CHAPTER 5

RESULTS & DISCUSSION

5.1 Dust dispersion with varying depth and wind direction

For the study of the dust dispersion with varying depth, mine 'B' had been considered, at the different depths of the operations from 50 m to 250 m, with an interval of 50 m for the different wind directions. Results of the dust dispersion with varying depth vis-à-vis wind direction had been plotted as contours for the areas outside the mine boundary. The area under consideration had been the zone of influence of dust dispersion up to the threshold limit value of PM_{10}.

5.1.1 Dust dispersion with varying depth and the easterly wind

In the western part of the mine 'B', haul road and coalface had been observed. This working was at the bottom of the mine. The direction of the wind was observed to be easterly for all the five depth variations. Figure 5.1 shows the variations in PM_{10} concentration outside the mine boundary. X and Y axes denote distances in X and Y direction from the centre of the mine 'B'.

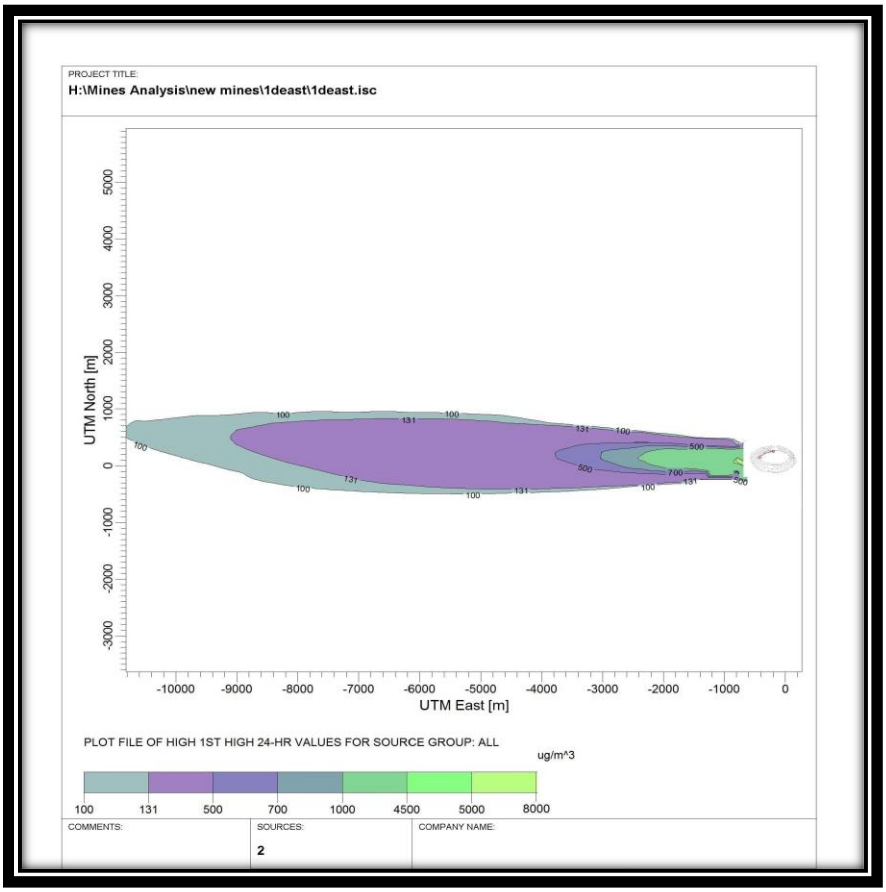

Figure 5.1: Contours of PM_{10} concentrations generated from the dust sources at 50 m depth of mine 'B' with the easterly wind

It was observed from figure 5.1 that the maximum concentration obtained during the case, when the depth was 50 m, happened to be 8,000 µg/m^3. This concentration was for a very small area, nearly 0.5 km^2, near the mine boundary. It may be noted that these concentrations were almost lethal. It is advisable that most efficient remedial measures are to be taken for it. As one moves away from the mine boundary, it may be noted that the concentration of the PM_{10} dropped to 5,000 µg/m^3 at the distance of 2,000 m and it came down to 500 µg/m^3 at a distance of 3,500 m from the centre of the mine. After this distance, the concentration levels of PM_{10} came down to 131 and 100 µg/m^3 levels which are threshold values for it. These levels existed to a distance of 10,000 m from the centre of the mine. Figure 5.2 shows the contours of PM_{10} concentration generated from the dust sources at 100 m depth of mine 'B' with the easterly wind.

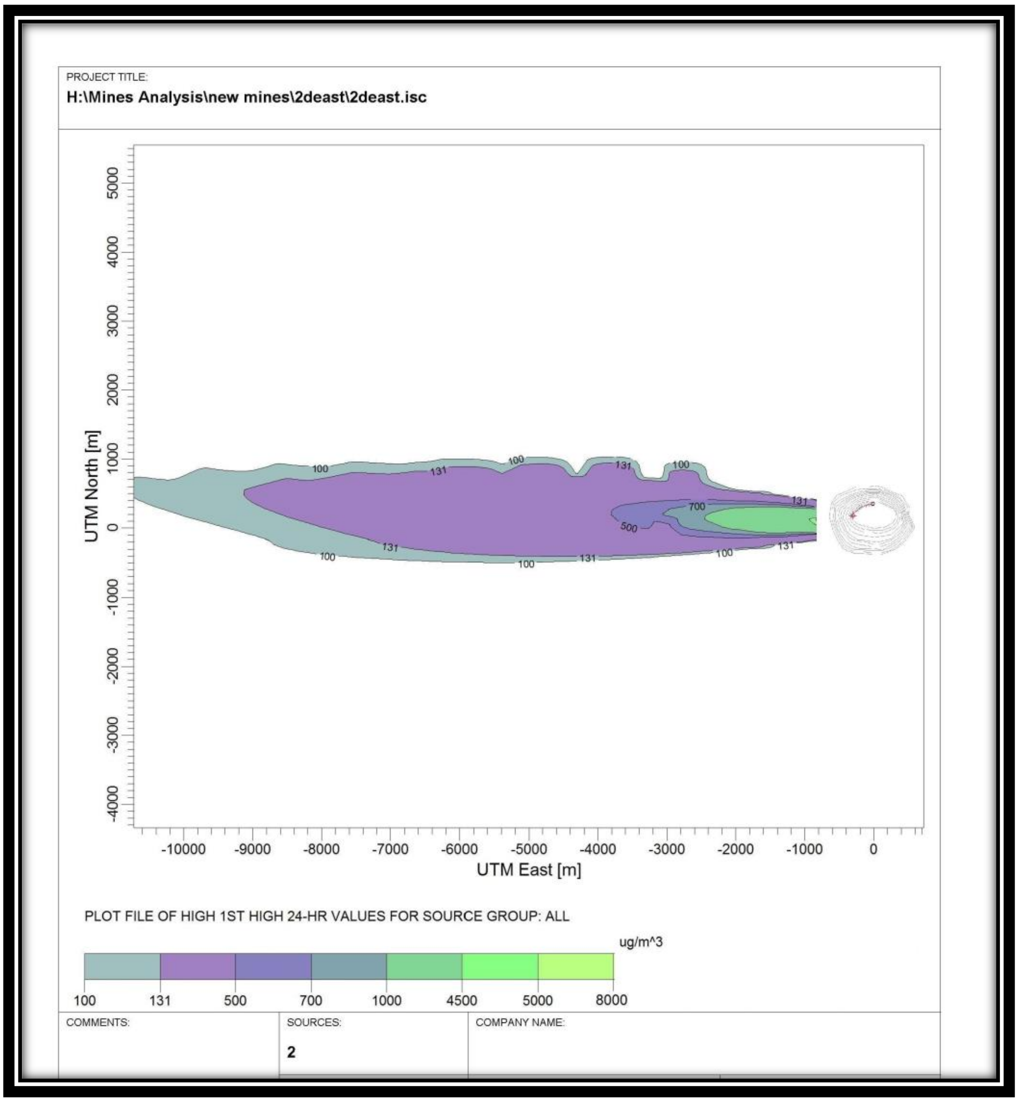

Figure 5.2: Contours of PM_{10} concentrations generated from the dust sources at 100 m depth of mine 'B' with the easterly wind

In can be observed from the figure 5.2 that the high level of concentration of a range of 1,000 to 8,000 µg/m^3 are restricted up to a distance of 2500 m from the centre of the mine. These levels came down at 100 to 700 µg/m^3, after this distance till 10,000 m. Very serious preventive measures were required up to a distance of 2500 m from the centre of the mine for the depth of 100 m. Figure 5.3 depicts contours of PM_{10} concentration generated from the dust sources at 150 m depth of mine 'B' with the easterly wind.

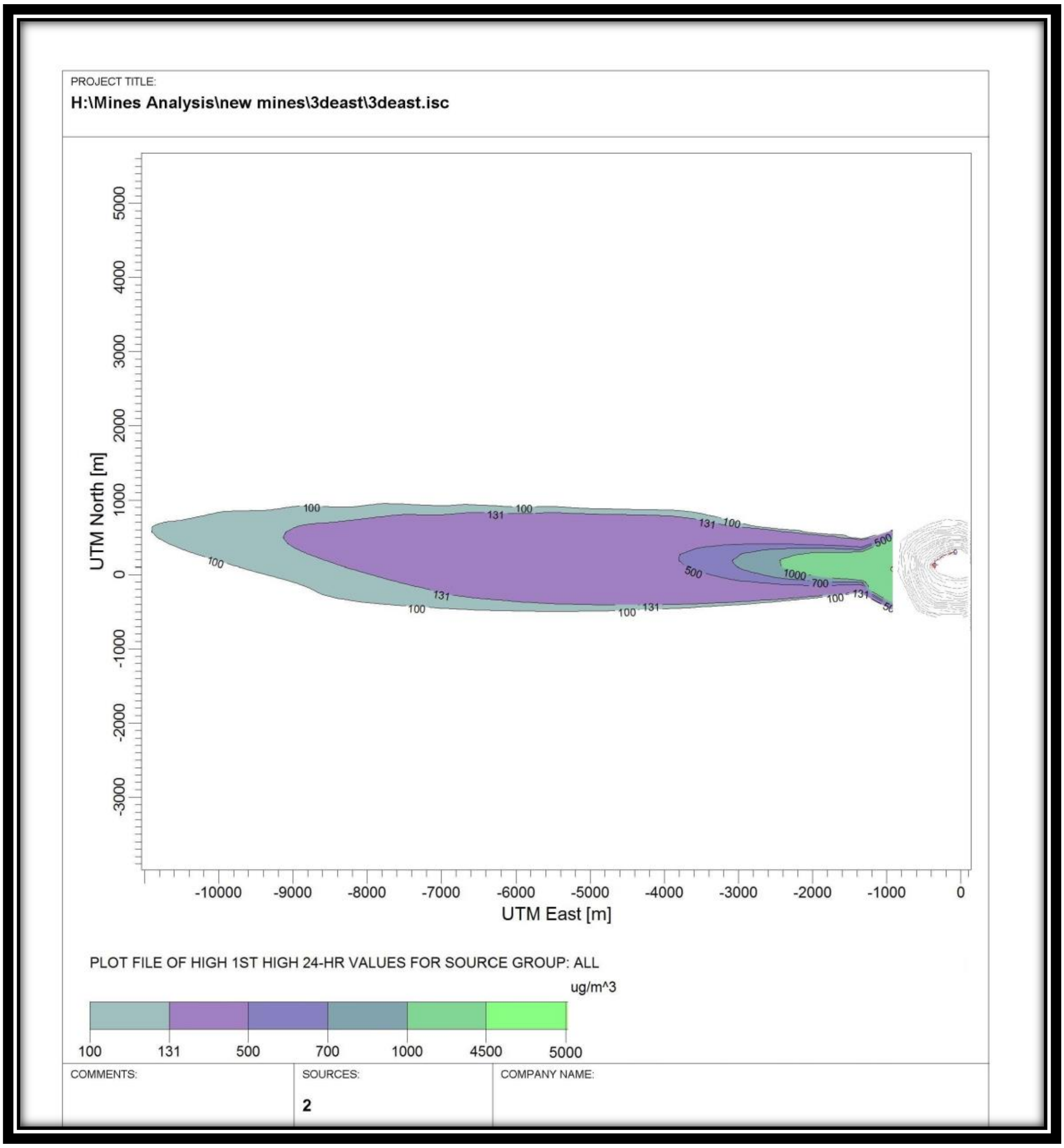

Figure 5.3: Contours of PM_{10} concentrations generated from the dust sources at 150 m depth of mine 'B' with the easterly wind

It is evident from the figure 5.3 that the concentration levels of PM_{10} had come down at 1,000 to 5,000 µg/m^3 for the 150 m depth of the mine 'B'. The PM_{10} dispersion was observed up to a distance of 2,500 m from the centre of the mine. These levels had been quite high at the same distance for the depth of 50 m and 100 m respectively. After this distance up to 10,000 m, the PM_{10} concentration levels suddenly came down at 100 to 500 µg/m^3. It could be seen from the figure 5.1, 5.2 and 5.3 that when the depth reached 150 m, the dust gets trapped inside the mine. Consequently, the concentration levels of PM_{10} decreased nearer the mine boundary. This reduction in PM_{10} concentration was also observed away from the mine boundary. Figure 5.4 depicts the contours of PM_{10} concentration, generated from the dust sources at 200 m depth of mine 'B' with easterly wind.

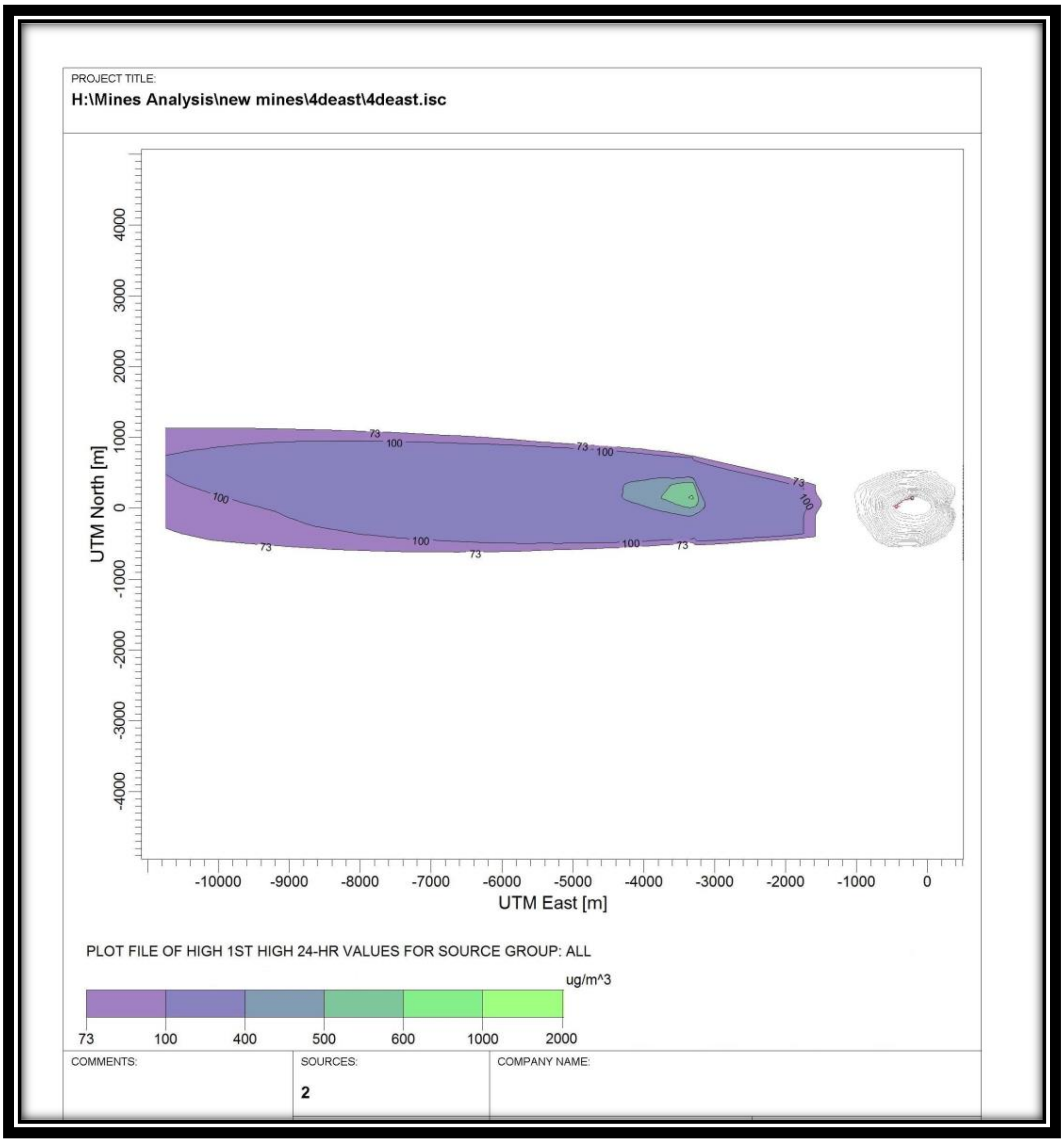

Figure 5.4: Contours of PM_{10} concentrations generated from the dust sources at 200 m depth of mine 'B' with the easterly wind

It is obvious from the figure 5.4 that the concentration levels of PM_{10} had come down at 100 to 2, 000 µg/m^3 for 200 m depth of mine 'B' outside the mine boundary. These levels had been quite high at a distance of 2500 m for the depth of 50 m, 100 m and 150 m respectively from the mine boundary. High levels of concentration of a range of more than 100 to 2000 µg/m^3 has been seen only in the area between 3,000 to 4,500 m distances from the mine boundary for the 200 m depth as shown in figure 5.4. This is due to significant increase in the air velocity just outside the mine as stated by Nago & Letchford (2008) for larger depth of the mine. Due to this the dust particles are transported to the larger distances. The availability of larger area, outside the mine, after the transportation of dust particles from the mine, reduces the dust concentration. Higher concentrations were limited to smaller area of about 1 km^2. Therefore, the overall concentration levels had come down significantly in comparison to shallower depths (around 150 m). Figure 5.5 shows contours of PM_{10} concentration, generated from the dust sources at 250 m depth of mine 'B' with the easterly wind.

