Methodology

With the completion of Step 4 of the ODOT's PDP for Major Projects, several freeway mainline and interchange alternatives were recommended and approved for further study in Step 5.

Depending on whether the alternative was a mainline alignment or interchange, the method of concept development varied. Step 5 procedures, as included in the current version of the ODOT *Location and Design Manual* (LDM) Section 1400, were employed at a minimum and in many ways that level of effort was exceeded. More in-depth means of evaluation were used in areas where more uncertainty could result in higher risk of increased cost or questionable feasibility.

The LDM stipulates rather general assessment criteria such as conceptual typical sections and 2-D alignment layout. However, the physical space within the project limits is highly constrained by buildings, parallel arterial streets, Mill Creek and railroad tracks within close proximity to the existing project roadways. As a consequence and with the approval of the Department, the mainline alignment alternatives have been engineered using Geopak both horizontally and vertically. Roadway profiles and cross sections were generated and assessed for ways to reduce collateral impacts using a single design iteration. As such, the alignment solutions should not be considered optimized, however, a relatively high degree of confidence in the alignments can be assumed.

Design criteria applied in the development of alternatives is shown below. The design approach is consistent with the LDM and AASHTO *A Policy on Geometric Design of Highways and Streets* 2004 (hereafter referred to as the "Green Book") for given roadway classifications and design speeds. Cross section generation was accomplished using an unmodified ODOT Geopak criteria file and visual inspection for retaining wall limits. Geometric layouts were developed using design-level aerial mapping supplied by ODOT Office of Aerial Engineering as well as the model TIN (terrain model) used to generate profiles and cross sections. Mainline alternative earthwork and retaining wall quantities were calculated from the Geopak generated cross sections.

For efficient use of time, only Microstation was utilized without applying Geopak for interchange alternative layout. As such, no vertical information (profiles or cross sections) was created for ramps or arterial streets and, consequently, accuracy of interchange concepts is lower than that of the mainline. The exception is the proposed I-74 directional ramps where profiles were designed to determine their feasibility.

Interchange intersections were analyzed using Synchro v6 (for signals) and RODEL v1 (for modern roundabouts) using 2030 design year turning movement volumes. Ultimately, signalized

intersection analyses will be performed with the Highway Capacity Software (HCS) as required in PDP Step 6. Synchro was used to provide a reasonably high degree of confidence of expected intersection operation. Intersections were designed for a LOS D which is acceptable as per the Green Book. In the course of evaluating the PDP Step 4 alternatives, several alternatives were found to be potentially deficient. Additional alternatives recommended for further evaluation have been identified and are listed below.

The following table lists the alternatives recommended for further evaluation in Step 5:

Step 4 Recommended Alternatives			
Alternative	**Description**	**Alternative**	**Description**
I75-NB	No Build Plus Minor Improvements	**MIT-NB**	No Build Plus Minor Improvements
I75-A	4-Lane Continuity with Auxiliary Lanes	**MIT-A**	Tight Urban Diamond Interchange
I75-B	5-Lane Continuity		
I75-C	4-Lane Continuity with Elevated Express Lanes	**NOR-NB**	No Build Plus Minor Improvements
		NOR-A	Modified Interchange with Additional Ramp Lanes
HOP-NB	No Build Plus Minor Improvements		
HOP-A	Tight Urban Diamond Interchange	**TOW-NB**	No Build Plus Minor Improvements
HOP-B	Offset Roundabout Diamond Interchange	**TOW-A**	Close Ramps
I74-NB	No Build Plus Minor Improvements	**PAD-NB**	No Build Plus Minor Improvements
I74-A	Fully Directional Interchange with Local Access	**PAD-A**	Low Impact Improvement
I74-B	Fully Directional Interchange with No Local Access	**PAD-B**	Double Roundabout Diamond Interchange
COL-NB	No Build Plus Minor Improvements		
COL-A	Low Impact Improvement with Full Movements		
COL-B	Double Roundabout Diamond Interchange		

The following table lists four alternatives that were added after Step 5 began:

Additional Step 5 Alternatives			
Alternative	**Description**	**Alternative**	**Description**
I75-D	5/4-Lane	**COL-A1**	Low Impact Improvement with Full Movements (WB Ramp Loop)
HOP-B1	Offset Diamond Interchange (No Roundabout)	**COL-B1**	Double Roundabout Diamond Interchange (WB Ramp Loop)

In general, the freeway alternatives have been evaluated independently from the interchange alternatives since each are planned to be self-contained construction projects in the future. In so far as practical, a qualitative evaluation of system-level operation has been made and is discussed later in this report.

