Appendix E

TSS RUNWAY 8 WHITE PAPER

ABQ INTERNATIONAL SUNPORT

Sustainable Airport Master Plan

RUNWAY 8 APPROACH SURFACE PENETRATION
WHITE PAPER
Prepared by Coffman Associates for
ALBUQUERQUE INTERNATIONAL SUNPORT
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Existing Condition

Each runway end has a defined approach surface (not to be confused with the Part 77 Approach Surface) which is designed to protect the use of the runway in both visual and instrument conditions. The approach surface is also referred to as the threshold siting surface (TSS). The approach surface typically has a trapezoidal shape that extends away from the runway along the centerline and at a specific slope, expressed in horizontal to vertical ratio. The specific size, slope, and starting point of the approach surface depends upon the visibility minimums and the type of procedure associated with the runway end.

When approach surfaces are entirely clear of obstacles, instrument approach procedures can provide the optimum visibility and cloud ceiling minimums. When obstacles penetrate the approach surface, mitigation measures may include:

- Higher visibility minimums;
- Higher than normal glide path angles;
- Non-standard threshold crossing heights; and
- Final approach offset.

Exhibit 1 depicts the current Runway 8 approach surface which begins 200 feet behind the displaced landing threshold. The inner width is 800 feet, the outer width is 3,800 feet, and it is 10,000 feet long. The surface slopes up and away from the inner width at a 34:1 angle. Runways with a precision instrument approach, such as Runways 8 and 3 at the Sunport, also have a defined final approach "X" surface which must also meet the same obstacle clearing standards. The "X" surface begins at the sides of the approach surface, extending outward to 200 feet at a slope of 7:1.

Since the Runway 8 landing threshold is displaced by 1,000 feet, the approach surface and associated "X" surface encompass aircraft movement areas, most notably all or portions of Taxiways A, A1, A2, and E1. This includes runway hold lines on these taxiways. Therefore, an analysis of the height of aircraft in position at the hold lines must be undertaken to determine if they would be a penetration to the approach surface. **Table 1** presents this analysis when considering the three most critical aircraft in regular use at the Sunport (B757-200, B767-300, A300-600).

There is 24.58 feet of clearance at Taxiway A1 and E1 and 11.88 feet of clearance at Taxiway A2. The tail of all three aircraft will penetrate the approach surface at all three hold positions. The fuselage of the 757 and 767 is clear at Taxiway A1 and E1, but each aircraft fuselage penetrates the approach surface at Taxiway A2.

Because Taxiway E1 is longer than Taxiways A1 or A2, there is a possibility that the hold line could simply be moved back to provide adequate clearance of the approach surface. An additional row is included in the table to present the distance the Taxiway E1 hold line would have to be moved to provide that clearance for the three aircraft. For the 757-200 to clear the "X" approach surface, the hold line at

Taxiway E1 would need to move back (south) 68.25 feet. For the longer and taller A300-600, the hold line would have to move back (south) 112.63 feet. It is assumed that the solution to the hold line issue for Taxiway E1 is to move it back (south) based on the critical design aircraft (A300-600).

TABLE 1
Approach Surface Penetration Analysis: Taxiways A1, A2, and E1
Albuquerque International Sunport

Aircraft Characteristics	Boeing 757-200	Boeing 767-300	Airbus 300-600
Length	155.25'	180.25'	177.42'
Fuselage Height	21.17'	24.58'	25.33'
Tail height	45.08'	52.58'	54.58'
Approach Surface Penetration Results at Taxiway A1 Hold Line			
Fuselage Penetration	Clear by 3.41'	Equal to TSS (Clear)	0.75'
Tail Penetration	20.5'	28.0'	30.0'
Approach Surface Penetration Results at Taxiway A2 Hold Line			
Fuselage Penetration	9.29'	12.7'	13.45'
Tail Penetration	33.2'	40.7'	42.7'
Approach Surface Penetration Results at Taxiway E1 Hold Line			
Fuselage Penetration	Clear by 3.41'	Equal to TSS (Clear)	0.75'
Tail Penetration (X Surface)	9.75'	13.68'	16.09'
Distance to shift hold line for clearance	68.25'	95.76'	112.63'

Assumptions at the hold line:
Twy A1 and E1: Ground Elevation (5,312.0'); Approach Surface Height (5,336.58'); Clearance (24.58')
Twy A2: Ground elevation (5,313'); Approach Surface Height (5,324.88'); Clearance (11.88')

The following design alternatives address the approach surface penetration that exists when certain aircraft hold at either Taxiway A1 or A2.