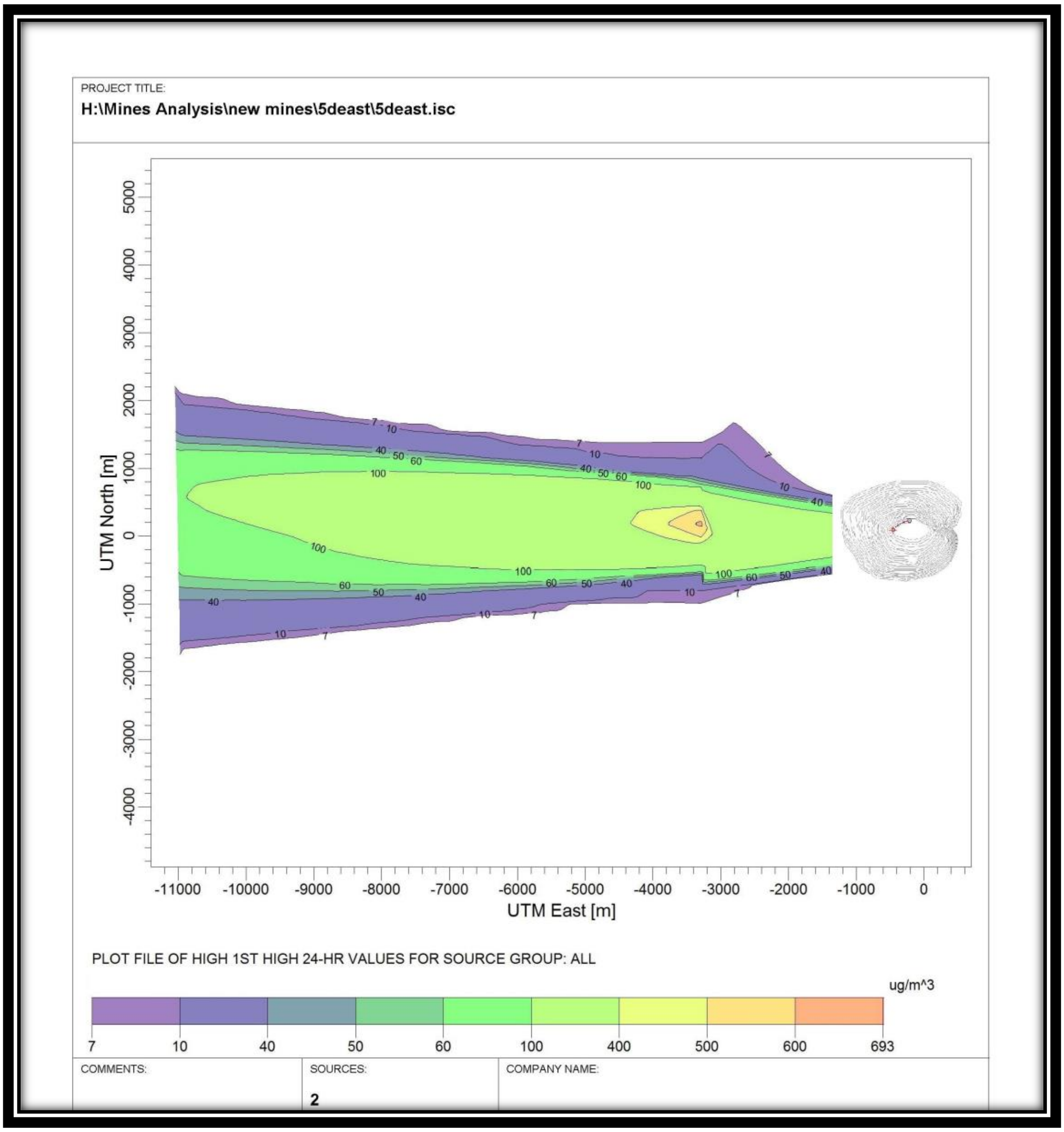

Figure 5.5: Contours of PM_{10} concentrations generated from the dust sources at 250 m depth of mine 'B' with the easterly wind

In the end, concentration of PM_{10} had been estimated outside the mine, for a depth of 250 m of mine 'B'. It can be seen from figure 5.5 that these estimated concentrations for 250 m depth were lowest among all the depths of mine 'B'. It ranged from 7 to 693 µg/m^3. Similarly in this case too, high concentration levels of the range of more than 100 to 693 µg/m^3 had been found only in the area between 3,000 to 4,500 m distances from the mine boundary. This is due to significant increase in the air velocity, just outside the mine, as stated by Nago & Letchford (2008) for greater depth of the mine. This reduces the overall concentration levels significantly in comparison to shallower depths (around 150 m) similar to 200 m depth case. In all the depth scenario, the highest level of PM_{10} concentration were found for the 50 m, 100 m and 150 m depths. As the depths increased, the estimated concentration of PM_{10} were lower. This was due to the trapping of the dust inside the mine for greater depths. Similarly, as the depth of the mine increased, the dust sources reached deeper and most of the emissions did not reach the top of the mine surface. Due to this, the dust concentration levels had reduced significantly with depth.

5.1.2 Dust dispersion with varying depth and westerly wind

The haul roads and the coal face had been observed at the west side. These were located at the bottom of the mine 'B'. The direction of the wind was observed to be westerly for all the five depth variations of these cases. Figure 5.6 shows the variations in PM_{10} concentration outside the mine boundary. X and Y axes denote distances in X and Y direction from the centre of the mine 'B'.

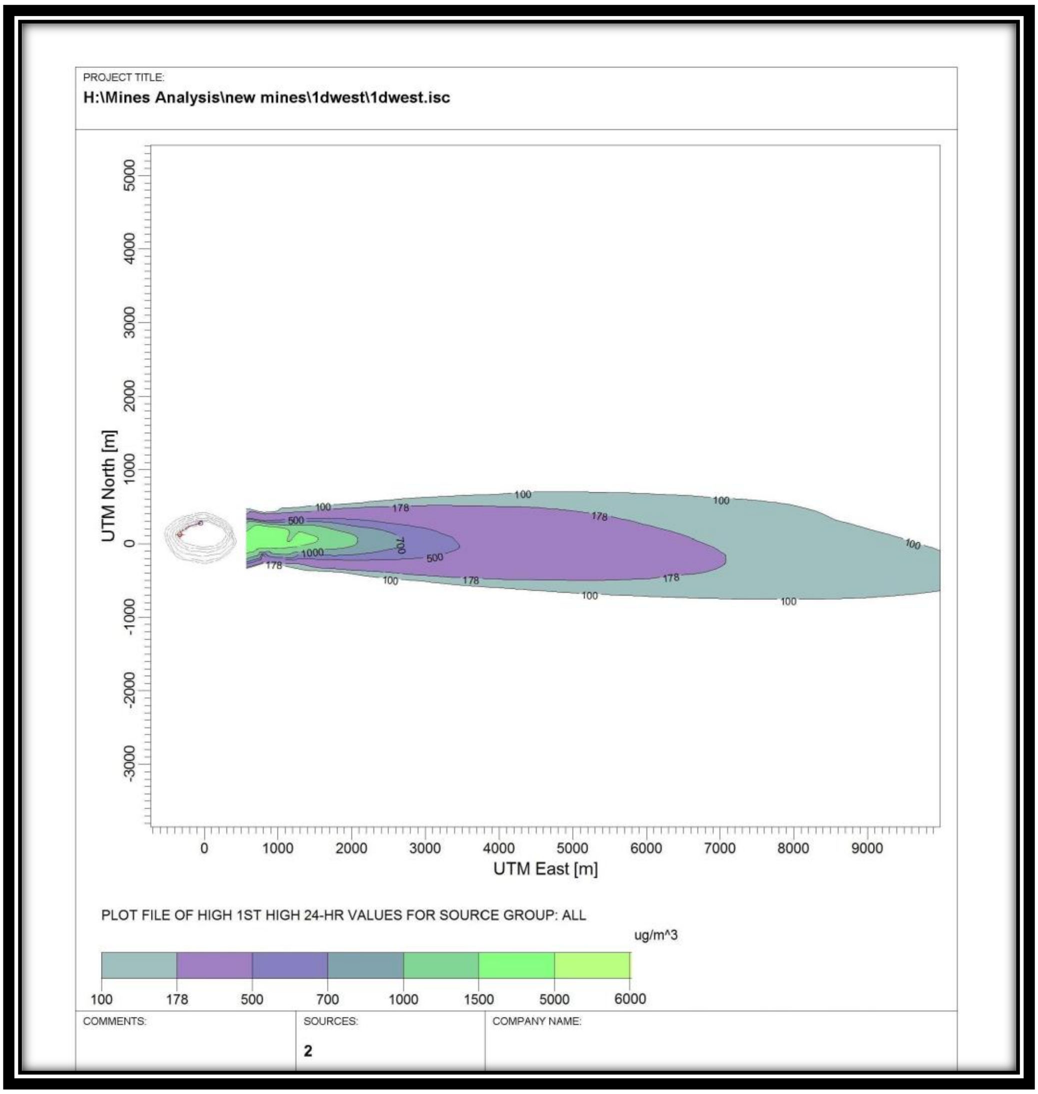

Figure 5.6: Contours of PM_{10} concentrations generated from the dust sources at 50 m depth of mine 'B' with the westerly wind

The figure 5.6 shows that the maximum concentration obtained during this case, when the depth was 50 m, happened to be 6,000 µg/m^3. High level of concentrations of a range of 700 to 6,000 had been seen up to a distance of 2,000 m, from the centre of the mine. These concentration were for an area of 1.250 km^2, near the mine boundary. It may be noted that these concentrations were almost fatal. It is logical that most efficient remedial measures were to be taken for it. As one moves away from the mine boundary, it may be noted that the concentration of PM_{10} dropped to 500 µg/m^3 at the distance of 3,750 m and it reached to less than 500 µg/m^3 after this distance from the centre of the mine. At this distance the concentration levels of PM_{10} reached between 178 and 100 µg/m^3, which were near the threshold values. These levels could be seen up to a distance of 10,000 m, from the centre of the mine. Figure 5.7 shows contours of PM_{10} concentration generated from the dust sources at 100 m depth of mine 'B' with the westerly wind.

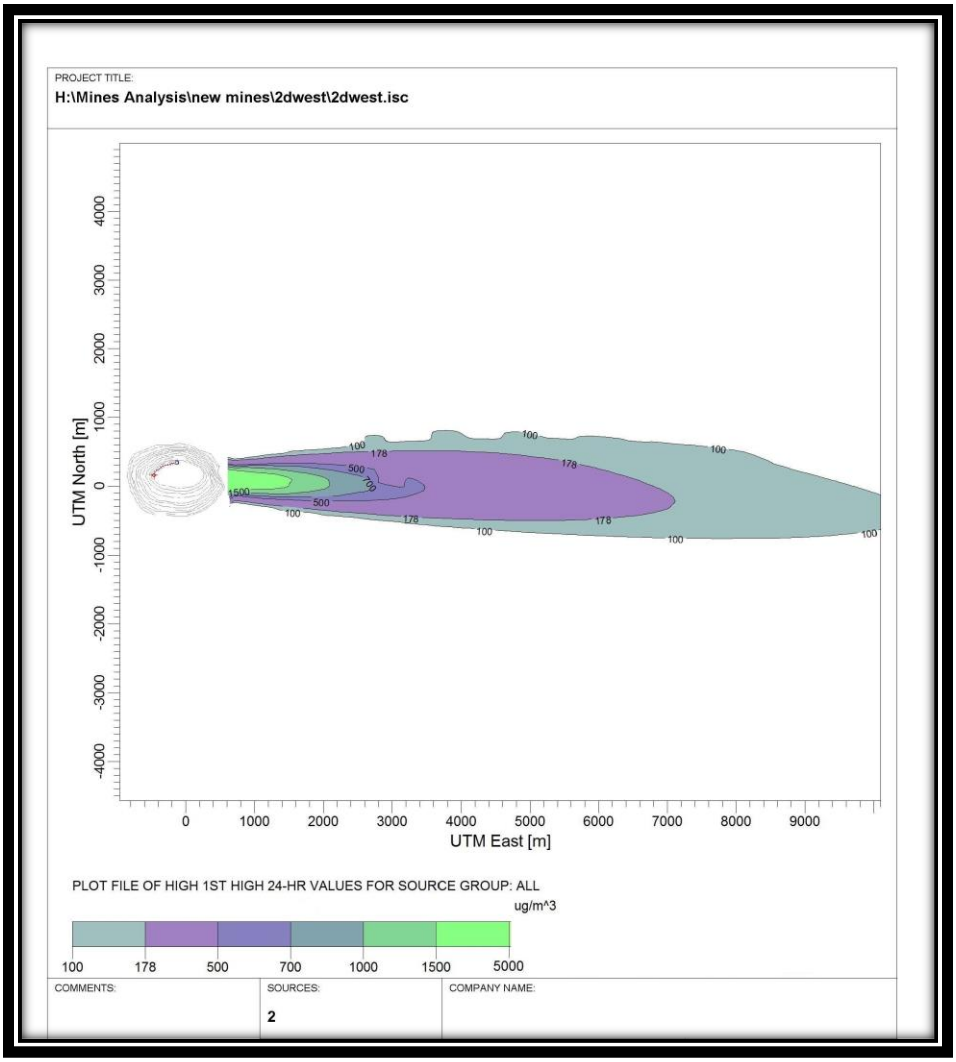

Figure 5.7: Contours of PM_{10} concentrations generated from the dust sources at 100 m depth of mine 'B' with the westerly wind

It is evident from the figure 5.7 the high level of concentration of PM_{10} between of 1,000 to 5,000 µg/m^3 were found up to a distance of 2,500 m, from the centre of the mine. These levels decreased between 100 to 700 µg/m^3 after this distance till 10,000 m. Severe preventive measures are required up to a distance of 2500 m from the centre of the mine for the depth of 100 m. Figure 5.8 depicts contours of PM_{10} concentration, generated from the dust sources at 150 m depth of mine 'B' with the westerly wind.

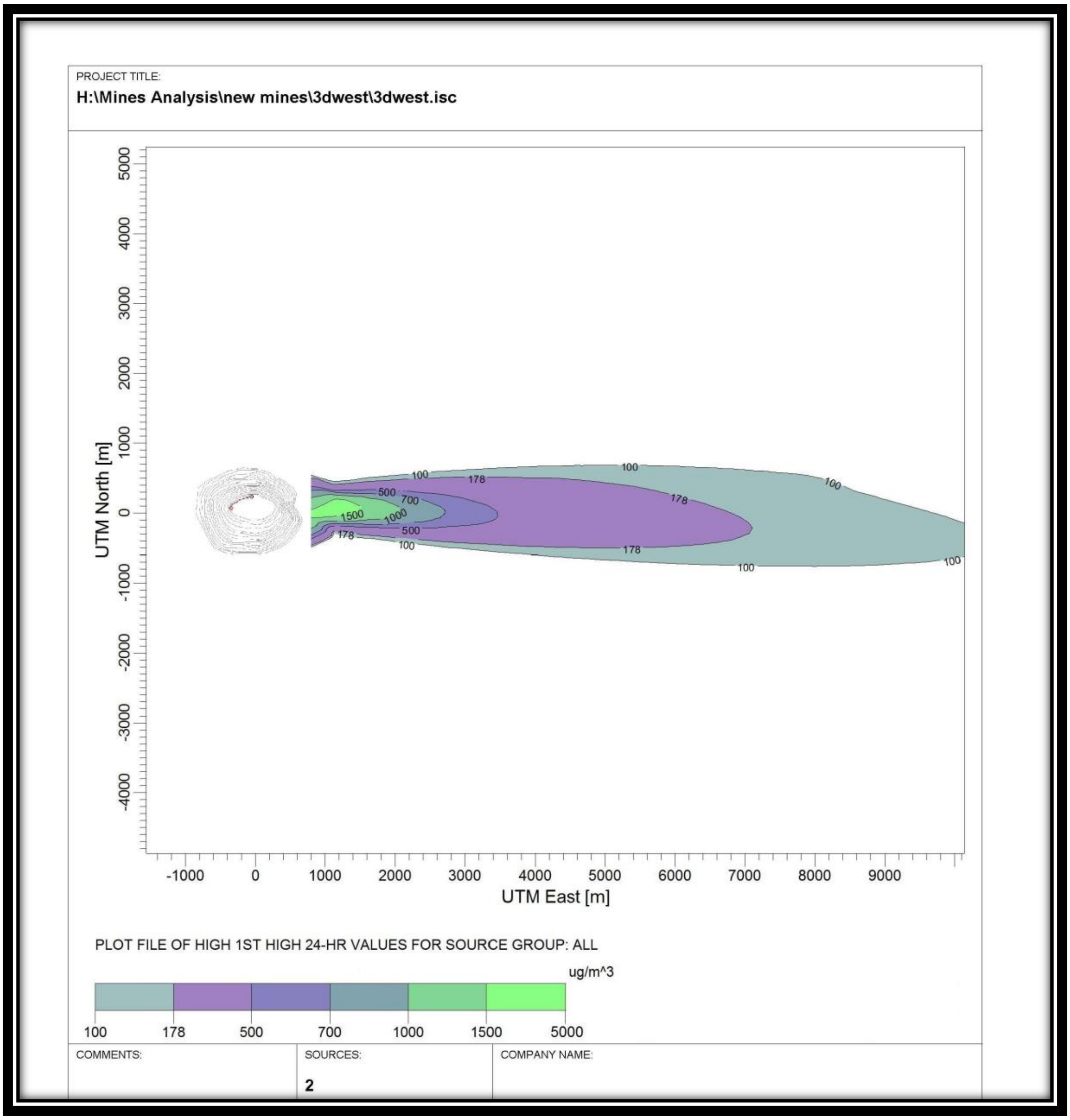

Figure 5.8: Contours of PM_{10} concentrations generated from the dust sources at 150 m depth of mine 'B' with the westerly wind

In can be observed from the figure 5.8 that the higher level of concentration of PM_{10} of a range of 1,000 to 5,000 µg/m^3 were restricted to a distance of 2,500 m, from the centre of the mine. These levels were similar to those of the depth of 100 m of mine 'B'. These levels had come down at 100 to 700 µg/m^3, after this distance till 10,000 m. The only difference of concentration levels between 100 m and 150 m depth of mine was that 100 µg/m^3 concentration levels were smoother and narrower on the north side for the 150 m depth. Severe preventive measures were required up to a distance of 2,500 m, from the centre of the mine for the depth of 100 m. Figure 5.9 shows contours of PM_{10} concentration, generated from the dust sources at 200 m depth of mine 'B' with the westerly wind.