Conceptual Design Designations

The following table summarizes the project design designations:

Design Designations				
Route	**Freeway**	**Directional Ramp**	**Service Ramp**	**Local Street**
Design Functional Classification	Urban Interstate	Urban Interstate	Urban Ramp	Urban Arterial
Terrain[1]	Level	Level	Level	Level
Access Permit	State	State	State	Local
Design Speed	60 MPH	60 MPH Upper 45 MPH Middle	50 MPH Upper 40 MPH Middle 30 MPH Lower	40 MPH[2]
Opening Year	2010	2010	2010	2010
Design Year	2030	2030	2030	2030
Design Vehicle	WB-67	WB-67	WB-67	WB-50[3]
Desirable Design LOS[4]	D	D	D	D
Minimum Design LOS	Existing	Existing	Existing	D
Projected Traffic Volumes	Refer to Traffic Volume Exhibits			

Notes:

1. The terrain designation is proposed to be "level" as per LDM Section 103.2 which describes level terrain as "Any combination of grades and horizontal and vertical alignment permitting heavy vehicles to maintain approximately the same speed as passenger cars. This generally includes grades of no more than 2 percent for a distance of no more than ½ mile." Although there are isolated instances of grades greater than 2% within the project limits, these are short length, do not exceed 4% and are used to avoid costly impacts (such as railroad tracks).

2. With most local streets having a legal speed of 35 MPH or less, this study assumes 40 MPH for local street design speeds. Actual design speeds for local streets will be determined in subsequent PDP Steps when appropriate.

3. Except at Mitchell Avenue where the Department has specifically requested a WB-67 truck be used as the design vehicle.

4. Minimum LOS C is preferred in an urban environment; however, ODOT has determined that a lower LOS is acceptable with MPO and FHWA approval where increased cost and impacts are considered too great.

Design Criteria

A basis for design must be assumed even though ODOT may not have approved design criteria for the project at the initial steps of the PDP. In order to design to specific standards of the LDM, values for curvature, grades, transitions, lane and shoulder widths, etc. were determined based upon known or assumed design designations.

The following table summarizes the LDM criteria used for project conceptual design:

Design Element	Value	L&D Ref	Value	L&D Ref	Value	L&D Ref	Value	L&D Ref
Route	**Freeway**		**Directional Ramp[1]**		**Service Ramp[2]**		**Local Street**	
Horizontal Alignment								
Max Centerline Deflection w/o Horizontal Curve	1° 00'	Fig 202-1E	1° 00' 1° 45'	Fig 202-1E	1° 15' 2° 15' 3° 45'	Fig 202-1E	2° 15'	Fig 202-1E
Maximum Deg of Curve	4° 15'	Fig 202-2E	4° 15' 8° 45'	Fig 202-2E Fig 202-10E	6° 45' 11° 15' 21° 00'	Fig 202-2E Fig 202-10E Fig 202-10E	11° 45'	Fig 202-9E
Max Curve without Super	0° 33'	Fig 202-3E	0° 33' 0° 57'	Fig 202-3E	0° 47' 1° 10' 1° 57'	Fig 202-3E	4° 40'	Fig 202-3E
Maximum Superelevation	6.00%	Fig 202-8E	6.00%	Fig 202-8E Fig 202-10E	6.00%	Fig 202-8E Fig 202-10E	4.00%	Fig 202-9E
Vertical Alignment								
Maximum Grade[3]	3%	Fig 203-1E	3%	Fig 203-1E	4%	Fig 203-1E	7%	203-1
Max Vertical Deflection without a Vertical Curve	0.30%	Fig 203-2E	0.30% 0.55%	Fig 203-2E	0.45% 0.75% 1.30%	Fig 203-2E	0.75%	Fig 203-2E
K-Values								
Crest Vertical Curve	151	Fig 203-3E	151 61	Fig 203-3E	84 44 19	Fig 203-3E	44	Fig 203-3E
Sag Vertical Curve[4]	136	Fig 203-6E	136 79	Fig 203-6E	96 64 37	Fig 203-6E	64	Fig 203-6E
Sight Distance								
Stopping Sight Distance	570'	Fig 201-1E	570' 360'	Fig 201-1E	425' 305' 200'	Fig 201-1E	305'	Fig 201-1E
Min. Passing Sight Distance	---	---	---	---	---	---	1470'	Fig 201-3E
Intersection Sight Distance	---	---	---	---	---	---	445' Left 385' Right	Fig 201-5E
Decision Sight Distance	1150' (B) 1280' (E)	Fig 201-6E	1150' (B) 1280' (E) 800' (B) 930' (E	Fig 201-6E	910' (B) 1030' (E) 690' (B) 825' (E) 490' (B) 620' (E)	Fig 201-6E	690' (B) 825' (E)	Fig 201-6E
Clearances (New & Reconstructed)								
Lateral On Bridge (>=200'long)	14' Rt. 14' Med.	Fig 302-1E	14' Rt. 6' Lt.	Fig 302-1E	8' Rt. 6' Lt.	Fig 302-1E	1'-2'	Fig 301-4E
Lateral On Bridge (<200'long)	14' Rt. 14' Med.	Fig 302-1E	14' Rt. 6' Lt.	Fig 302-1E	8' Rt. 6' Lt.	Fig 302-1E	1'-2'	Fig 301-4E
Vertical	17.0' Pref. 15.5' Min.	Fig 302-1E	17.0' Pref. 15.5' Min.	Fig 302-1E	17.0' Pref. 15.5' Min.	Fig 302-1E	17.0' Pref. 15.5' Min.	Fig 302-1E