Alternative A – Relocate Hold Lines

Exhibit 1 presents the first alternative which re-positions the hold line from Taxiway A1 to Taxiway A at a location between Taxiways A2 and A3. This would be positioned at the front of the approach surface. Once cleared for departure by the control tower, aircraft would then proceed for 1,150 feet to the runway centerline using Taxiway A1. The current hold line is 250 feet from the runway centerline. Aircraft transiting from the passenger terminal to the runway would have the option to position behind the second hold line that would be established on the terminal taxilane 550 feet from the runway centerline. The taxi distance to the runway from this hold line would be nearly identical to that of the hold line on Taxiway A.

This arrangement will have a negative impact on airfield capacity and delays as aircraft will have a significantly longer taxi time after being cleared for departure. Arriving aircraft will have a longer sequence time as the tower will have to provide additional separation time for the taxiing aircraft to reach the departure threshold, power up, and takeoff. This alternative will also increase aircraft queueing on Taxiway A and on the terminal taxilane, especially during the morning peak times. In

LEGEND

- Runway Safety Area (RSA)
- Runway Protection Zone (RPZ)
- Central Portion of RPZ
- Taxilane Object Free Area
- TSS Approach Surface (Runway 8 - 34:1, Runway 12 - 20:1)
- Runway 8 Final Approach "X" Surface (TERPS) 7:1
- Glide Slope Critical Area
- RPZ Incompatible Land Uses (7.77 acres)
- Precision Obstacle Free Zone (POFZ)
- Refueler Route Inside RPZ
- Pavement to be Removed
- Taxilane Island

HOLD LINE

HOLD LINE

NO-TAXI ISLAND

EXISTING 8' GROUND CLEARANCE FROM RUNWAY 8 APPROACH SURFACE

EXISTING 24' GROUND CLEARANCE FROM RUNWAY 8 APPROACH SURFACE

HOLD LINE

7.77 acres

757

737-800

737-800

757

737-800

A300-600

A1

A2

A3

A

E1

E3

E

NORTH

0 300 600

SCALE IN FEET

Exhibit 1
APPROACH SURFACE MITIGATION ALTERNATIVE A

addition, access for arriving aircraft to the northwest side of the terminal (Concourse A) will effectively be blocked by aircraft holding for departure.

Procedurally, this alternative will reduce existing movement efficiency and reduce capacity while increasing controller workloads. For these reasons, airport management desires an alternate solution.

Another safety consideration with the current runway threshold is the location of the air carrier refueling stand within the runway protection zone (RPZ). This alternative would maintain the stands within the RPZ, albeit on the edge of and well below the "X" surface.

Alternative B – Create Hold Pad

The second alternative, shown on **Exhibit 2**, considers holding aircraft to the west of the terminal taxilane. Under this alternative, existing ramp area between the terminal area apron and the snow barn would be converted into dual taxilanes to create a holding pad. Aircraft would queue awaiting their turn to depart.

The taxi distance from the closest of the two taxilanes (westernmost) is approximately 600 feet from the runway centerline. The distance from the second taxilane is approximately 800 feet to the runway centerline. The hold lines on the hold pad depicted on the exhibit are located at the edge of the Taxiway Object Free Area (TOFA), which is 129.5 feet from the centerline of Taxiway A. This location also provides adequate clearance under the "X" surface.

While a shorter taxi distance than Alternative A, this alternative still presents some significant challenges. The hold line on Taxiway A previously discussed with Alternative A will still be needed. Aircraft approaching the Runway 8 threshold from the east on Taxiway A would need to wait for clearance to proceed west to the terminal taxilane, then turn north on the terminal taxilane. These aircraft then turn to the west to line up to the hold pad queuing area. Finally, they would be released to proceed to the runway for departure. This procedure represents many stop and go movements and it may be confusing to pilots unfamiliar with the layout.

The hold pad concept does little to solve concerns with aircraft queueing on Taxiway A and, in some ways, could make it more challenging because of all the turns. In addition, the hold line on Taxiway A would still be required, thus slowing access to the northwest side of the terminal.

Utilization of this area for a holding apron could create conflicts for service vehicles because of the immediate proximity to the snow barn, refueling station, fuel truck storage, and glycol truck storage areas. These vehicles would need to traverse the holding area to reach the aircraft at the terminal. The distance from the runway centerline is reduced compared to Alternative A (1,050 feet), but at 600 to 800 feet is still two to three times longer than the current hold line distance to the runway.