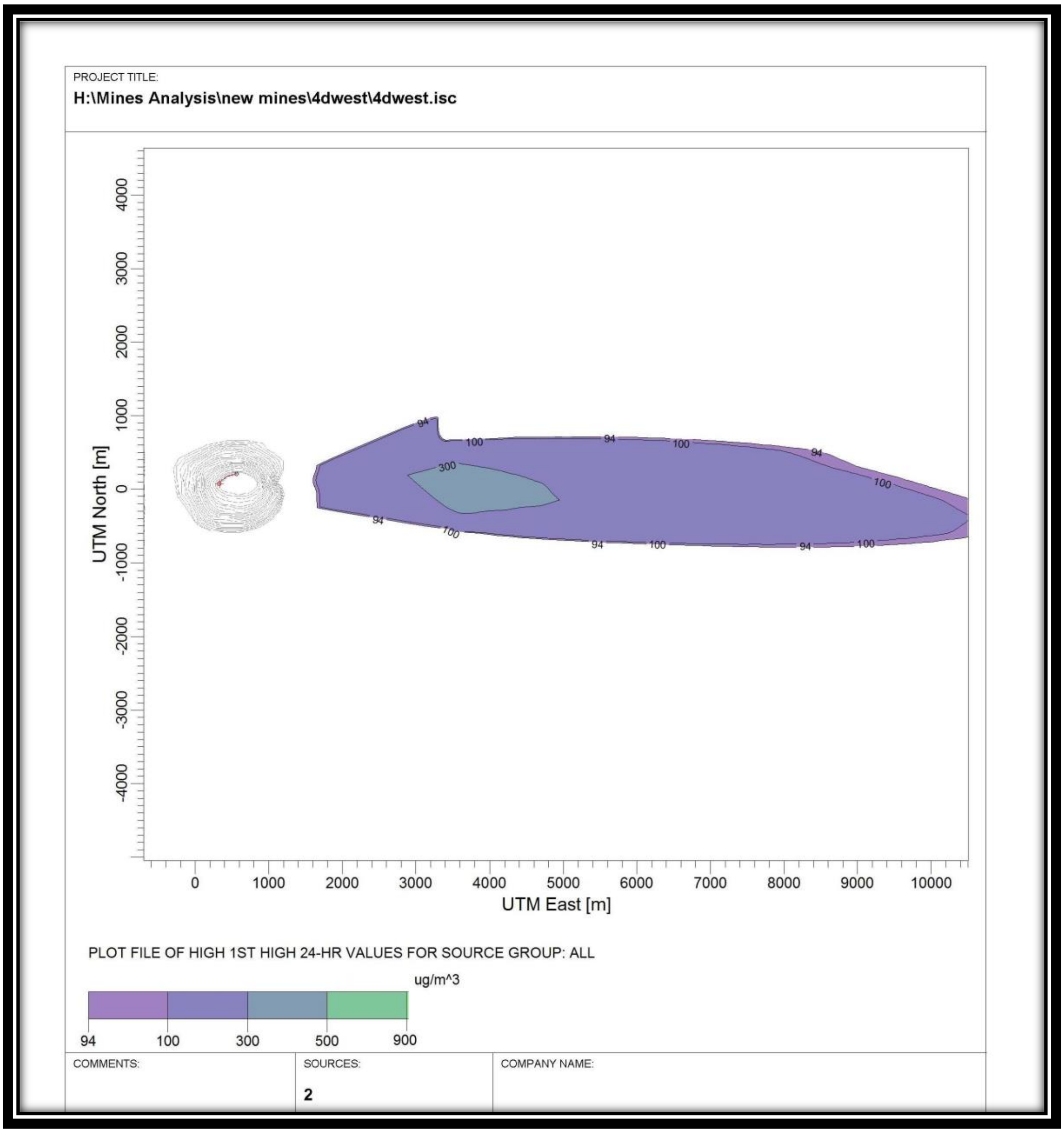

Figure 5.9: Contours of PM_{10} concentrations generated from the dust sources at 200 m depth of mine 'B' with the westerly wind

It is observed from figure 5.9 that high concentration levels of PM_{10} reached suddenly to 900 µg/m^3 for 200 m depth of mine 'B'. These levels were of 5000 µg/m^3 range for the depth of 150 m. The concentration levels of 300 µg/m^3 have been also observed from 2500 m to 5000 m for an area around 2.5 km^2. This is due to significant increase in the air velocity just outside the mine, as stated by Nago & Letchford (2008) for greater depths of the mine. This allows dust particles to travel larger distances in restricted area. Higher PM_{10} concentrations are limited to small area only. Therefore, overall concentration levels had come down significantly in comparison to shallower depth (around 150 m). In rest of the area, only 100 µg/m^3 concentration levels were spread. Figure 5.10 shows contours of PM_{10} concentration generated from the dust sources at 250 depth of mine 'B' with the westerly wind.

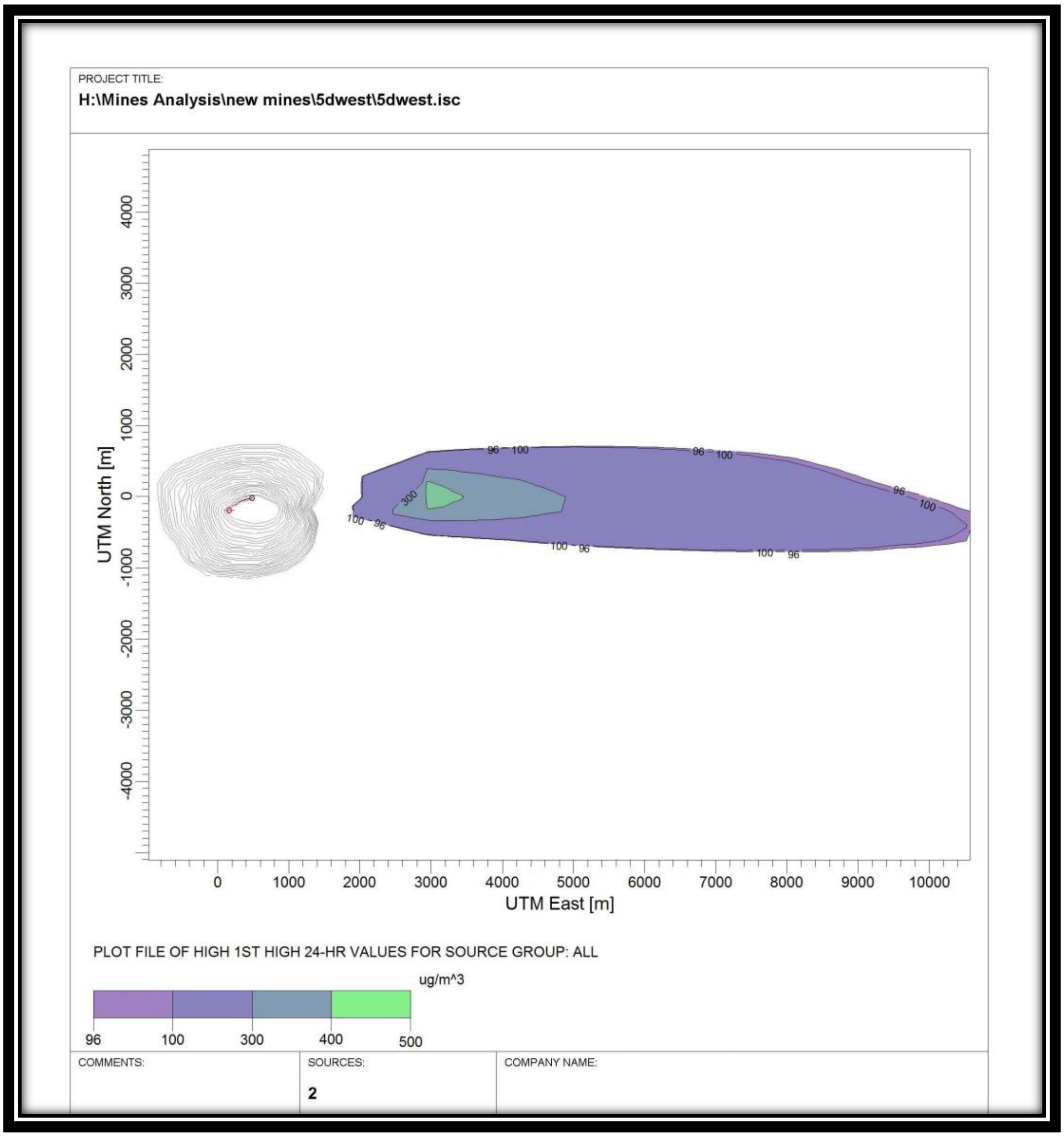

Figure 5.10: Contours of PM_{10} concentrations generated from the dust sources at 250 m depth of mine 'B' with the westerly wind

It can be seen from figure 5.10 that these estimated concentrations for the 250 m depth were lowest among all the depths of mine ‘B’ for the westerly wind. It ranged from 96 to 500 µg/m^3. In all the depth scenario, the highest level of PM_{10} concentration levels were found for 50 m depth of mine ‘B’. As the depth increased, the estimated concentrations of PM_{10} were lower. This is due to the trapping of the dust inside the mine at greater depths. As the depth of the mine increased, the dust sources went deeper and most of the emissions could not reach the top of the mine. Due to this, the dust concentration levels reduced significantly for the greater depths. Further, it can be seen from figures the 5.1 to 5.10, that when the wind was easterly in nature, overall dust concentration levels were high in comparison to those when the wind was westerly in nature. This was due to the position of the dust sources. As the sources were on the west side and wind was westerly in nature, PM_{10} emission had more volume and time to escape from the mine, and this consequently reduced the dust concentration levels outside the mine for the westerly wind.

5.1.2 Dust dispersion with varying depth and southerly wind

In the western part of the mine ‘B’, haul roads and coalface had been observed. This working was at the bottom of the mine. The direction of the wind was observed to be southerly for all the five depth variations. Figure 5.11 shows the variations in PM_{10} concentrations outside the mine boundary in the north direction. X and Y axes symbolise distances in X and Y direction from the centre of the mine ‘B’.

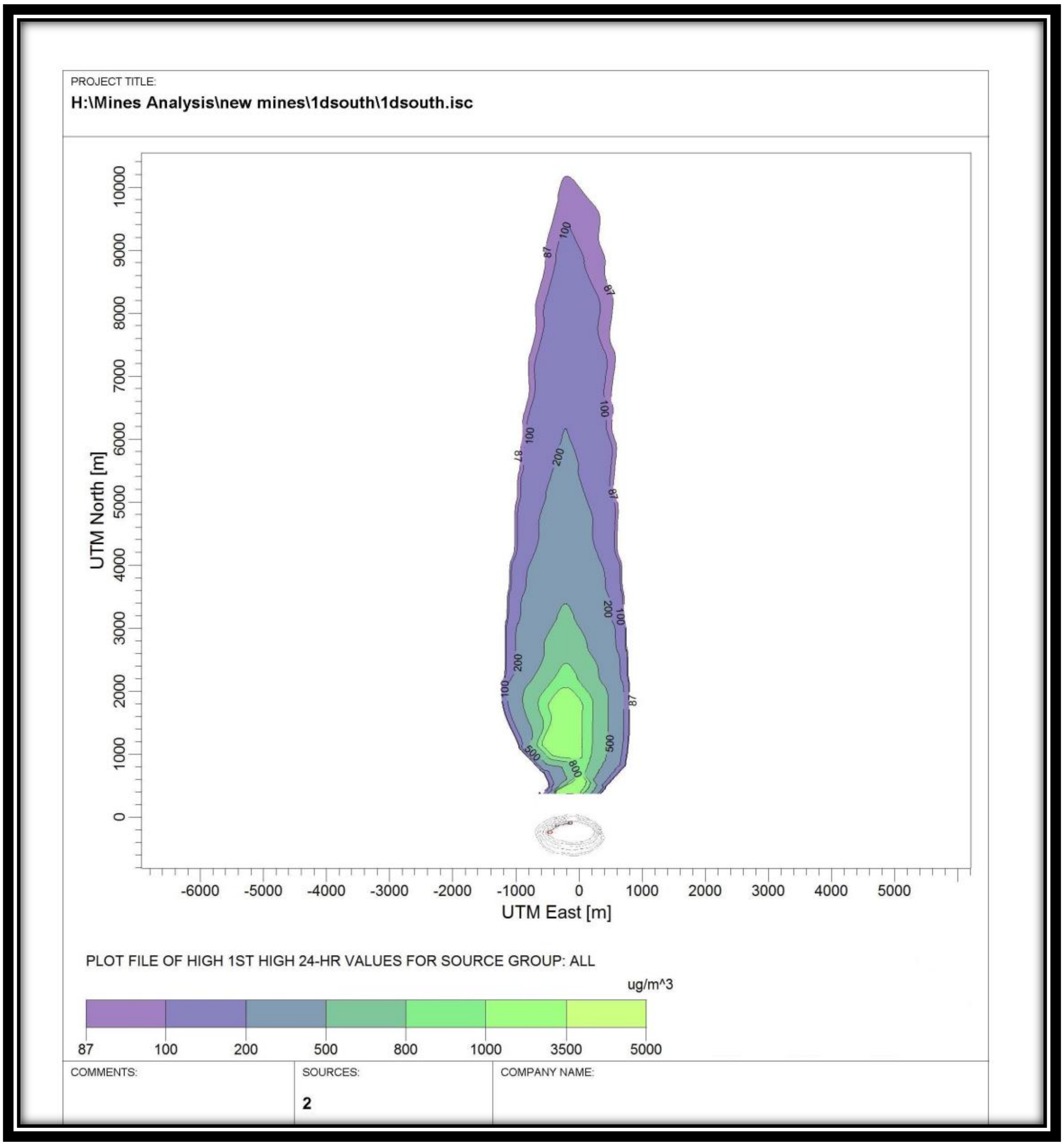

Figure 5.11: Contours of PM_{10} concentrations generated from the dust sources at 50 m depth of mine 'B' with the southerly wind

It was observed from the figure 5.11 that the maximum concentration obtained during this case, when the depth was 50 m, was 5,000 µg/m^3. This concentration was for a distance of 2000 m from the mine boundary. As one moves away from the mine boundary, it was found that the concentrations of PM_{10} dropped to 3,500 µg/m^3 after the distance of 2,000 m and it reduced to 500 µg/m^3 at a distance of 3,500 m from the centre of the mine. After this distance the concentration levels of PM_{10} comes down to 81 and 100 µg/m^3 levels that were the threshold values of it. These levels could be seen prevail to a distance of 10,000 m from the centre of the mine. Figure 5.12 shows the contours of PM_{10} concentrations generated from the dust sources at 100 m depth of mine 'B' with southerly wind.

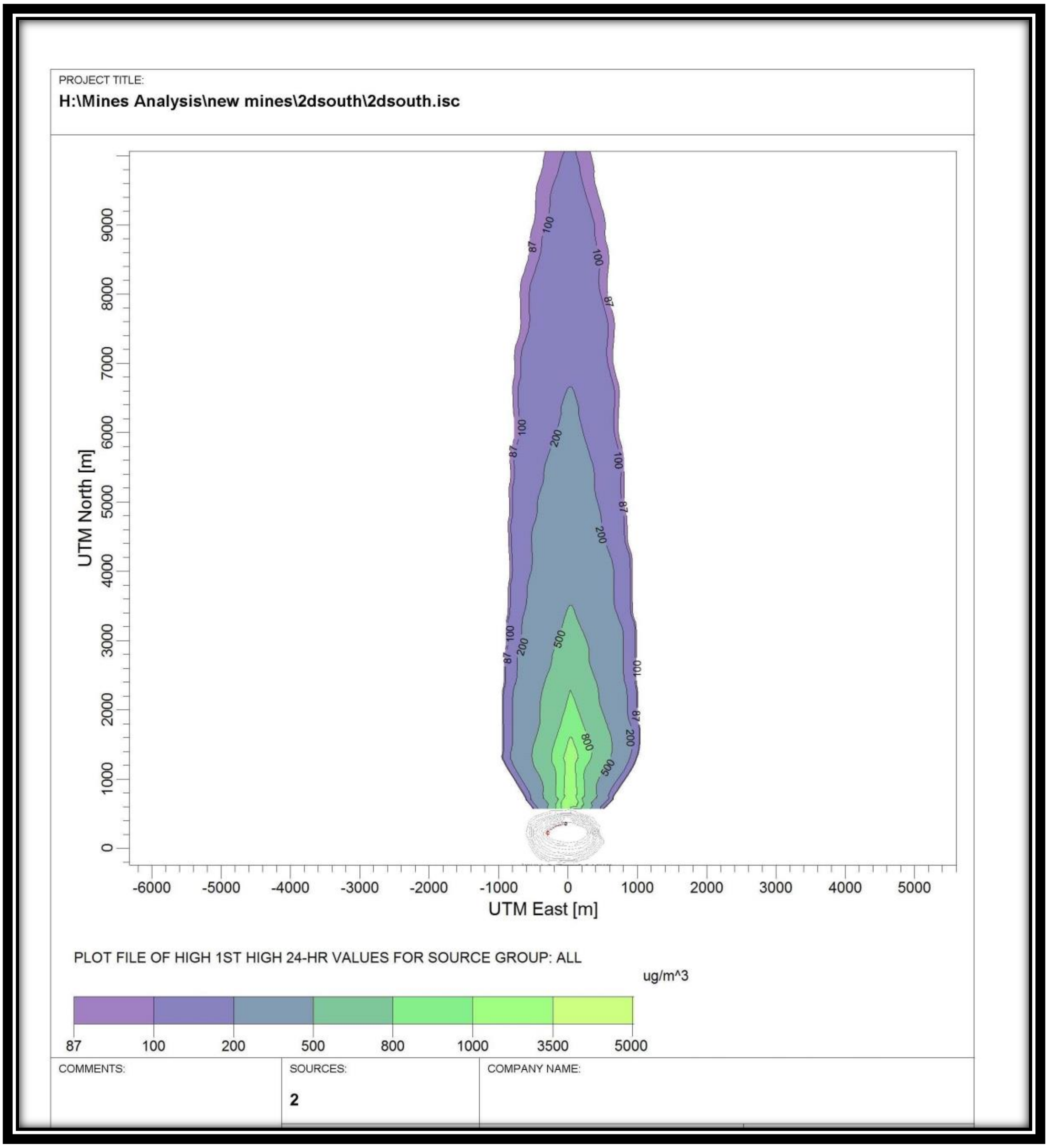

Figure 5.12: Contours of PM_{10} concentrations generated from the dust sources at 100 m depth of mine 'B' with the southerly wind

In can be observed from the figure 5.12 that the high level of concentration at the level of 800 to 5,000 µg/m^3 were restricted up to a distance of 2,000 m from the centre of the mine. These levels had reduced to the level of 87 to 500 µg/m^3 after this distance, till 10,000 m. Almost every contour of the variation in the concentration levels was equally distributed from the centre of the mine in north direction, for the 100 m depth. Figure 5.13 depicted the contours of PM_{10}

concentration, generated from the dust sources at 150 m depth of mine 'B' with the southerly wind.