Design Element	Value	L&D Ref	Value	L&D Ref	Value	L&D Ref	Value	L&D Ref
Route	**Freeway**		**Directional Ramp[1]**		**Service Ramp[2]**		**Local Street**	
Clearances (Existing)								
Lateral On Bridge (>=200'long)	10' (3.5') Rt. 3.5' Med.	Fig 302-2E	10' (3.5') Rt. 3.0' Lt.	Fig 302-2E	6' (3')	Fig 302-3E	6' (3')	Fig 302-3E
Lateral On Bridge (<200'long)	10' Rt. 3.5' Med.	Fig 302-2E	10' Rt. 3.0' Lt.	Fig 302-2E	6' (3')	Fig 302-3E	6' (3)'	Fig 302-3E
Vertical	14.5' Min.	Fig 302-2E	14.5' Min.	Fig 302-2E	14.0' Min.	Fig 302-3E	14.0' Min.	Fig 302-3E
Clear Zone								
Foreslope 6:1 or Flatter	30'	Fig 600-1E	30' 19'	Fig 600-1E	19" 15' 15'	Fig 600-1E	15'	Fig 600-1E
Foreslope Steeper than 6:1 to 4:1	30'	Fig 600-1E	30' 26'	Fig 600-1E	26' 17' 17'	Fig 600-1E	17'	Fig 600-1E
Backslope 6:1 or Flatter	28'	Fig 600-1E	28' 21'	Fig 600-1E	21' 15' 15'	Fig 600-1E	15'	Fig 600-1E
Backslope Steeper than 6:1 to 4:1	28'	Fig 600-1E	28' 19'	Fig 600-1E	19' 15" 15'	Fig 600-1E	15'	Fig 600-1E
Backslope Steeper than 4:1	23'	Fig 600-1E	23' 15'	Fig 600-1E	15' 15' 15'	Fig 600-1E	15'	Fig 600-1E
Lanes								
Number of Thru Lanes	> 3 (by alt)		2 or 1		2 or 1		Varies	
Lane Width	12'	Fig 301-4E	12' (2-lane) 16' (1-lane)	Fig 301-4E	12' (2-lane) 16' (1-lane)	Fig 301-4E	12' 11' (Min.)	Fig 301-4E
Shoulders								
Treated Width	12' Rt. 12' Med.	Fig 301-3E	10' R / 4' L 6' R / 4' L	Fig 303-3E	6' Rt. 3' Lt.	Fig 303-3E	2' Curb & Gutter	Fig 301-4E
Graded Width with Barrier or Foreslopes Steeper Than 6:1	17' Rt. 17' Med.	Fig 301-3E	15' R / 9' L 11' R /9' L	Fig 303-3E	14'	Fig 303-3E	---	---
Graded Width without Barrier and Foreslopes 6:1 or Flatter	12' Rt. 10' Med.	Fig 301-3E	10' R / 6' L 8' R / 6' L	Fig 303-3E	10'	Fig 303-3E	---	---
Normal Barrier Offset	12' Rt. 12' Med.	Fig 301-3E	12' R / 8' L 8' R / 6' L	Fig 303-3E	8' Rt. 6' Lt.	Fig 303-3E	4' Min.	602.1.5.1
Assumed Median Width[5]	31'	---	---	---	---	---	---	---
Terminal Classification								
Freeway Terminal	---	---	High-Speed	Fig 503-2aE	High-Speed	Fig 503-2aE	---	---