The area is currently used for parking RON (remain overnight) aircraft. Conversion to a holding apron would require relocation of the RON space to a location east of the terminal that would be very inconvenient for airlines operating from the gates on Concourse A. The Master Plan does have an east RON area planned to provide additional RON capacity. If this alternative is implemented, additional space for RON aircraft would need to be constructed.

As with Alternative A, the fuel stands would continue to be within the RPZ.

Alternative C – Remove Runway 8 Displaced Threshold

Alternative C considers removing the Runway 8 displaced threshold altogether, thereby relocating the beginning of the approach surface 200 feet beyond the runway end. As a result, the taxiways would no longer be impacted by it. This alternative would allow aircraft to hold at Taxiways A1 and A2 in their current locations without penetration of the approach surface. The hold line on Taxiway E1, however, would need to be set back an additional 100 feet to be outside the relocated glide slope critical area. **Exhibit 3** presents this alternative.

Runway 8 is equipped with an Instrument Landing System (ILS). It is critical that the ½-mile minimums associated with this approach be preserved, especially at a medium hub commercial service airport. At present, the ILS equipment is required to support these minimums, meaning the glide slope, approach lights, and touchdown zone lights would need to be relocated, along with other runway marking and signage. The exhibit depicts the relocated glide slope antenna along with the associated glide slope critical area. The glide slope critical area must be clear of any aircraft or other objects that could potentially disrupt its signal. Part of the reason for the current runway displacement is to maintain the critical area off Runway 12-30. Since the glide slope critical area associated with relocation would cross Runway 12-30, this runway would need to either be shortened or shifted southeast to avoid conflicts with the glide slope signal. The exhibit shows the Runway 12 threshold relocated 600 feet. At an airport elevation of 5,355 feet, it is likely that some general aviation aircraft that use the runway would be more weight restricted. Those aircraft may need to utilize one of the other two runways available. Small piston aircraft that are not turbocharged could be the most impacted by a reduction in length. Wind rose analysis indicates that small aircraft would use this runway 3.6 percent of the time for crosswinds, compared to 10.5 percent on the other runways. The draft Master Plan recommended a length of 5,500 feet which would provide design crosswind runway coverage. As shown on the exhibit, a length of 5,400 feet could be maintained without an extension on the other end of Runway 12-30.

The medium intensity approach lighting system with runway alignment indicator lights (MALSR) would need to be relocated 1,000 feet west to coincide with the end of the runway. The bases of the existing MALSR lights could still be used, but five new foundations for new and taller towers would be needed for the light lane relocation. The final two would be west of University Boulevard but would remain on Sunport property. With the steep falling terrain beyond the end of the runway safety area (RSA), the foundation for the lights farthest from the runway would be at an elevation approximately 135 feet below the runway elevation. The portion of the MALSR currently installed in-pavement would be deactivated.

The runway and taxiway geometry resulting from this alternative would better meet design standards, and in many ways, is superior to what currently exists. Perhaps most importantly, this layout allows for the runways to be completely decoupled with no back-taxi on Runway 12-30. The access to the Runway 12 threshold is redesigned to be less confusing by providing a typical 90-degree threshold taxiway. This would eliminate the need for back-taxiing to the Runway 12 threshold (assumes access from Taxiway E-1 is eliminated as already proposed in the Master Plan). The existing wide expanse of pavement created by the confluence of Taxiways E, E1, and G would be eliminated. This too would be an improvement on what exists currently, as just a small portion of the RSAs of the two runways would be in common.

The approach RPZ leading to Runway 8 would also be shifted farther to the west. With this shift, additional incompatible land uses would be introduced to the RPZ. Currently, there are approximately 7.77 acres of incompatible land uses in the existing RPZ. These include rental car facility parking lots and structures and a portion of Access Road B. Shifting the RPZ would encompass a total of 15.69 acres of

LEGEND

- Runway Safety Area (RSA)
- Runway Protection Zone (RPZ)
- Central Portion of RPZ
- Taxilane Object Free Area
- TSS Approach Surface (Runway 8 - 34:1, Runway 12 - 20:1)
- Runway 8 Final Approach "X" Surface (TERPS) 7:1
- Glide Slope Critical Area
- RPZ Incompatible Land Uses (7.77 acres)
- Precision Obstacle Free Zone (POFZ)
- Refueler Route Inside RPZ
- Pavement to be Removed
- Taxilane Island