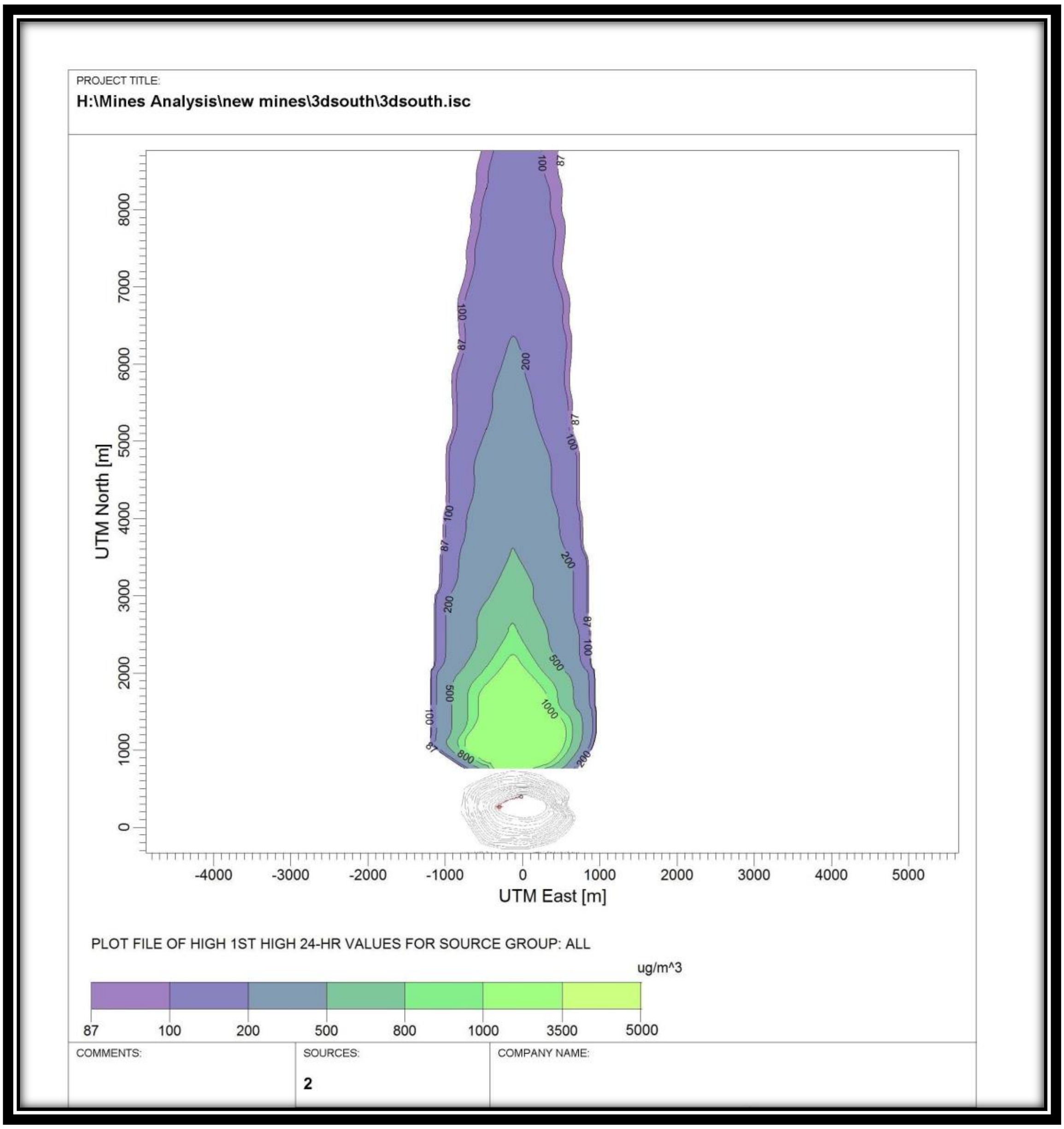

Figure 5.13: Contours of PM_{10} concentrations generated from the dust sources at 150 m depth of mine 'B' with southerly wind

In can be observed from the figure 5.13 that the high level of the concentration of a range of 1,000 to 5,000 µg/m^3 were restricted up to a distance of 2000 m, from the centre of the mine, similar to figure 5.12. These levels had lowered from 87 to 800 µg/m^3 after this distance, till 10,000 m. Almost every contour of the different concentration levels was equally distributed, from the centre of the mine in north direction, for the 150 m depth. Concentration of a range of 500 to 5000 µg/m^3 were broadly dispersed due to expansion of the mine. Figure 5.14 depicts the contours of

PM_{10} concentration generated from the dust sources at 200 m depth of mine 'B' with the southerly wind.

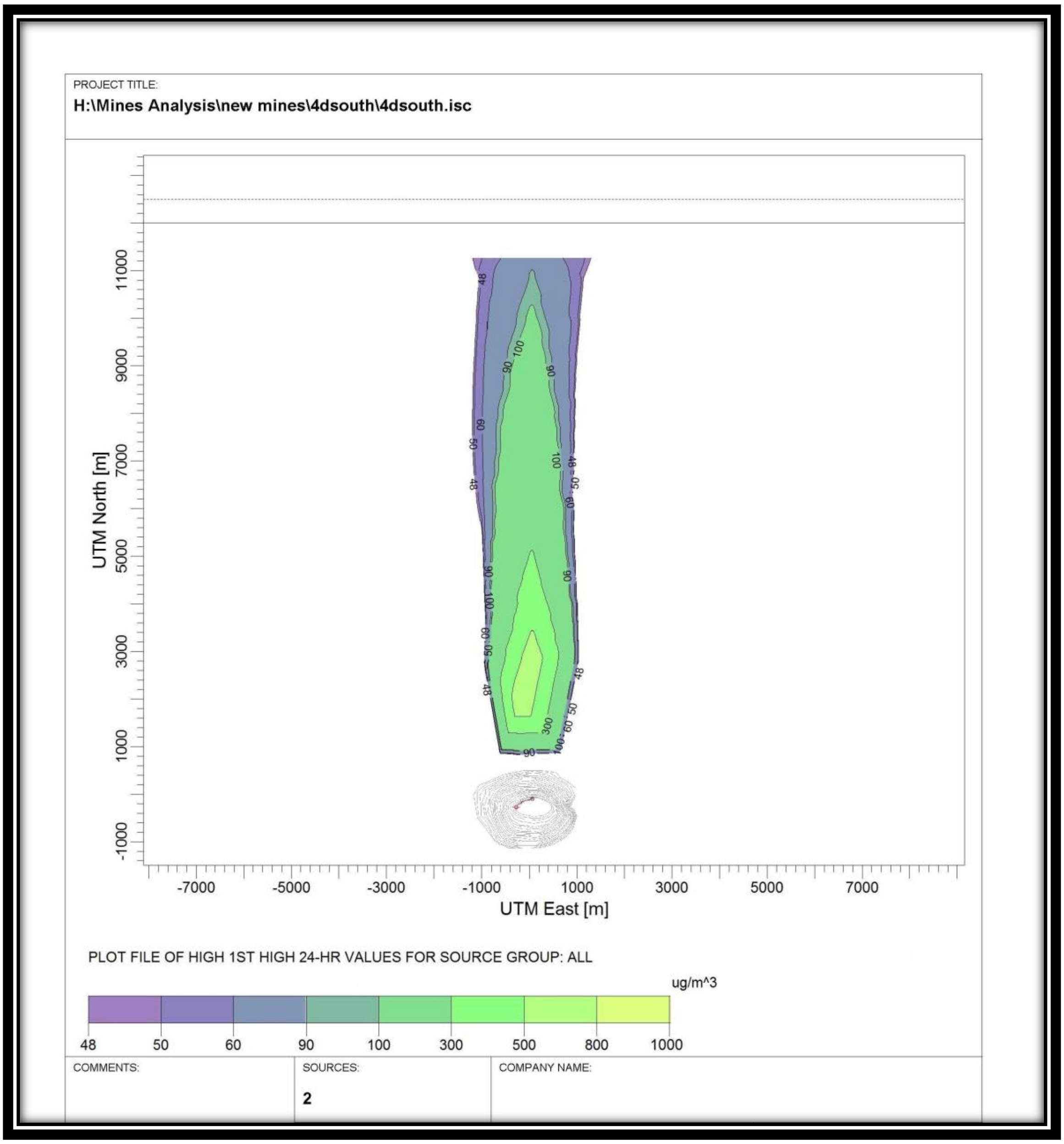

Figure 5.14: Contours of PM_{10} concentrations generated from the dust sources at 200 m depth of mine 'B' with the southerly wind

It is evident from the figure 5.14 that the high concentration levels of PM_{10} lowered suddenly to 1,000 µg/m^3 for the 200 m depth of mine 'B'. These levels were 5000 µg/m^3, for the depth of 150 m. The concentration levels of 300 µg/m^3 had also been observed up to a large distance of 5,000 m, from the centre of the mine. These concentration levels were almost concentric in nature, spread in lesser area. This was due to significant increase in the air velocity just outside the mine. It allowed the dust particles to travel the larger distances in the restricted area. Higher concentrations were limited to only in small area. Less number of preventive measures can reduce the concentration of PM_{10} in the area near mine boundary. Therefore, the overall concentration level had come down significantly in comparison to shallower depths (around 150 m). In rest of the area, 48 to 100 µg/m^3 concentration levels were spread. Figure 5.15 shows the contours of the PM_{10} concentration, generated from the dust sources at the 250 depth of mine 'B' with the southerly wind.

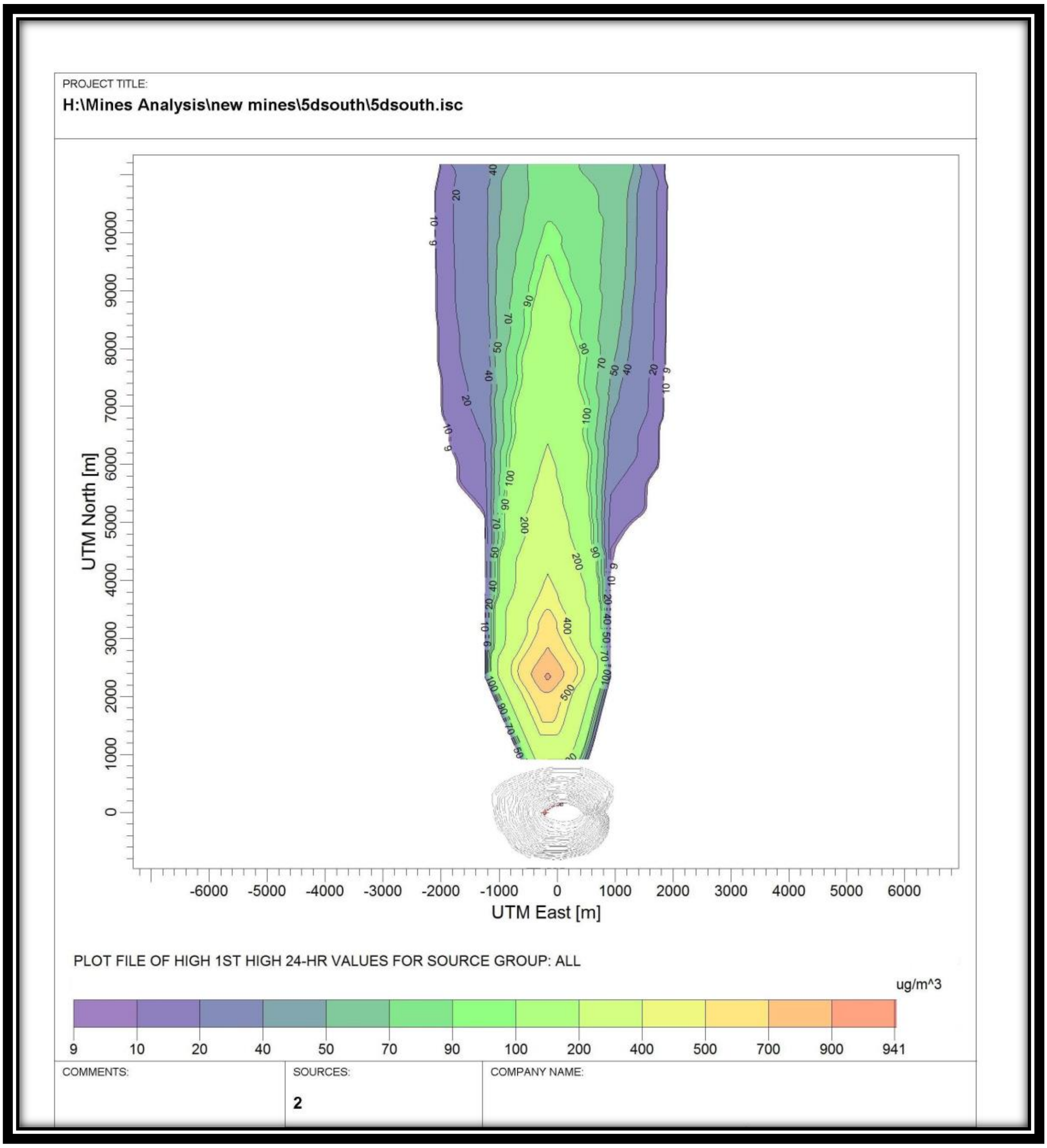

Figure 5.15: Contours of PM_{10} concentrations generated from dust sources at 250 m depth of mine 'B' with southerly wind

Finally, the concentration of PM_{10} had been estimated outside the mine for a depth of 250 m of mine 'B'. It can be seen from the figure 5.15 that these estimated concentrations for the 250 m depth, were the lowest among all the depths of mine 'B'. It ranged from 9 to 941 µg/m^3. In all the depth scenario, the highest level of PM_{10} concentrations were found for 50, 100 and 150 m depths. As the depth increased, the estimated concentration of PM_{10} had come down. This was due to the trapping of the dust inside the mine for the greater depths. As the depth of the mine increased, the dust sources went deeper and the most of their emissions did not reach to the top of the mine. Due to this, the dust concentration reduced significantly for greater depths.

Figure 5.16 shows the variations of the maximum dust concentrations generated at the different depths of the mine 'B' with the different wind directions.

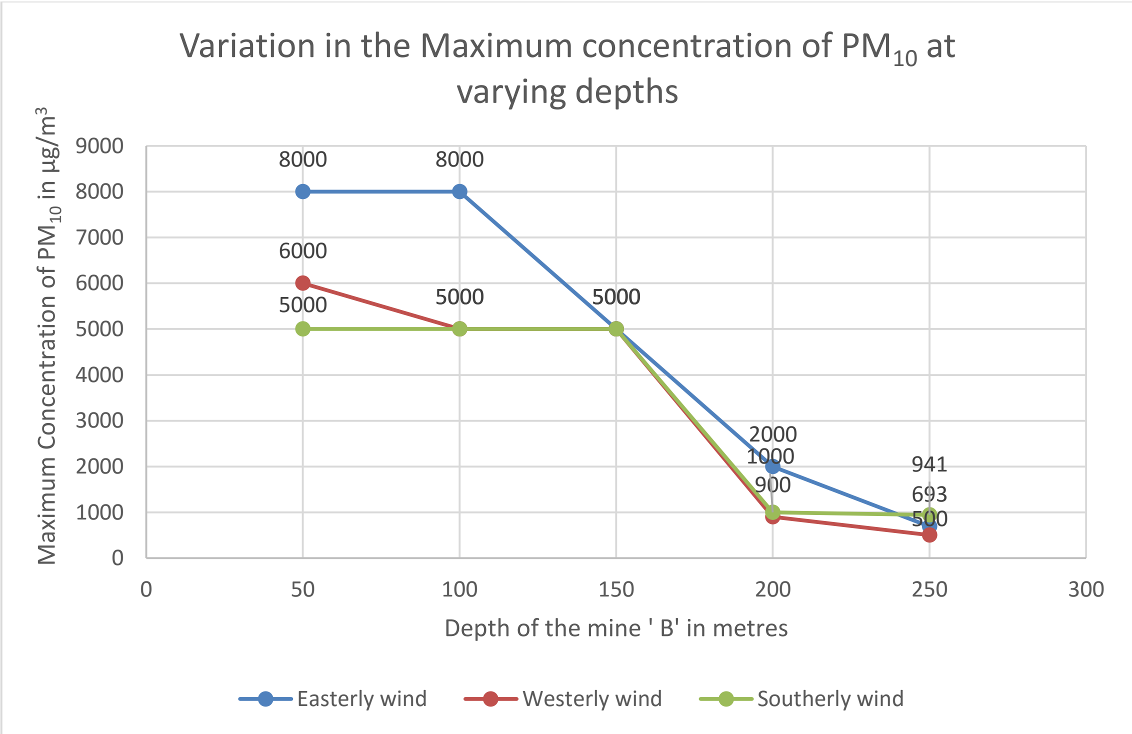

Figure 5.16: Comparative variation of the maximum dust concentration generated from the dust sources for the different depths of the mine 'B' with the different wind directions

From figure 5.16, it can be observed that the maximum concentration of PM_{10} had been found similar for 50 and 100 m depth of mine 'B' for the easterly wind. These were also similar for 50,100 and 150 m depths for the southerly wind. These concentration levels reduced at different depths of mine 'B' for westerly wind, except for the 150 m depth. Concentration levels of the PM_{10} were decreasing for all three wind directions, after the 150 m depth. The decrease in concentration of

PM_{10} was the highest for the westerly wind. Most of the deposition of the dust had happened inside the mine for the westerly wind. Consequently this had reduced the concentration of PM_{10} outside the mine.