Notes:

1. For Directional Ramps, top line indicates upper range speed (60 MPH), second line indicates middle range speed (45 MPH).
2. For Service Ramps, top line indicates upper range speed (50 MPH), middle line indicates middle range speed (40 MPH), bottom line indicates lower range speed (30 MPH).
3. Grades may be increased by 1% for freeways in developed areas where a flatter grade is precluded.
4. Where street lighting is present, the length of sag vertical curve is 3 times the speed.
5. Assumed median width of 31' will not eliminate the need for barrier in the median.

Consideration of Design Exceptions

Under ODOT's PDP, alternatives developed during Step 5 are not supposed to assume the use of any design exceptions that would be pervasive throughout the project length, such as reduced shoulder width, restricted sight distance or inadequate superelevation transition lengths. However, in a very tight corridor, such as the I-75 corridor, the question was raised as to whether design exceptions would be clearly indicated to reduce impacts or costs.

During the development of mainline alignments during Step 5, the project team discussed whether utilizing no design exceptions would yield the best information for the purposes of comparing alternatives at this point in the process. In other words, the project team wanted to be sure to compare alternatives in Step 5 based upon what would likely be built. The alignment in progress with no design exceptions had the potential for high retaining walls on the east side. ODOT District 8 questioned whether an alternative with design exceptions would be able to reduce the retaining wall costs and impacts on the Mt. Storm Park.

In order to answer this question, ODOT commissioned the design team to perform a study of one segment of the project (from I-74 to Mitchell Avenue), where the corridor is the most constrained by natural features and built-up areas. Because the project is focused on improving safety, major design exceptions (such as lane width, shoulder width, or degree of curvature) are not likely to be proposed and approved. Therefore, the team evaluated three different mainline alignments, considering design exceptions only where needed to achieve a specific avoidance objective. These three mainline options are described below.

Option A had no design exceptions. It had the benefit of eliminating all design exceptions and avoiding the relocation of electric transmission towers and billboards. This alternative also had the least impact on railroad property. However, it was primarily an east shift into the hillsides. Consequently, it was expected to be the highest cost alternative due to an extensive amount of retaining wall at a premium cost per square foot.

Option B's objective was to match the existing centerline as much as possible. Minor adjustments were made to the horizontal curves at the I-74 interchange to reduce the number of design exceptions. The resulting design exceptions would be 50 mph for horizontal stop sight distance and transition length. Option B fell between Option A and Option C on cost.

Option C's primary intent was to reduce parkland impacts and hill side retaining wall by shifting the freeway to the west. While this option results in much lower retaining wall construction on the east than Option A, it has the greatest impact on west side features including relocation of billboards and a transmission tower. It was not possible to reduce the total impacted park acreage due to

geometric constraints. It also would require a 50 mph design exception for transition length. This option was initially expected to save $5 million compared to Option A.

The preliminary drawings, impacts and costs were reviewed by a committee consisting of ODOT District 8, ODOT's Offices of Roadway Engineering Services (ORES) and Geotechnical Engineering (OGE), and FHWA. Based upon the preliminary comparison, Alternative C would be expected to save approximately $5 million; however, there would be no benefit in terms of reduced park impacts. The ODOT District 8 and OGE geotechnical engineers expressed concerns about known soil instability on the west side, which could not be accounted for in the cost estimates at this early stage of project development. This issue could potentially erode the likely $5 million savings. Option C would also add the project schedule complexity of relocation of a transmission tower.

So, given the uncertainty of acquiring railroad land nearer to the tracks, the schedule complexities and costs of utility relocations, the uncertainty of costs associated with poor soils on the west side, plus the design exceptions of Option C, ODOT determined that Option A proved the most desirable. Therefore, the project team was directed to continue with the assumption of no alignment design exceptions in Step 5 consistent with ODOT's Project Development Process. As a result, no options shown within this report contain any pervasive design exceptions. There are isolated locations where design exceptions are anticipated, such as the shoulder width under the existing Paddock Road bridge. Where these isolated design exceptions occur, they have been noted in the Design Issues section of this report.