HOLD LINE

HOLD LINES

HOLD LINE

EXISTING 8' GROUND CLEARANCE FROM RUNWAY 8 APPROACH SURFACE

EXISTING 24' GROUND CLEARANCE FROM RUNWAY 8 APPROACH SURFACE

HOLD LINE

7.77 acres

757

757

757

757

737-800

757

737-800

A300-600

A

A1

A2

A3

E1

E3

E

NORTH

0 300 600

SCALE IN FEET

Exhibit 2
APPROACH SURFACE MITIGATION ALTERNATIVE B

FUTURE APPROACH LIGHT STANDARDS

EXISTING APPROACH LIGHT STANDARDS

15.69 acres

NO-TAXI ISLAND

RELOCATED GLIDE SLOPE

HOLD LINE

737-800

A300-600

600'

SCALE IN FEET

0 300 600

NORTH

A

A1

A3

E3

E

E3

G

E1

G1

12

Runway 12-30 5,400' x 150'

LEGEND

- Runway Safety Area (RSA)
- Runway Protection Zone (RPZ)
- Central Portion of RPZ
- TSS Approach Surface (Runway 8 - 34:1, Runway 12 - 20:1)
- Runway 8 Final Approach "X" Surface (TERPS) 7:1
- Glide Slope Critical Area
- RPZ Incompatible Land Uses (15.69 acres)
- Precision Obstacle Free Zone (POFZ)
- Ultimate Airfield Pavement
- Refueler Route Inside RPZ
- Pavement to be Removed

Exhibit 3
APPROACH SURFACE MITIGATION ALTERNATIVE C

incompatible land uses. While all the structures from the rental car facility would be removed from the RPZ, a two-story office building west of University Boulevard would fall within the RPZ, although outside of the central portion of the RPZ. Additional road segments would be introduced including more of Access Road B, University Boulevard, and George Road. It should be noted, however, that all the incompatible land uses, both existing and future, are at elevations 40 to 100 feet below the Runway 8 threshold. All but some roadway segments are outside the area referred to as the central portion of the RPZ. This is an important mitigating factor when considering RPZ land use compatibility.

This alternative would remove not only the fuel stand from the RPZ, but also the service road used by empty refueler trucks as the return route to the fuel stand.

Alternative D – Move Runway 8 Displaced Threshold 600 Feet

Options of moving the displaced threshold to a point between its current location and the Runway 8 end were considered. **Exhibit 4** depicts a 400-foot displaced threshold, which would be 600 feet west of its current location.

The problem created by the current displaced threshold location is that aircraft holding on Taxiways A1 and A2 penetrate the TSS approach surface, as do aircraft on the segment of Taxiway A between those two taxiways. Alternative D would allow aircraft to hold on A2 for an intersection take-off and still be able to use 13,300 feet of runway for takeoff. Aircraft preferring to utilize the entire 13,793 feet of runway would hold on Taxiway A just beyond A2 until cleared. A concern with Taxiway A2 is direct access from the terminal area taxilane. This could be resolved by relocating the taxilane 150 feet west, as proposed for a Concourse B extension in the Master Plan and shown on **Exhibit 4**.

As with Alternative C, the glide slope and MALSR would need to be relocated, but only three new bases for approach light standards would be required instead of four. All would remain east of University Boulevard. The greatest elevation change from a light standard base and the runway end would be 120 feet. Like Alternative C, Runway 12-30 would need to be shortened to approximately 5,400 feet to remain outside of the glide slope critical area.

Alternative D reduces the acres of incompatible uses within the RPZ when compared to Alternative C. The RPZ also avoids the office building across University Boulevard, although part of the building's parking lot is inside the RPZ. In fact, it has the least amount of building square footage inside the RPZ of all five alternatives. As with the other alternatives, the only incompatible uses inside the central portion of the RPZ are roadways. **Exhibit 4** does show how a portion of University Boulevard could be relocated outside the RPZ, reducing the incompatible acreage inside the RPZ from 13.6 acres to 11.5 acres.

As with Alternative C, this alternative would remove the fuel stand from the RPZ, although a portion of the service road used as the return route by empty refuelers would remain just inside.