5.2 Dust dispersion due to internal overburden dump with the varying depth and wind direction

The study of dust dispersion with the internal overburden dump had been carried out at the different depths of the operation from the 50 m to 250 m, at an interval of 50 m of mine 'B'. These internal overburden dumps were observed at the western side of the mine 'B'. This has been done with different wind directions. Results of the dust dispersion with the varying depths vis-à-vis wind direction were plotted as contours for the areas outside the mine boundary.

5.2.1 Dust dispersion due to internal overburden dump with the varying depth and the easterly wind

The internal overburden dump was observed in the western part of mine 'B'. The direction of the wind was observed to be easterly for all the five depth variations. At the mining depth of 50 m, the internal overburden dump was 60 m of height. Figure 5.17 shows the variations in PM_{10} concentration outside the mine boundary for this depth and dump. X and Y axes represented the distances in X and Y direction from the centre of the mine 'B'.

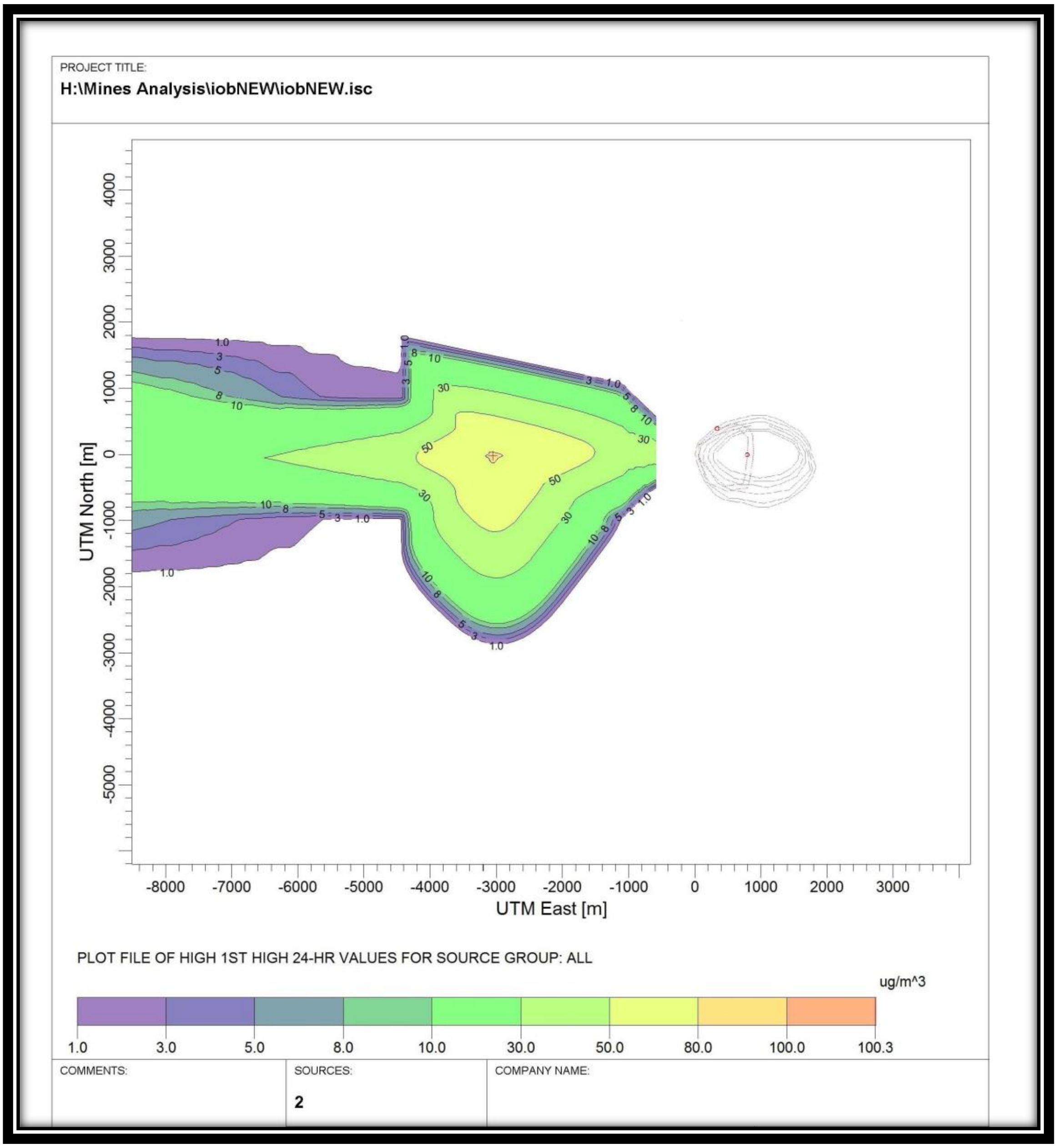

Figure 5.17: Contours of PM_{10} concentrations generated from the internal overburden dump at 50 m depth of the mine 'B' with the easterly wind

It was observed that the maximum concentration obtained during this case was 100.3 μg/m^3. This concentration is the threshold value of the PM_{10}. This concentration was for a very small area of nearly 0.5 km^2. This had been found at a distance of 3,000 m, from the centre of the mine. This was due significant increase in the air velocity just outside the mine. The internal overburden dump usually takes the shape of the mine and allows the dust particles to travel larger distances, in the restricted area due to an increase in the velocity, at the top of the dump. These concentrations were limited only in to a small area. At the mine boundary, it was observed that the concentration of PM_{10} dropped significantly, ranging between 1 to 80 µg/m^3. Figure 5.18 shows contours of the PM_{10} concentration generated from the internal overburden dump at 100 m depth of mine 'B', with the easterly wind.

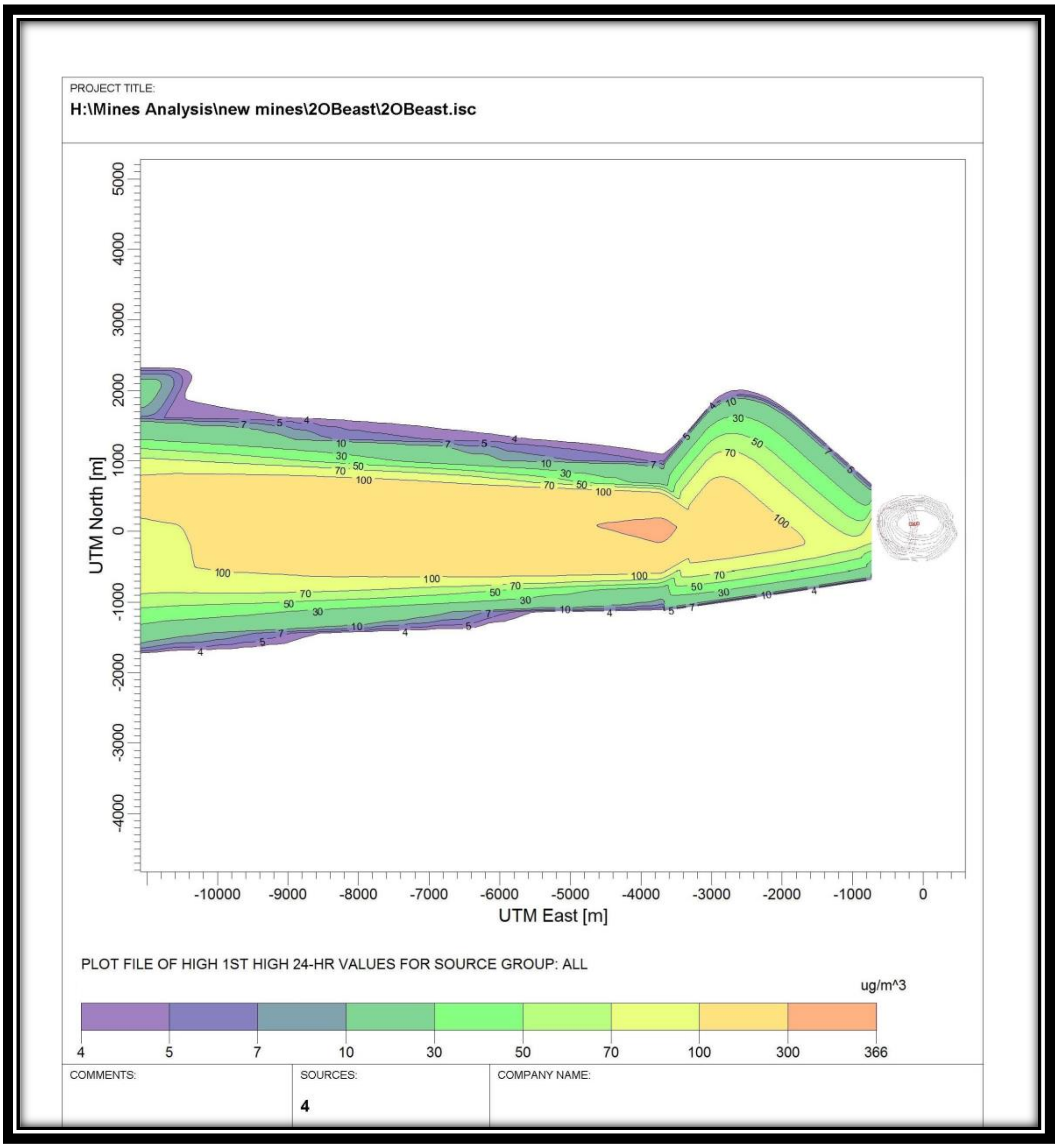

Figure 5.18: Contours of PM_{10} concentrations generated from the internal overburden dump at 100 m depth of the mine 'B' with the easterly wind

The internal overburden dump reached 120 m height, when the mine depth was 100 m. The maximum concentration obtained during this case was between 300 to 366 µg/m^3. This concentration was for a very small area of nearly 0.75 km^2 located at a distance of 4,000 m from the centre of the mine. This was also due to the significant increase in the air velocity, just outside the mine. The dust particles travelled larger distances in the restricted area, due to the increase in the velocity at the top of the dump. These concentrations were limited in small area only. As one moves around the mine boundary, it may be noted that the concentration of the PM_{10} dropped significantly between 4 to 100 µg/m^3. Figure 5.19 shows contours of the PM_{10} concentration generated from the internal overburden dump at the 150 m depth of the mine 'B', with the easterly wind.

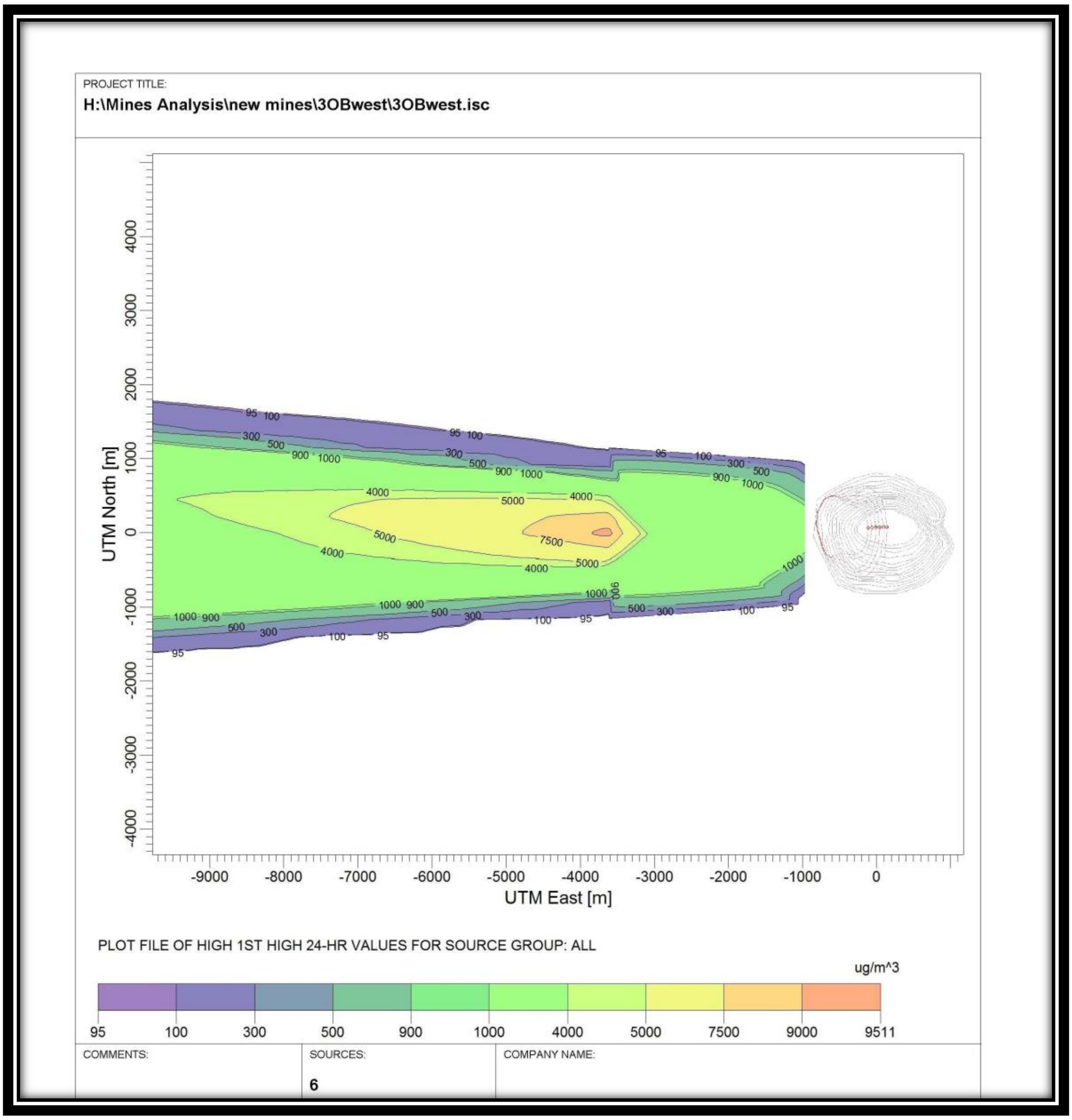

Figure 5.19: Contours of PM_{10} concentrations generated from the internal overburden dump at 150 m depth of the mine 'B' with the easterly wind

The height of internal overburden dump reached to 180 m, at the mine depth of 150 m. The maximum concentration obtained during this case when the depth was 150 m was 9,511 µg/m^3. These concentration levels were found to be very high. The concentration levels was in the range of 1,000 to 9,511 µg/m^3. This concentration were observed over a very large area of nearly 6 km^2. The contours of the PM_{10} concentration levels were of concentric nature due to the shape of the dump. Increase in the air velocity, just outside the mine also influenced it significantly. The dust particles travelled larger distances in restricted area, due to increase in the velocity at the top of the dump. As one moves around the mine boundary, it may be noted that the concentration of PM_{10} was also found between 95 to 100 µg/m^3. These were only at the edges of the contours. Figure 5.20 shows the contours of PM_{10} concentrations generated from internal overburden dump at 200 m depth of the mine 'B', with the easterly wind.

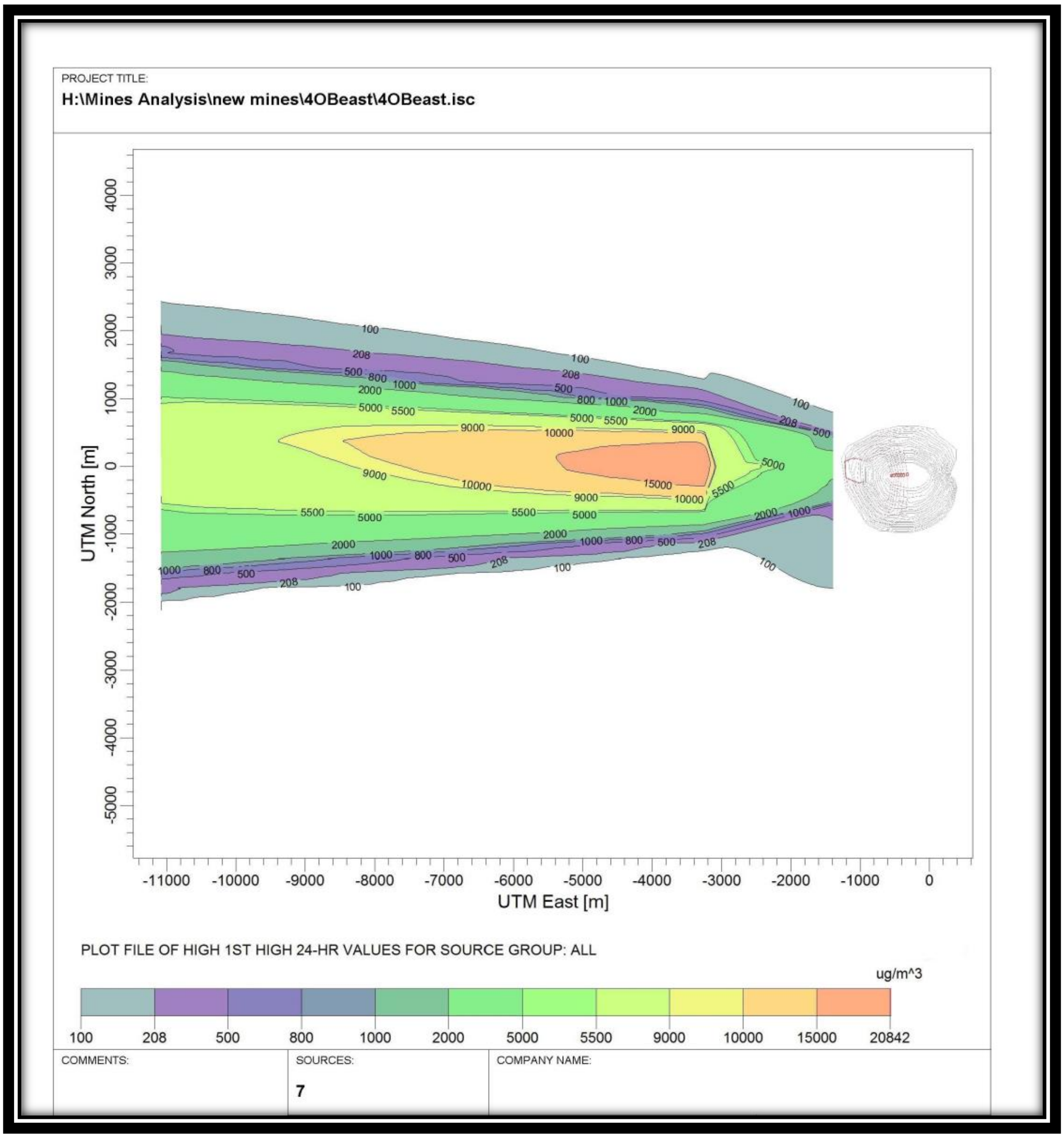

Figure 5.20: Contours of PM_{10} concentrations generated from the internal overburden dump at 200 m depth of the mine 'B' with the easterly wind

The internal overburden dump was of 210 m height when the depth of the mine was 200 m. It was observed from the figure 5.20 that the maximum concentration obtained to be 20,842 µg/m^3. These concentration levels are found to be extremely high, ranging from 1,000 to 20,842 µg/m^3. This concentration were spread over a very large area of nearly 30 km^2. These concentration were almost incurable. Substantial preventive measure were required to be taken. These concentration levels were of concentric nature due to the shape of the dump. Increase in the air velocity, just outside the mine also contributed to this high concentration. As an internal overburden dump usually takes the shape of the mine, allowing dust particles to travel larger distances in the restricted area, due to the increase in the velocity at the top of the dump. As one moves around the mine boundary, it may be noted that the concentration of the PM_{10} was also found between 100 to 500 µg/m^3, at the edge of the contours. Figure 5.21 shows contours of the PM_{10} concentration generated from the internal overburden dump at 250 m depth of the mine 'B', with the easterly wind.