Post Construction Stormwater Best Management Practices Threshold Determination

ODOT's LDM Volume II, Section 1115.1, provides a checklist for determining whether a project must include post construction stormwater best management practices (BMP). A project must include BMP's if it disturbs more than one acre and meets any <u>one</u> of the following criteria:

- ✓ 30 feet or greater of impervious surface width (cross section width) drained in one direction
- NO ADT is greater than 30,000 and the roadway is classified as Rural
- ✓ More than 80% (for the entire project) of the drained area is discharged through a closed storm sewer
- ✓ Project is located within an ODOT MS4, Phase II regulated area
- ✓ Storm water outfall is into a TMDL regulated stream where the highway runoff has been identified as a regulated pollutant source

BMP's will be required due to the project's location within a regulated MS 4, Phase II area. In addition, the stormwater discharges into the Mill Creek, which is TMDL regulated for Phosphorous and Nitrogen. At this point in the process, it is not yet known in detail how much width will be drained in one direction, nor what exact percentage of pavement drainage is expected to be discharged through a closed storm sewer, however it is likely that both of these criteria will also be exceeded. Conceptual designs and locations for the BMP's will be determined during Step 6 of the PDP.

Description of Mainline Alternatives

The following summary provides a brief description of each mainline alternative:

I75-NB: No-Build Plus Minor Improvements

This alternative consists of the existing roadways and committed projects currently included in the OKI Transportation Improvement Plan (TIP) or local plans.

OKI Committed TIP Projects					
ODOT PID	**Facility**	**Project Description**	**Project Sponsor**	**Letting Year**	**Programmed Cost**
25499	SR 562	Rehabilitation	ODOT	2006	$6.205 million
75695	IR 74	Crackseal	ODOT	2012	$242,000
77484	US 27	Improve capacity at W. Fork/Virginia/US 27	Cincinnati	2008	$3.8 million
79382	US 27	Urban paving	Cincinnati	2009	$1.068 million

Minor improvements included in this alternative would be rehabilitate existing pavement and at-grade bridges, upgrade entrance and exit ramp terminals in accordance with current design standards, widen outside shoulders to 12 feet, and add auxiliary lanes where appropriate and not in conflict with overhead bridges.

I75-A: 4-Lane Continuity with Auxiliary Lanes

This alternative provides additional capacity north of the I-74 interchange by adding one lane each way to the existing three-lane section. South of I-74, the existing four-lane section would not receive an additional lane. (See Exhibits A1-A17.) Other improvements would include constructing standard width inside and outside shoulders, eliminating stopping sight distance (SSD) deficiencies, achieving minimum superelevation transitions and obtaining minimum clearances. The only design exception identified at this PDP Step for this alternative is shoulder width under the Paddock Road overhead bridge.

Traveling in the northbound (NB) direction:

- The single-lane Hopple Street entrance ramp would be added as an auxiliary lane becoming the fifth lane thus fulfilling the requirements of lane balance and number of lanes approaching the I-74 interchange.
- Traveling away from the I-74 interchange would be the I-74 NB entrance ramp merging onto the I-75 four lanes. This alternative is not expected to require reconstruction of the Ludlow Viaduct overhead bridge, but would involve modifying the south abutment to create space for the entrance ramp terminal.
- At Mitchell Avenue, a single exit ramp is proposed as is a single entrance ramp lane merging onto I-75.
- The Norwood Lateral (SR 562) is recommended to be comprised of a single exit ramp lane and two entrance ramp lanes. In order to maintain lane balance and number of lanes, the 2-lane entrance ramp would require a parallel-type terminal such that the resulting lane arrangement just prior to the entrance terminal would be four mainline plus two ramp lanes, then to five lanes (dropping the outside lane), and then to four lanes for the NB direction. In this scenario, the nearby Towne Street entrance and exit ramps would require closing.
- At the Paddock Road interchange, a single lane exit is proposed followed by a single lane ramp to auxiliary lane connecting to the nearby (≅ 2,300') Ronald Reagan Cross County Highway (SR 126) as part of the HAM-75-10.10 project. Although this condition violates the rules of lane balance, an exception for short length auxiliary lanes is acceptable (Green Book pg 812).

The following diagram illustrates lane balance for this alternative. Dotted lines indicated an existing condition, with solid lines indicating a proposed condition.