Alternative E – Maintain Runway 8 RPZ East of University Boulevard

At the request of the Federal Aviation Administration (FAA), an alternative that would keep University Boulevard outside the RPZ was examined. As depicted on **Exhibit 5**, this would limit moving the displaced threshold approximately 350 feet to the west of its current location.

While this alternative would keep University Boulevard outside of the RPZ, it does little to correct the queuing problems created by Alternatives A and B. The displaced threshold would be aligned with Taxiway A2, such that the precision object free area (POFA) would include the length of the taxiway. This would reduce the taxiway's effectiveness as a bypass taxiway. An aircraft at the hold line on Taxiway A awaiting clearance to proceed to the end of Runway 8 would block Taxiway A2 as well. Departing aircraft coming from Concourse B gates would still have to hold on the apron, blocking arriving aircraft from taxiing to Concourse B. The hold line on Taxiway E1 could be set approximately 50 closer to Runway 8 than with Alternative D.

As with the two previous alternatives, the glide slope and MALSR would need to be relocated. Since the shift in the displaced threshold is not on an increment of 200 feet, however, new foundations would be required for all seven relocated approach light standards. In addition, all in-pavement approach lights would have to be reset into new concrete cuts. The greatest elevation change from a light standard base and the runway end would still be approximately 120 feet. Like Alternatives C and D, Runway 12-30 would need to be shortened to approximately 5,400 feet to remain outside of the glide slope critical area.

At 9.5 acres, Alternative E would have less incompatible acreage inside the RPZ than either Alternative C or D. The air carrier fuel stands on the north side would not be inside the RPZ; however, the service road used as the return route and a portion of the queueing area for refuelers would still be inside.

Recommendation

If constructing these same runways from a brown field today, Alternative C would be preferred because it safely decouples the runways as well as eliminates the displaced threshold. Under present conditions, however, it is the most expensive of the five options. Clearly the least expensive is Alternative A, which would simply mark Taxiway A with a hold line between Taxiway A2 and A3. However, this has the most significant impact on airfield delay and aircraft movement efficiency due to the longer taxi distance from the hold line to the Runway 8 centerline. Alternative B would be more expensive and introduce multiple aircraft maneuvers and hold positions. Both Alternatives A and B would increase controller workload. In addition, the air carrier fuel stand would remain within the RPZ.

Alternatives C, D, and E shorten Runway 12-30 by 600 feet (the runway was extended from 5,000 feet to 6,000 feet in the 1990s). The RPZ in Alternative C would not only extend across University Boulevard, but also encompass an office building. University Boulevard could be relocated to the back of the RPZ, but not outside it without acquiring a portion of the privately-owned and operated parking lot to the west. Alternative D would keep the RPZ off the office building but would still cross University Boulevard. While most of University Boulevard could be relocated west of the RPZ, it would still need to run through a back corner portion of it to avoid relocating two private commercial/office buildings. Alternative E keeps the RPZ inside of University Boulevard, but at the expense of correcting the circulation efficiency and delay problems created by Alternatives A & B. It would also introduce multiple aircraft maneuvers and hold positions.

Alternative A is, at best, a short-term solution until a more permanent solution can be implemented. The better permanent solution would be Alternative C, but this is also the most expensive. The primary conflicts with Alternatives 3 and 4 are larger areas of incompatible uses within the RPZ than the alternatives that do not change the threshold displacement.

FUEL STANDS

HOLD LINE

NO-TAXI ISLAND

SCALE IN FEET 0 300 600

NORTH

737-800

737-800

A

A1

A3

REALIGN UNIVERSITY BOULEVARD

FUTURE APPROACH LIGHT STANDARDS

EXISTING APPROACH LIGHT STANDARDS

600'

E3

RELOCATED GLIDE SLOPE

11.5 acres

HOLD LINE

A300-600

RENTAL CAR SERVICE AREA

E

E3

12

G

E1

Runway 12-30 5,400' x 150'

G1

LEGEND

- Runway Safety Area (RSA)
- Runway Protection Zone (RPZ)
- Central Portion of RPZ
- TSS Approach Surface (Runway 8 - 34:1, Runway 12 - 20:1)
- Runway 8 Final Approach "X" Surface (TERPS) 7:1
- Glide Slope Critical Area
- RPZ Incompatible Land Uses (15.69 acres)
- Precision Obstacle Free Zone (POFZ)
- Ultimate Airfield Pavement
- Refueler Route Inside RPZ
- Pavement to be Removed