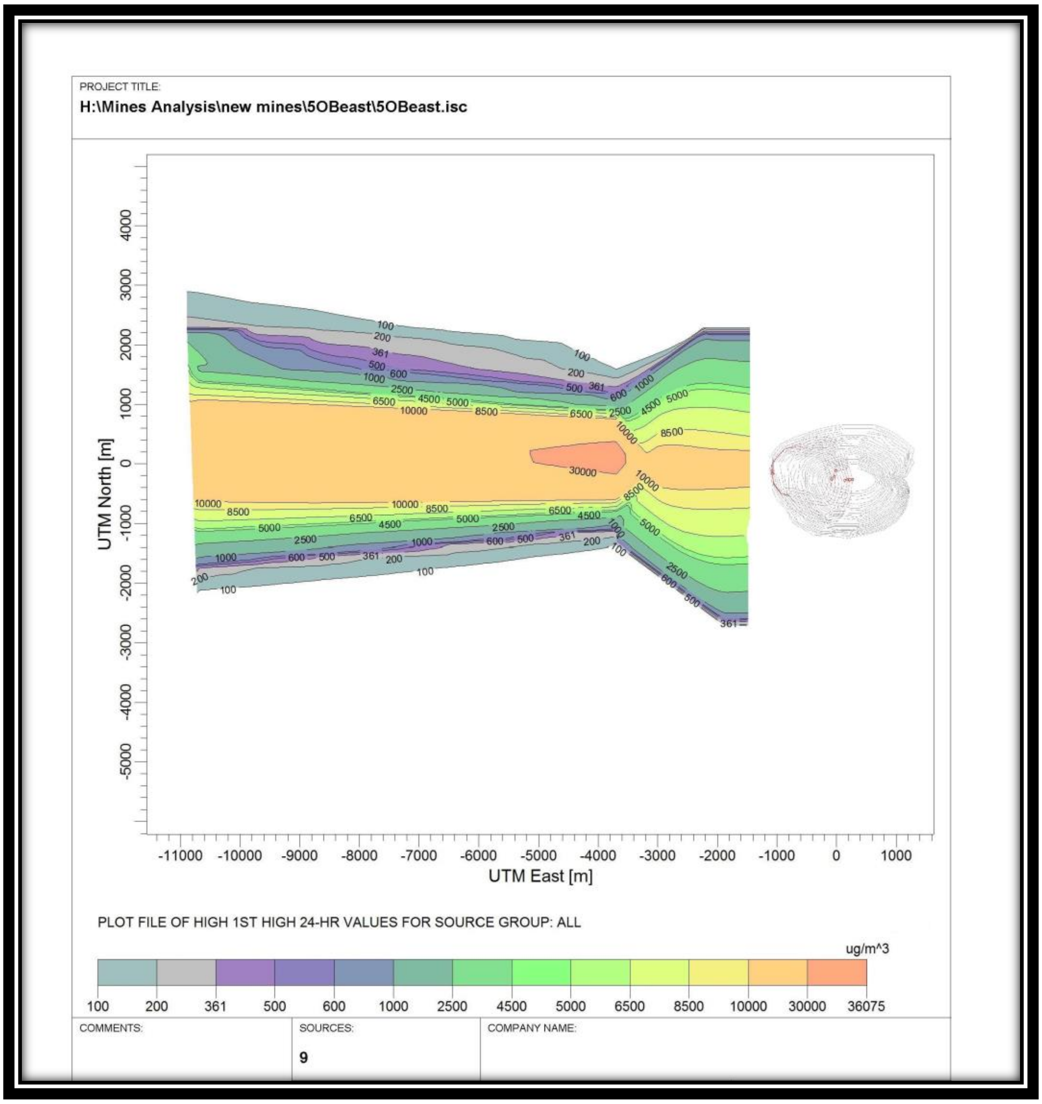

Figure 5.21: Contours of PM_{10} concentrations generated from the internal overburden dump at 250 m depth of the mine 'B' with the easterly wind

The internal overburden dump was of 270 m height when the mine depth was 250 m. The maximum concentration obtained was 36,075 µg/m^3. These concentration levels were found to be very high with a range of 1,000 to 36,075 µg/m^3. These concentrations were spread over a very large area of nearly 40 km^2. These concentration were incurable. Even substantial preventive measure would not be sufficient to reduce the concentration levels. As stated earlier, increase in the air velocity, just outside the mine also contributed to this high concentration. On moving around the mine boundary, it was found that the concentrations of PM_{10} were between 100 to 600 µg/m^3. These are only at the edges of the contours. It may be inferred from the above discussion that the PM_{10} concentration levels were the highest for the greatest depth of the mine 'B', i.e. 250 m. Further, it can be seen that overall PM_{10} concentration levels were increasing with the increase in the depth of the mine 'B', due to the increase in the height and volume of the internal overburden.

5.2.2 Dust dispersion due to internal overburden dump with the varying depth and the westerly wind

In the western part of mine 'B', internal overburden dump has been observed. The direction of the wind was observed to be westerly for all the five depth variations. The internal overburden dump was of 60 m height at a depth of 50 m. Figure 5.17 shows the variations in PM_{10} concentration outside the mine boundary, for this depth and dump. X and Y axes represent the distances in X and Y direction from the centre of the mine 'B'.

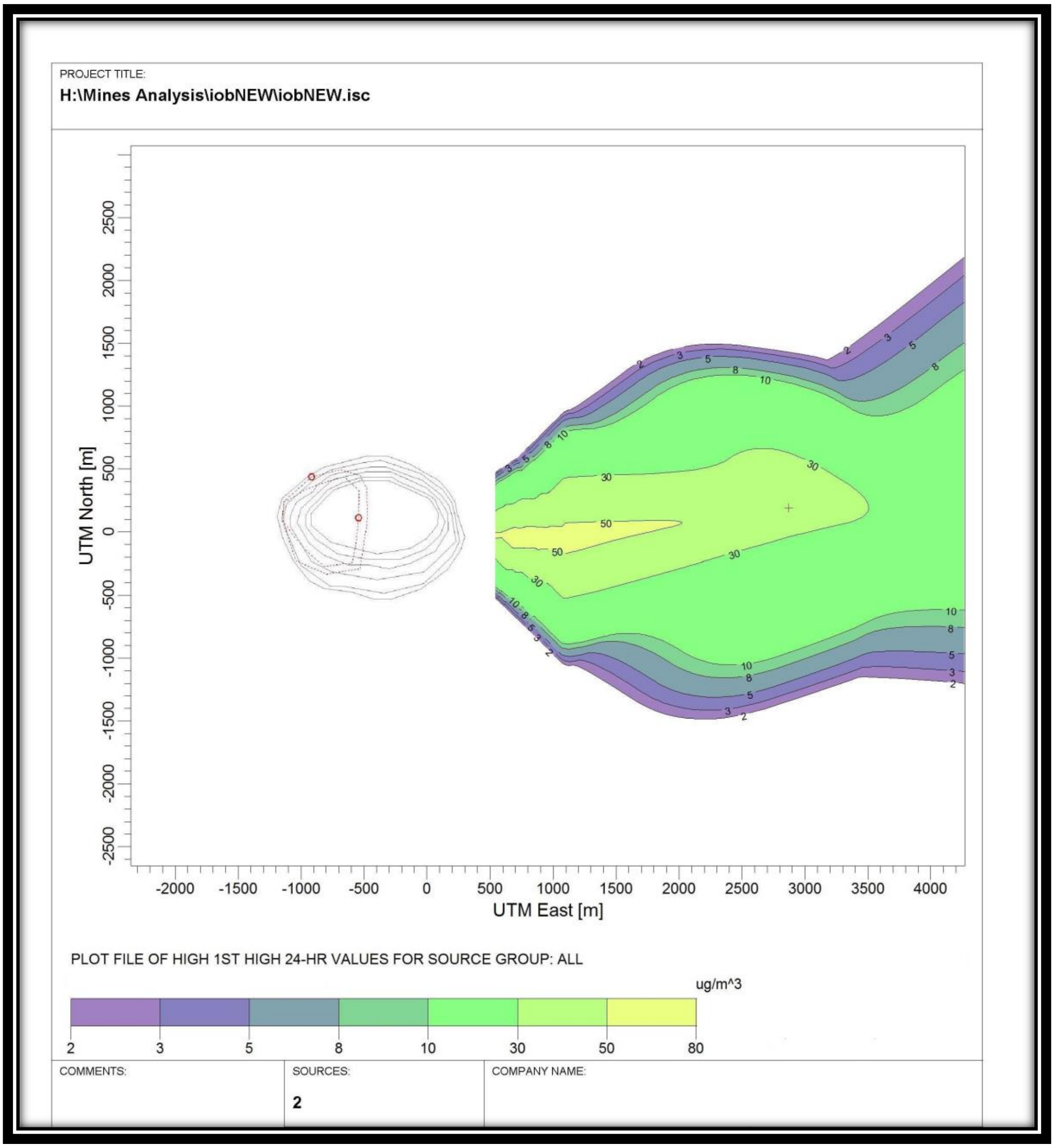

Figure 5.22: Contours of PM_{10} concentrations generated from the internal overburden dump at 50 m depth of the mine 'B' with the westerly wind

It was observed from figure 5.22 that maximum concentration obtained during this case was 80 µg/m^3. This concentration was much lower than the threshold value of the PM_{10}. Hence, no preventive measure were required for this depth of mine 'B'. As one moves around the mine boundary, it may be noted that the concentration of the PM_{10} dropped significantly between 1 to 50 µg/m^3. Figure 5.18 shows the contours of the PM_{10} concentrations generated from the internal overburden at 100 m depth of mine 'B' with the westerly wind.

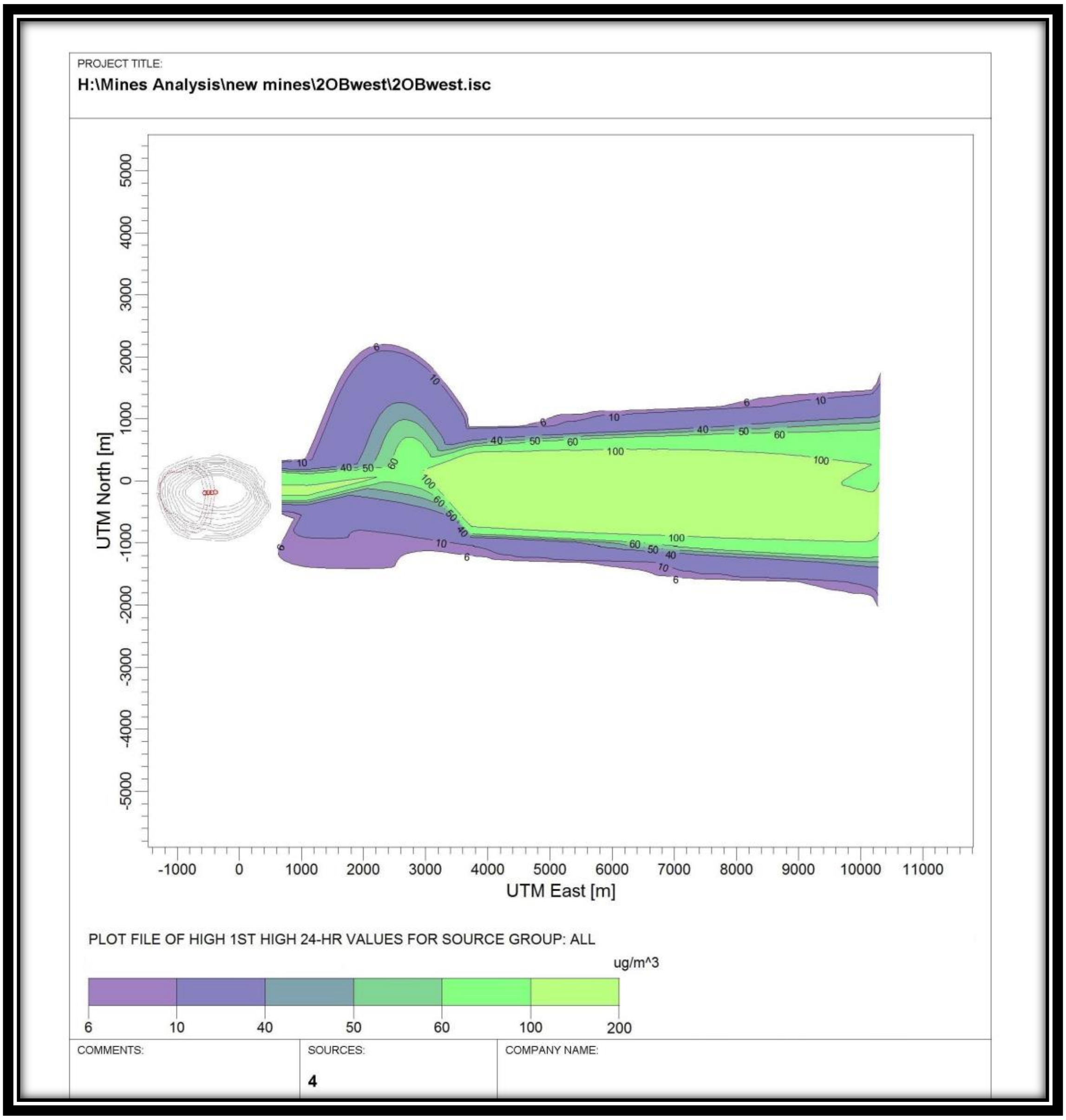

Figure 5.23: Contours of PM_{10} concentrations generated from the internal overburden dump at 100 m depth of the mine 'B' with the westerly wind

The internal overburden dump was of 120 m height at the depth of 100 m. The maximum concentrations obtained during this case was between 100 to 200 µg/m^3. This concentration was for a very small area of nearly 1 km^2. This had been found at a distance of 2,500 m from the centre of the mine for the reasons stated in previous cases. These concentrations were limited to the small area only. As one moves around the mine boundary, it may be noted that the concentrations of the PM_{10} dropped significantly ranging from 6 to 100 µg/m^3. These concentrations were below the threshold value for PM_{10}. Figure 5.24 shows the contours of the PM_{10}

concentrations generated from the internal overburden dump at the 150 m depth of the mine 'B' with the westerly wind.

