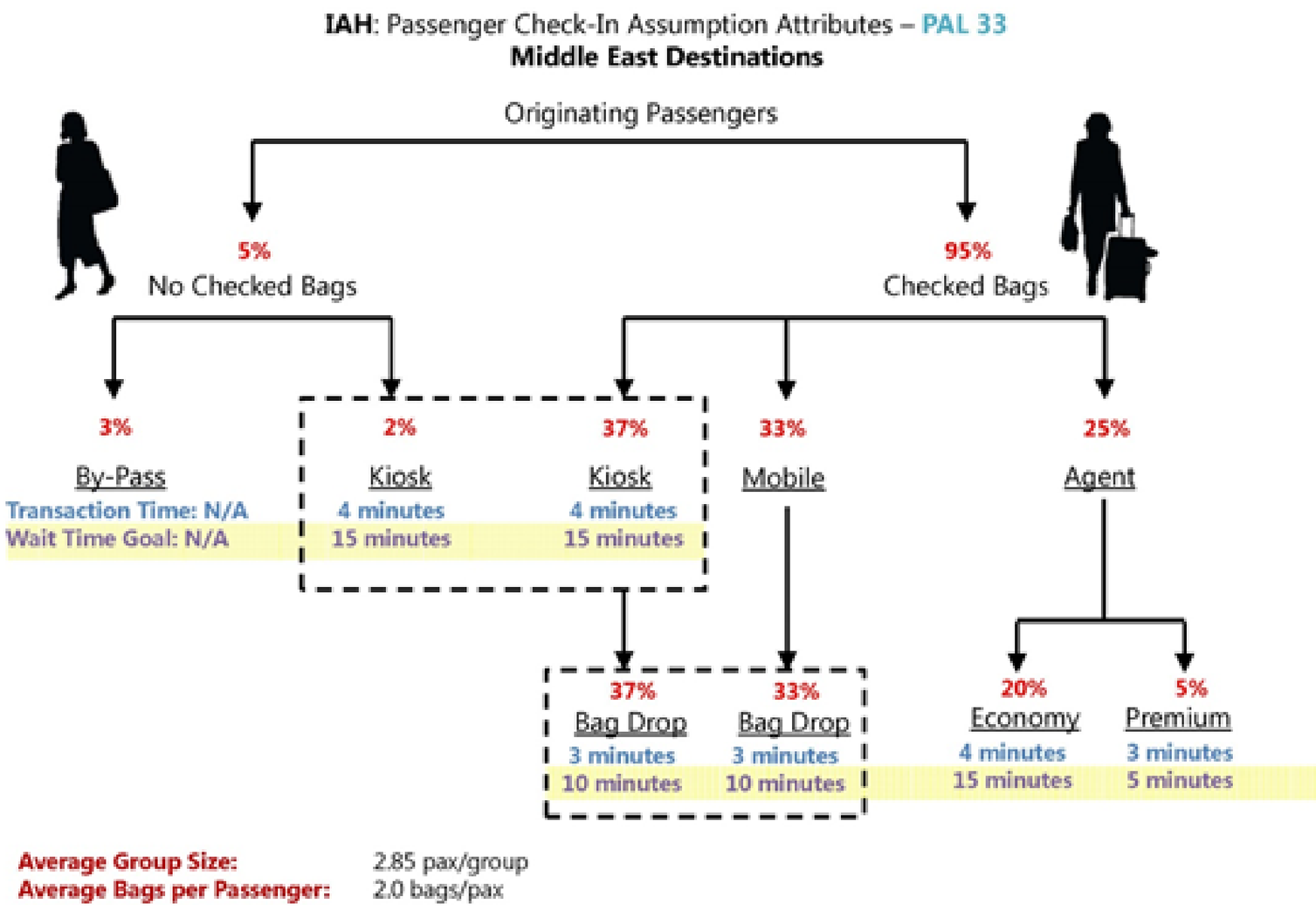
Source:
1/ Aeromexico survey
2/ Ricondo & Associates, Inc., May 2014.
Prepared by: Ricondo & Associates, Inc., May 2014.

Appendix B.3 - Check-In Attributes - Asia Bound



Source:
1/ Air China survey
2/ Ricondo & Associates, Inc., May 2014.
Prepared by: Ricondo & Associates, Inc., May 2014.

Appendix B.4 - Check-In Attributes - Middle East Bound



Source:
1/ Emirates Airline survey
2/ Ricondo & Associates, Inc., May 2014.
Prepared by: Ricondo & Associates, Inc., May 2014.