Exhibit 4
APPROACH SURFACE MITIGATION ALTERNATIVE D

FUEL STANDS

HOLD LINE

0 300 600
SCALE IN FEET

NORTH

NO-TAXI ISLAND

737-800

A

HOLD LINE

HOLD LINE

FUTURE APPROACH LIGHT STANDARDS

EXISTING APPROACH LIGHT STANDARDS (TO BE REMOVED)

A1

A3

600'

E3

9.5 acres

RELOCATED GLIDE SLOPE

HOLD LINE

A300-600

E

RENTAL CAR SERVICE AREA

E3

G

E1

12

Runway 12-30 5,400' x 150'

G1

LEGEND

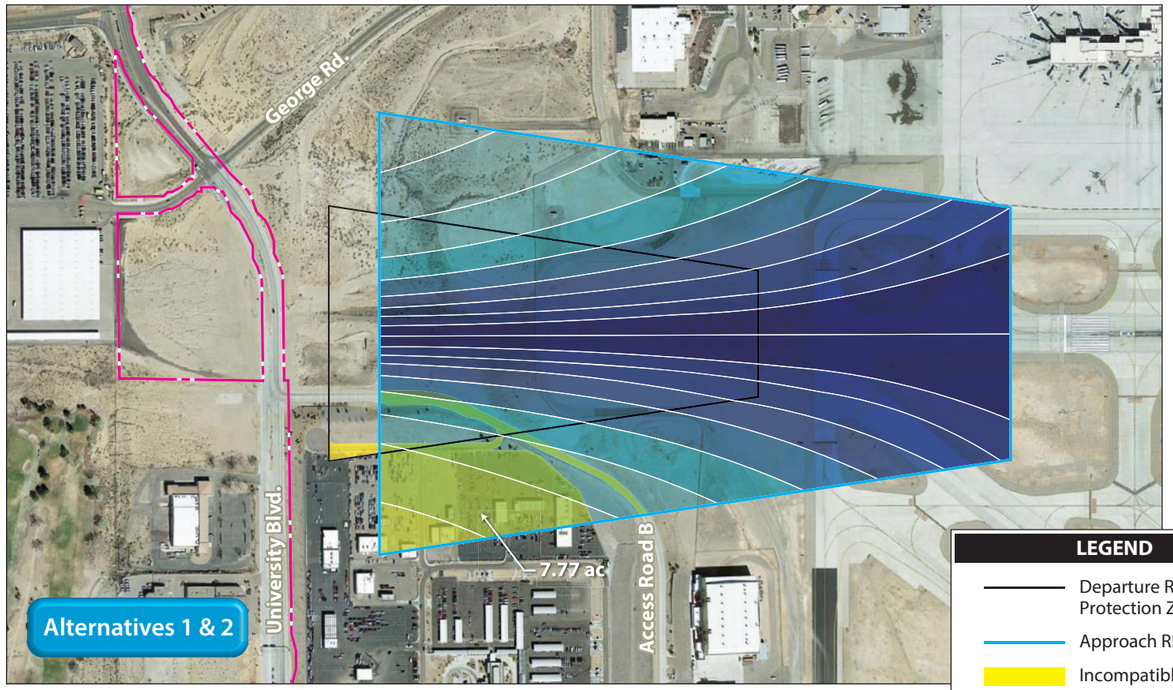
- Runway Safety Area (RSA)
- Runway Protection Zone (RPZ)
- Central Portion of RPZ
- TSS Approach Surface (Runway 8 - 34:1, Runway 12 - 20:1)
- Runway 8 Final Approach "X" Surface (TERPS) 7:1
- Glide Slope Critical Area
- RPZ Incompatible Land Uses (15.69 acres)
- Precision Obstacle Free Zone (POFZ)
- Ultimate Airfield Pavement
- Refueler Route Inside RPZ
- Pavement to be Removed