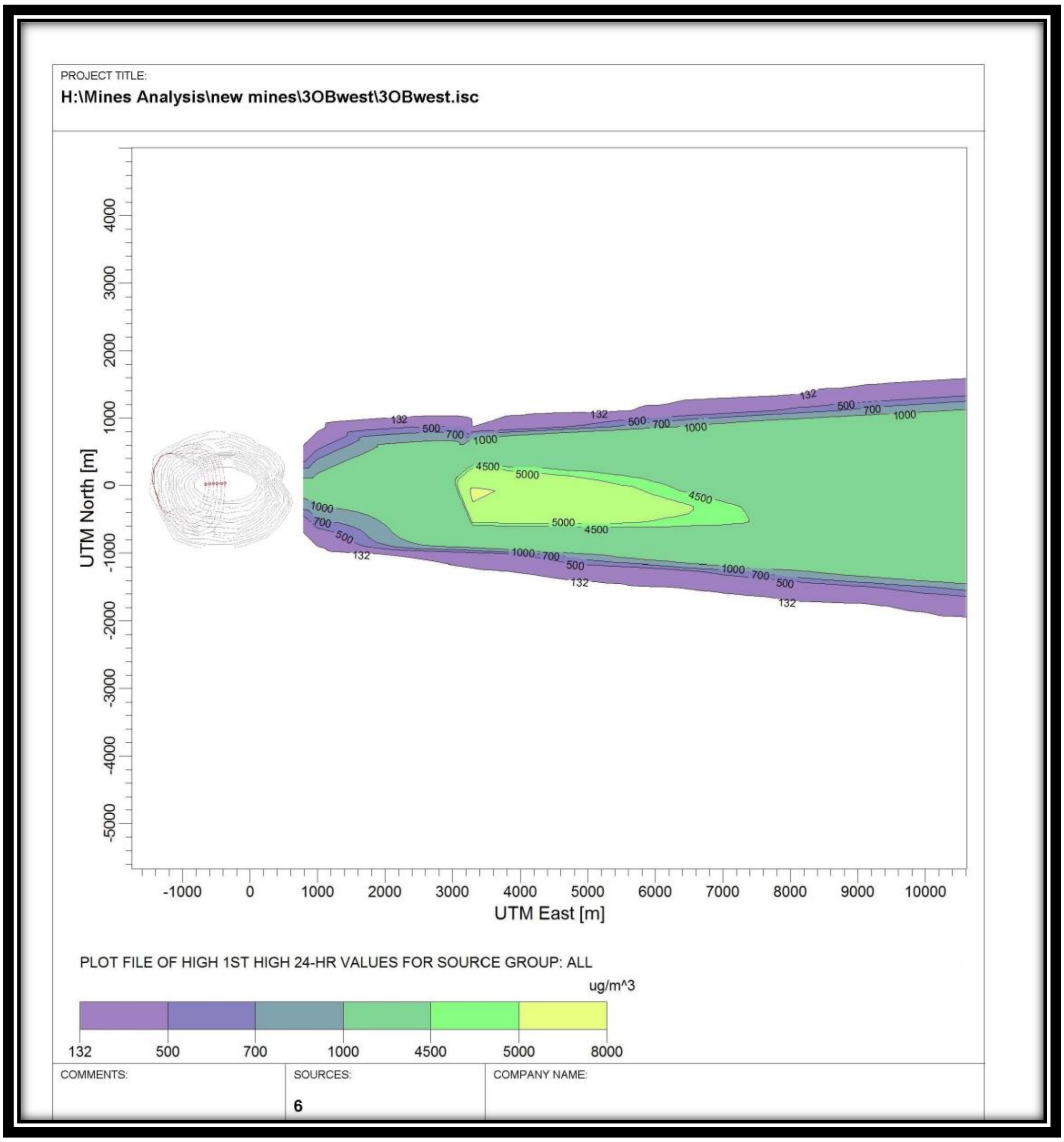

Figure 5.24: Contours of PM_{10} concentrations generated from the internal overburden dump at 150 m depth of the mine 'B' with the westerly wind

The internal overburden dump was of 180 m height at a depth of 150 m. The maximum concentration obtained during this case was 8,000 µg/m^3. These concentration levels were found to be very high ranging from 1,000 to 8,000 µg/m^3. These concentrations were spread over a very large area of nearly 20 km^2. These concentration levels were of concentric nature due to the shape of the dump due to reasons discussed before. On moving around the mine boundary, it may be noted that the concentration of the PM_{10} also found to vary between 100 to 700 µg/m^3. However, these were only at the edges of the contours. Figure 5.25 shows the contours of the PM_{10} concentrations generated from internal overburden at the 200 m depth of the mine 'B' with the westerly wind.

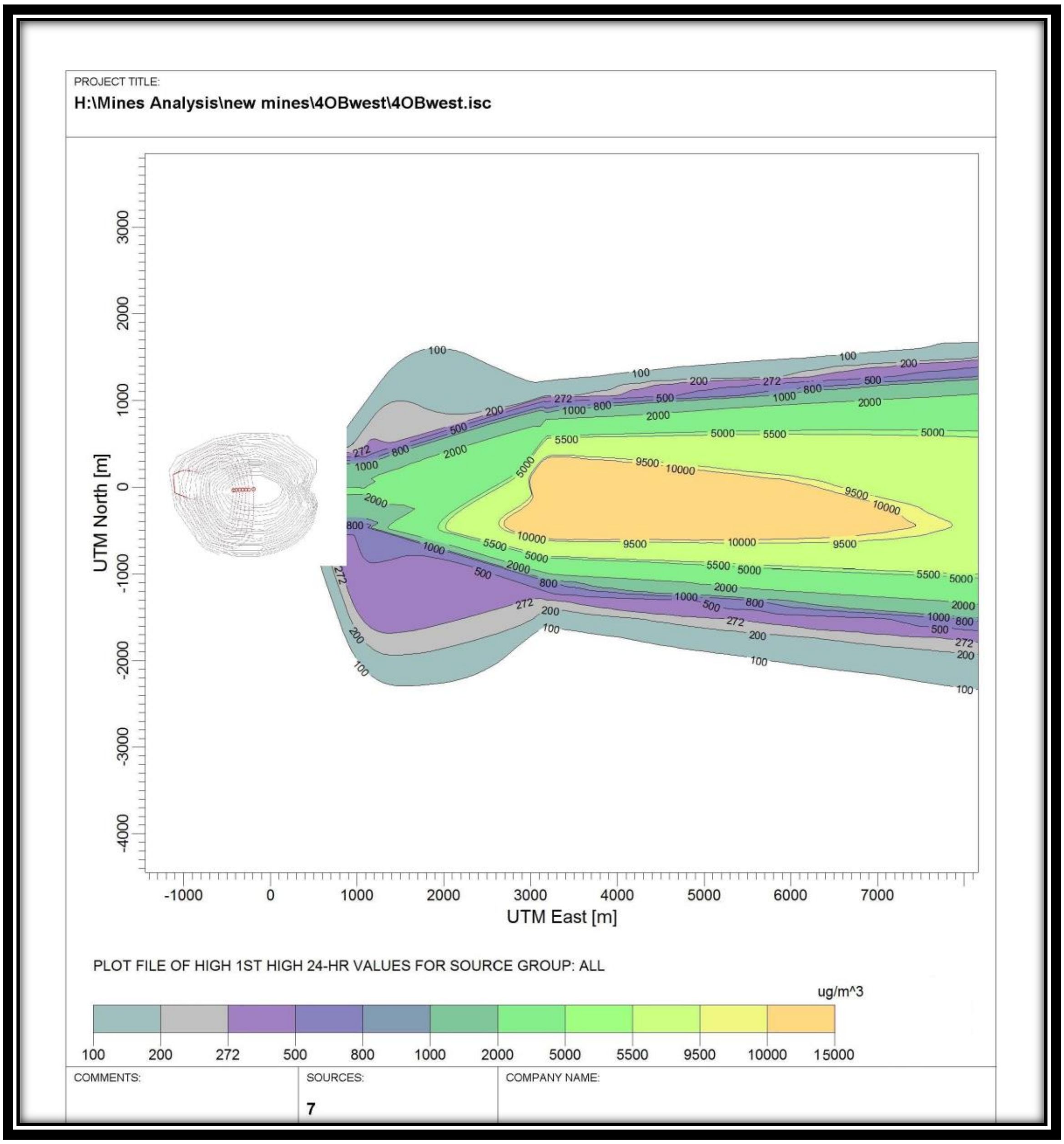

Figure 5.25: Contours of PM_{10} concentrations generated from the internal overburden at 200 m depth of mine 'B' with westerly wind

The height of the internal overburden dump was 210 m at the depth of 200 m. The maximum concentration obtained during this case was 15,000 µg/m^3. These concentration levels are found to be extremely and unsustainable ranging at 1,000 to 15,000 µg/m^3. This concentration were spread over a very large area of nearly 30 km^2. These concentration levels were of the concentric nature due to the shape of the dump due to the reasons as stated earlier in the study. As an internal overburden dump usually takes the shape of the mine, this allows the dust particles to travel larger distances, in the restricted area, due to the increase in the velocity at the top of the dump. As one moves around the mine boundary, it may be observed that the concentration of the PM_{10} were found to range between 100 to 800 µg/m^3. However, they were only at the edge of the contours. Figure 5.26 shows the contours of PM_{10} concentrations generated from the internal overburden at 250 m depth of the mine 'B', with the westerly wind.

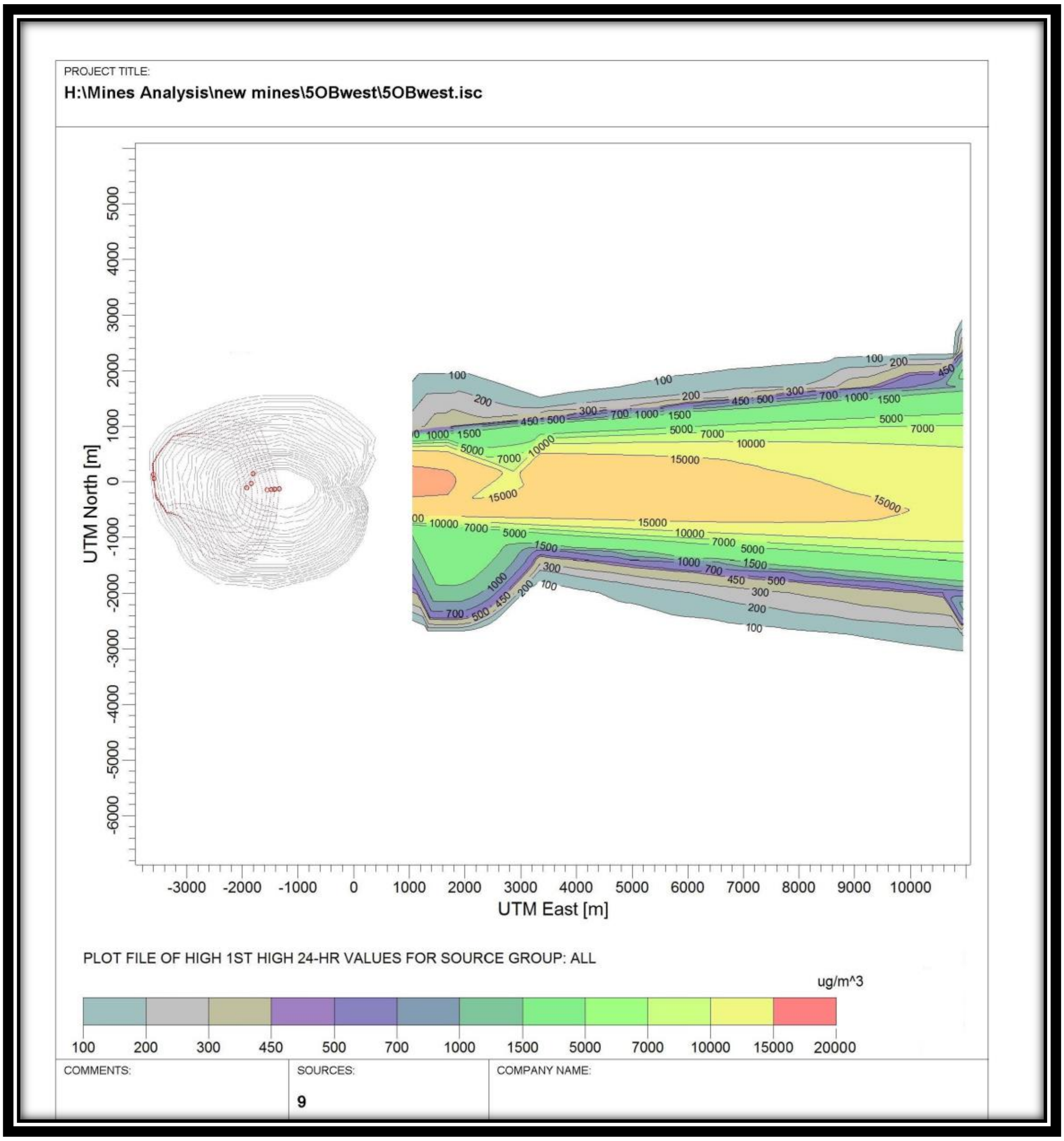

Figure 5.26: Contours of PM_{10} concentrations generated from the internal overburden at 250 m depth of the mine 'B' with the westerly wind

The height of the internal overburden dump was 270 m at the depth of 250 m. The maximum concentration obtained during the depth of 250 m was 20,000 µg/m^3.

These concentration levels were found to be very high, ranging at 1,000 to 20,000 µg/m^3. This concentration are spread over a very large area nearly 40 km^2. These concentrations were severe almost. Adopting substantial preventive measures would also not be sufficient to reduce the concentration levels. Air velocity just outside the mine increased significantly, as already discussed before. The concentrations of PM_{10} also found between 100 to 700 µg/m^3 around the mine boundary. However, they were only at the edges of the contours. It can be seen from figure 5.17 through 5.26 that the PM_{10} concentration levels outside of the mine for all the depths of mine 'B' were higher for the easterly wind than those of westerly wind. This was primarily due to the orientation of the internal overburden dumps, in the direction of the westerly wind. The PM_{10} had been settling inside the mine due to availability of the space. Whereas, in the case of the easterly wind, it was just reverse. Further, it could be seen that overall PM_{10} concentration levels were increasing with the increase in the depth of the mine 'B' due to the increase in the height and the size or volume of the internal overburden dump.

5.2.3 Dust dispersion due to the internal overburden dump with the varying depth and the southerly wind

In the western part of the mine 'B', internal overburden dumps had been observed. The direction of the wind was observed to be southerly for all the five depth variations. The internal overburden dump was of 60 m height at a depth of 50 m. Figure 5.27 shows the variations in PM_{10} concentrations outside the mine boundary for this depth. X and Y axes represented the distances in the X and Y direction from the centre of the mine 'B'.

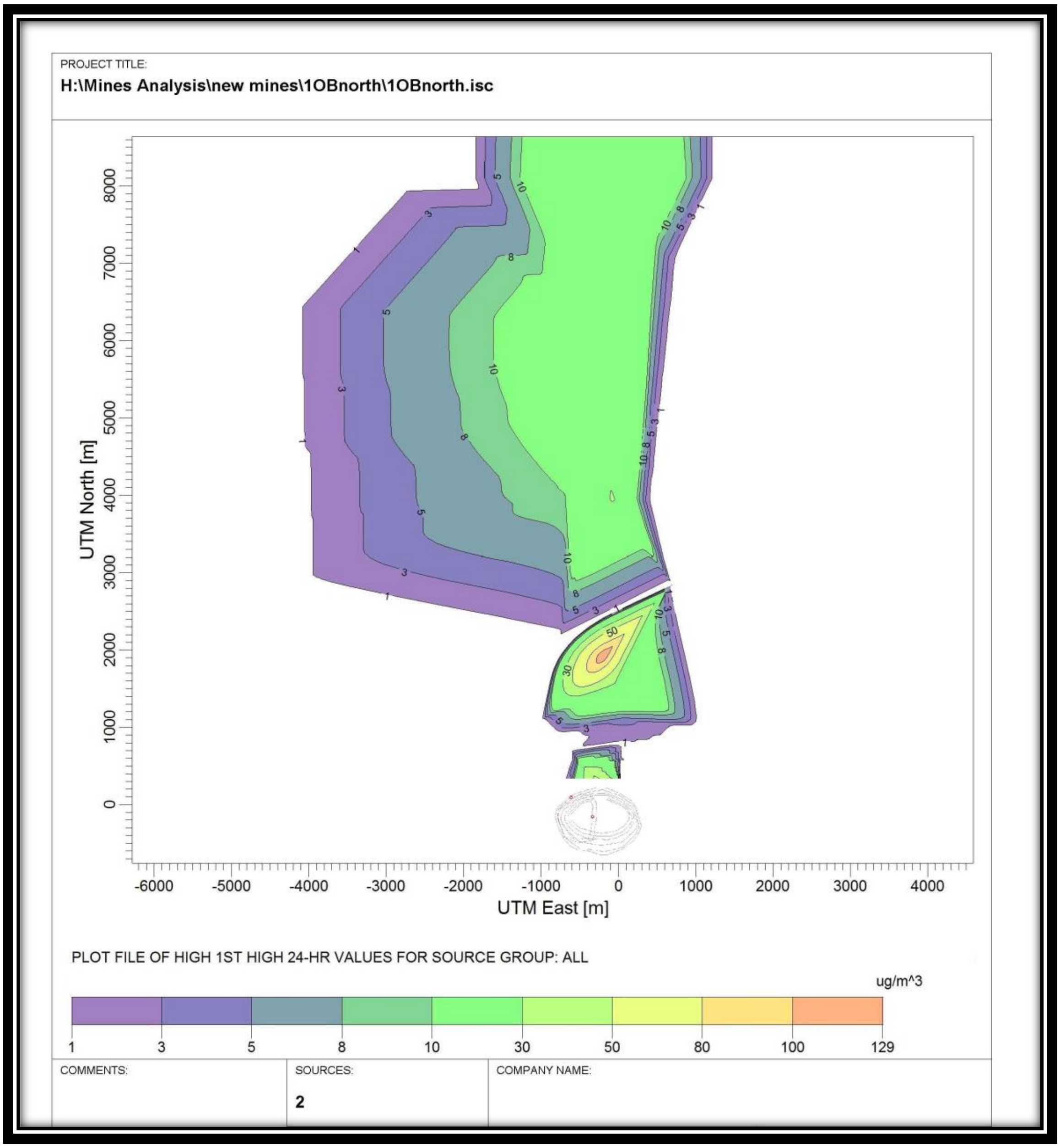

Figure 5.27: Contours of PM_{10} concentrations generated from the internal overburden dump at 50 m depth of the mine 'B' with the southerly wind

It has been observed from the figure 5.27 that the maximum concentration obtained during this case was 129 µg/m^3. This concentration was slightly more than the threshold value of the PM_{10}. Minimal preventive measure has been required for this depth of mine 'B' in this case. As one moves around the mine boundary, it may be noted that concentration of PM_{10} drops significantly between 1 to 100 µg/m^3. All the concentration levels were spread more over the north - west direction. This was due to the western location of the dump and northerly wind. Figure 5.28 shows the contours of the PM_{10} concentrations generated from the internal overburden dump at the 100 m depth of the mine 'B', with the southerly wind.