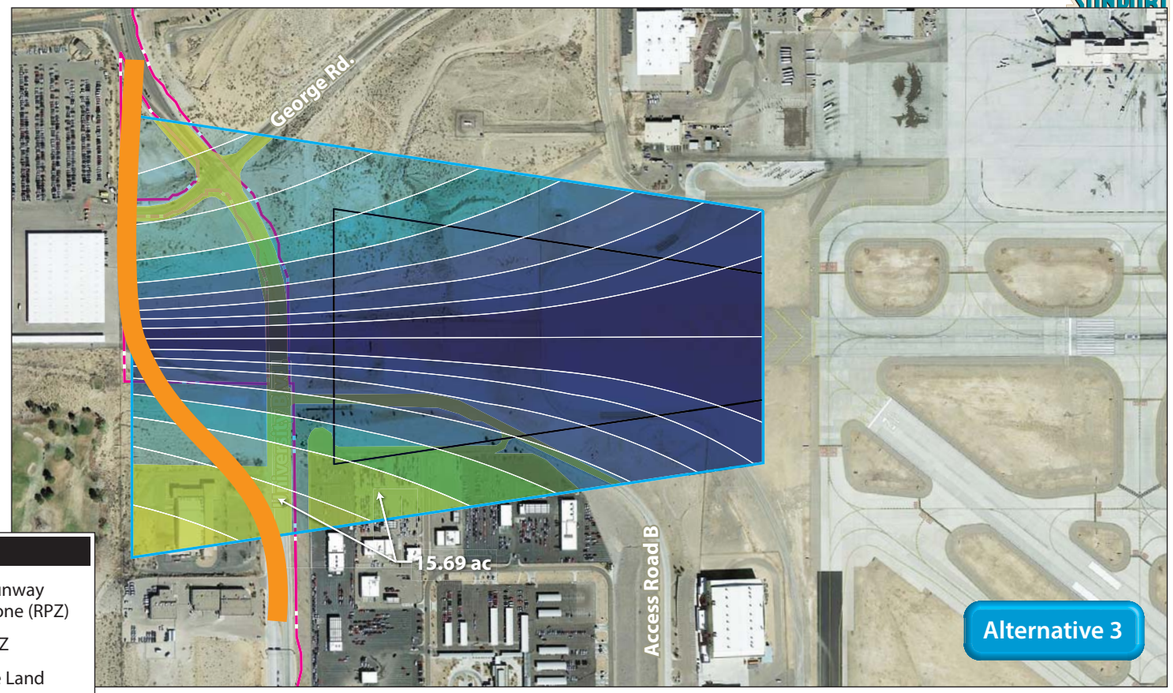
Exhibit 5
APPROACH SURFACE MITIGATION ALTERNATIVE E

Most of these conflicts are outside the central portion of the RPZ, except in the case of University Boulevard, which remains in the back portions of the RPZ. The Airport Cooperative Research Program (ACRP) funded Research Report 168 – *Runway Protection Zones (RPZs) Risk Assessment Tool Users' Guide*. The risk assessment tool was developed under ACRP Project 04-18, with the intent to to help airport operators conduct risk assessments in RPZs. The tool can be used to assess the risk of an aircraft accident within an RPZ and, based on the output, assess the risk to people and property, based on land use and population density.

Based upon site-specific data, the tool can generate crash likelihood contours within the RPZ, as well as statistical risk probability. A generalized set of likelihood contours have been placed on the RPZ for each alternative in **Exhibit 6**. As might be expected, locations closer to the runway's landing threshold and closer to the extended centerline have higher likelihoods of a crash than locations on the farther corners of the RPZ. Although more than 100 feet below the runway elevation, University Boulevard does encroach upon the RPZ with Alternatives C and D. The exhibit also depicts how this roadway could be re-routed, if necessary, to further reduce the potential risk.

It becomes evident from the exhibit that most of the incompatible land uses in each alternative are in areas of lower risk. To fully understand the level of risk and the risk differences between alternatives, the Sunport's data would need to be run in the Risk Assessment Tool for each alternative. Besides an alternative-specific likelihood contour, the analysis would provide results in the form of the "Annual RPZ Crash Likelihood" and the "Average Number of Years Between Accidents." These can then be weighed against other safety risks. Unless there would be a significant increase in risk with their implementation, Alternatives C or D would be the best long-term option for the Sunport. After review and discussion with the FAA, Alternative D was recommended as the preferred alternative.





LEGEND

- Departure Runway Protection Zone (RPZ)
- Approach RPZ
- Incompatible Land

Annual Crash Likelihood Contours

- 2.75e-008
- 4.44e-008
- 6.66e-008
- 9.82e-008
- 1.45e-007
- 2.19e-007
- 3.42e-007
- 5.75e-007
- 1.28e-006

Source: ACRP Research Report on Runway Protection Zone (RPZs) Risk Assessment Tool Users' Guide, 2016.

NORTH

0 600

SCALE IN FEET

Aerial Source: Google Earth 3/9/2014