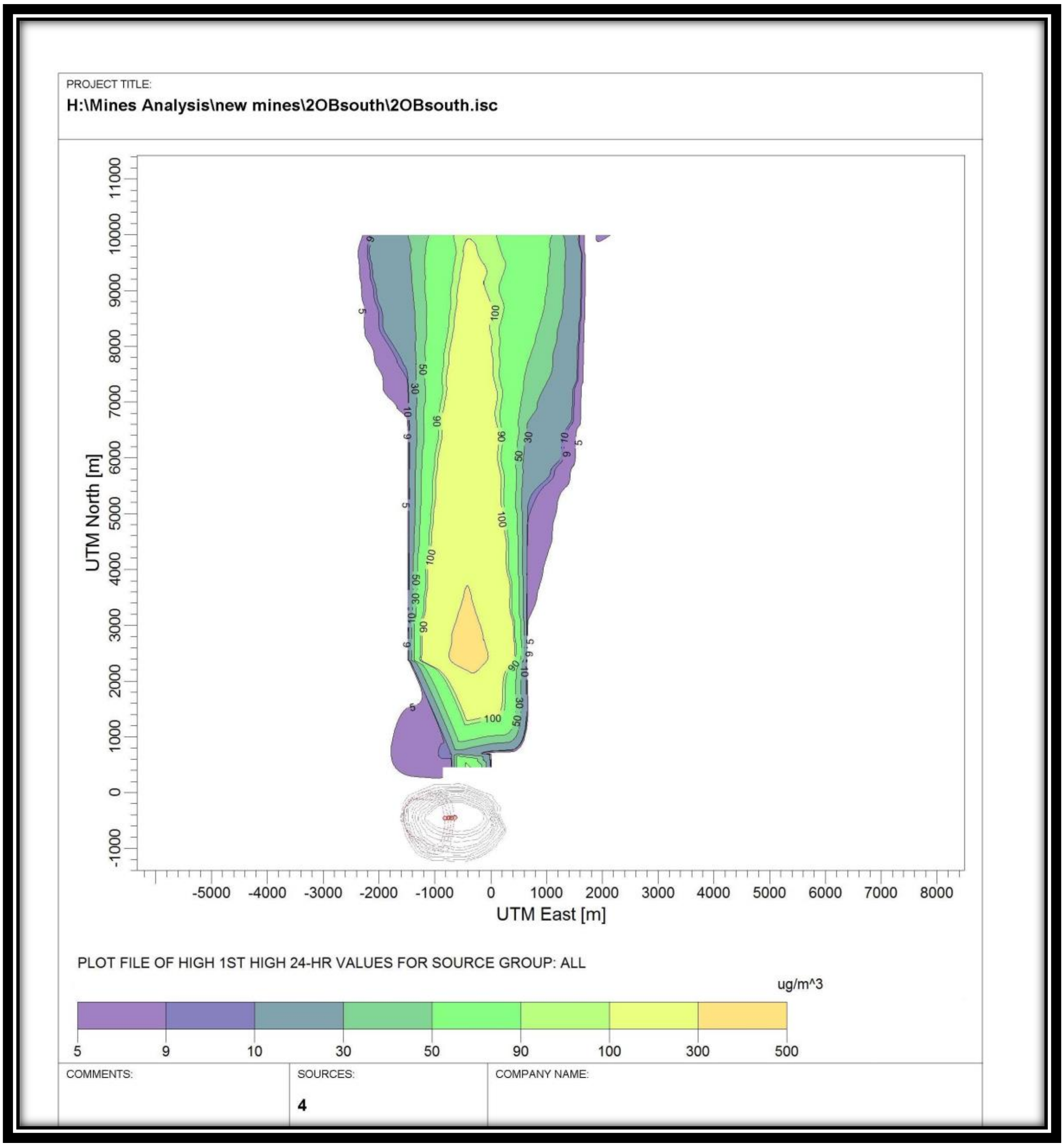

Figure 5.28: Contours of PM_{10} concentrations generated from the internal overburden dump at 100 m depth of the mine 'B' with the southerly wind

The internal overburden dump was of 120 m height at a depth of 100 m. The maximum concentration obtained during this case was between 300 to 500 µg/m^3. This concentration was for a very small area of nearly 1 km^2. This area had been found at a distance of 4,000 m from the centre of the mine. This was also due to significant increase in the air velocity just outside the mine as stated earlier. The internal overburden dumps usually have shape of the mine, allowing dust particles to travel larger distances in restricted area, due to increase in the velocity, at the top of the dump. On moving around the mine boundary, it might be noted that the concentration of the PM_{10} dropped significantly ranging between 6 to 100 µg/m^3.

These concentrations were well below threshold value of PM_{10}. Figure 5.29 shows the contours of the PM_{10} concentrations generated from the internal overburden dump at the 150 m depth of the mine 'B', with the southerly wind.

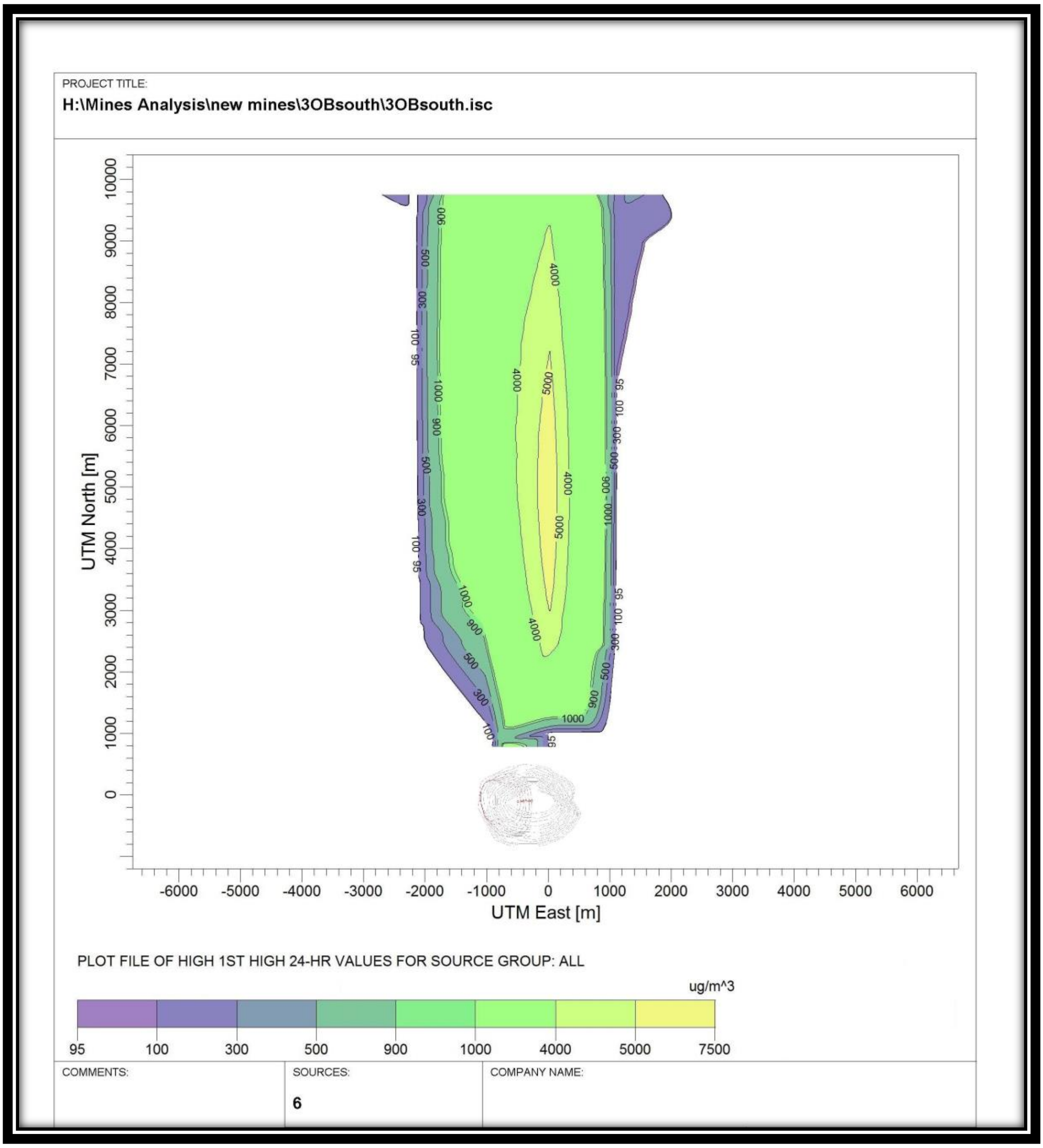

Figure 5.29: Contours of PM_{10} concentrations generated from the internal overburden dump at 150 m depth of the mine 'B' with the southerly wind

The internal overburden dump was of 180 m height at a depth of 150 m. The maximum concentration obtained during this case was 7,500 µg/m^3. These concentration levels were found to be very high ranging at 1,000 to 7,500 µg/m^3 and spread over a very large area of nearly 20 km^2. These concentrations were toxic.

Substantial preventive measure were required to be taken to accept sustainable mining activities. These concentration levels were of concentric nature due to the shape of the dump and air velocity effects as discussed earlier. Around the mine boundary, it may be noted that concentration of PM_{10} was between 100 to 900 $\mu g/m^3$. These were only existing at the edge of the contours. Figure 5.30 shows the contours of the PM_{10} concentration generated from the internal overburden dump at the 200 m depth of the mine 'B' with the southerly wind.

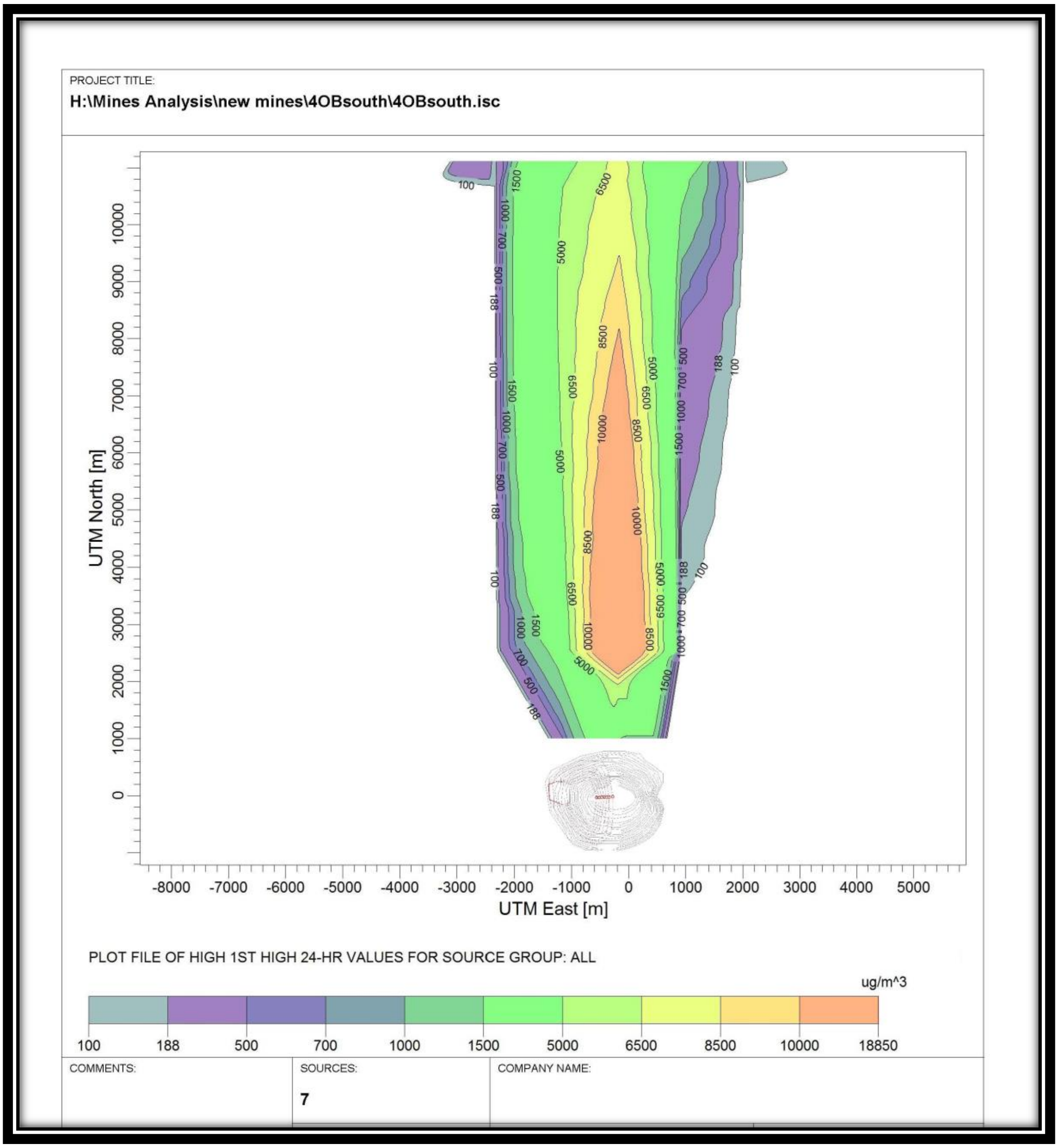

Figure 5.30: Contours of PM_{10} concentrations generated from the internal overburden dump at 200 m depth of the mine 'B' with the southerly wind

The internal overburden dump was of 210 m height at a depth of 200 m. It was observed from the figure 5.30 that the maximum concentration obtained during this case was 18,850 µg/m^3. These concentration levels were found to be very high, ranging at 1,000 to 18,850 µg/m^3. This concentration was spread over a very large area of nearly 30 km^2. These concentration are almost lethal needing substantial preventive measures. These concentration levels were of concentric nature due to the shape of the internal overburden dump. These higher levels of PM_{10} concentrations may be attributed to the significant increase in the air velocity, just outside the mine as stated earlier. As an internal overburden dump usually takes the shape of the mine, it allows the dust particles to travel larger distances in the restricted area due to increase in the velocity at the top of the dump. On moving around the mine boundary, it may observed that the concentration of the PM_{10} was between 100 to 700 µg/m^3. These were only found at the edges of the contours. Figure 5.31 shows the contours of the PM_{10} concentrations generated from the internal overburden at 250 m depth of the mine 'B' with the southerly wind.

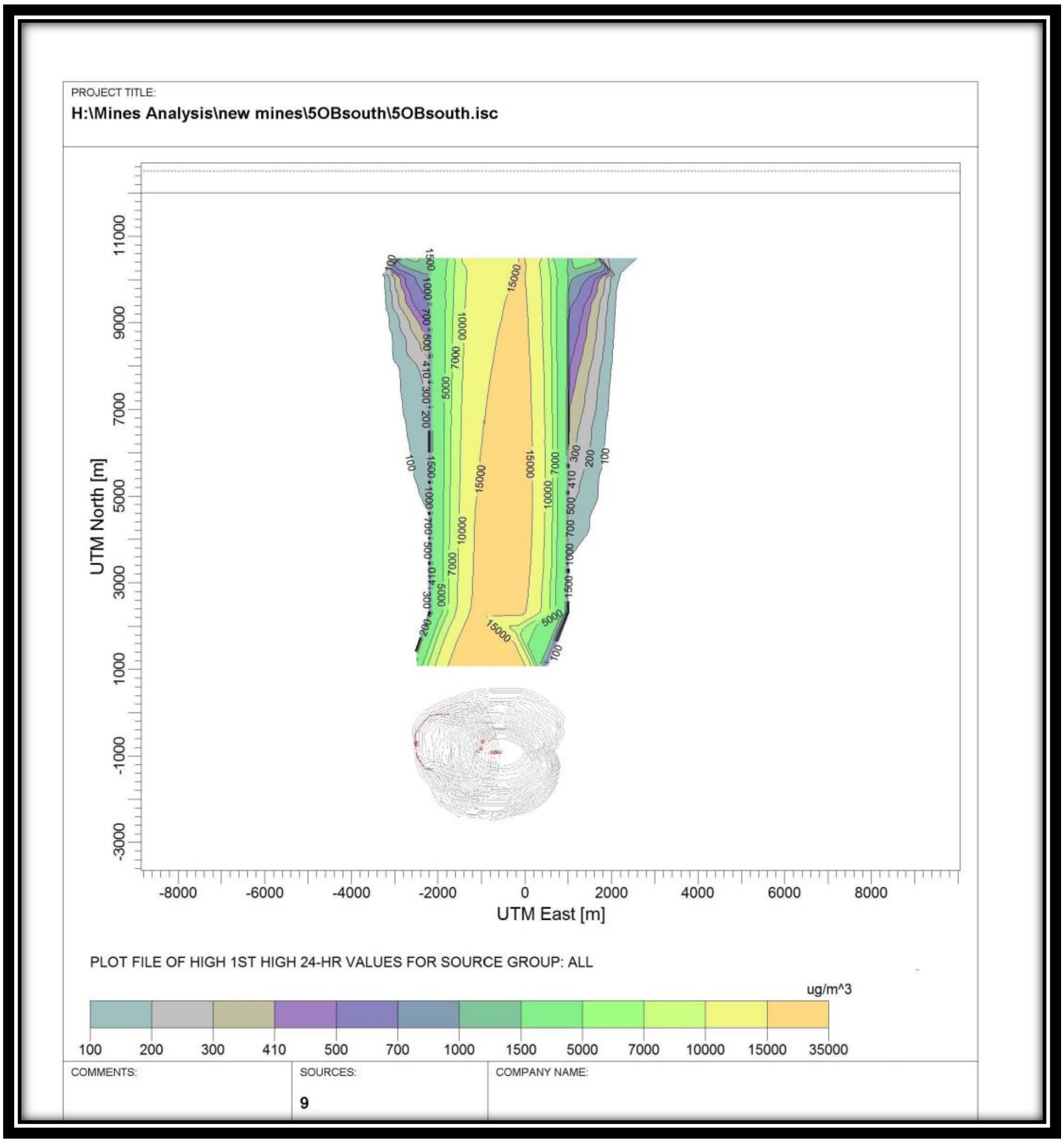

Figure 5.31: Contours of PM_{10} concentrations generated from the internal overburden dump at 250 m depth of the mine 'B' with the southerly wind

The height of internal overburden dump was 270 m at a depth of 250 m. Figure 5.31 shows that maximum concentration obtained at the depth of 250 m was 35,000 µg/m^3. These concentration levels were found to be very high and ranging between 1,000 to 35,000 µg/m^3. This concentrations was spread over a very large area of nearly 40 km^2. These concentrations were incurable, even with substantial preventive. Similar to previous cases, there was a significant increase in the air velocity just outside the mine. This allows dust particles to travel larger distances in restricted area, due to increase in the velocity at the top of the dump. On moving around the mine boundary, it may be noted that the concentration of PM_{10} was found to be between 100 to 700 µg/m^3. These were found only at the edges of the contours. It can be seen from the above discussion that as the depth was increasing, the overall PM_{10} concentration levels had continuously increased outside the mine. This may be due to the similar wind erosion conditions as in the case of easterly wind. Further, due to availability of the less space, as in comparison to the westerly wind case for the deposition of the dust, the estimated concentrations level of the PM_{10} were high for southerly wind at each depth as shown in figure 5.26 through 5.31.

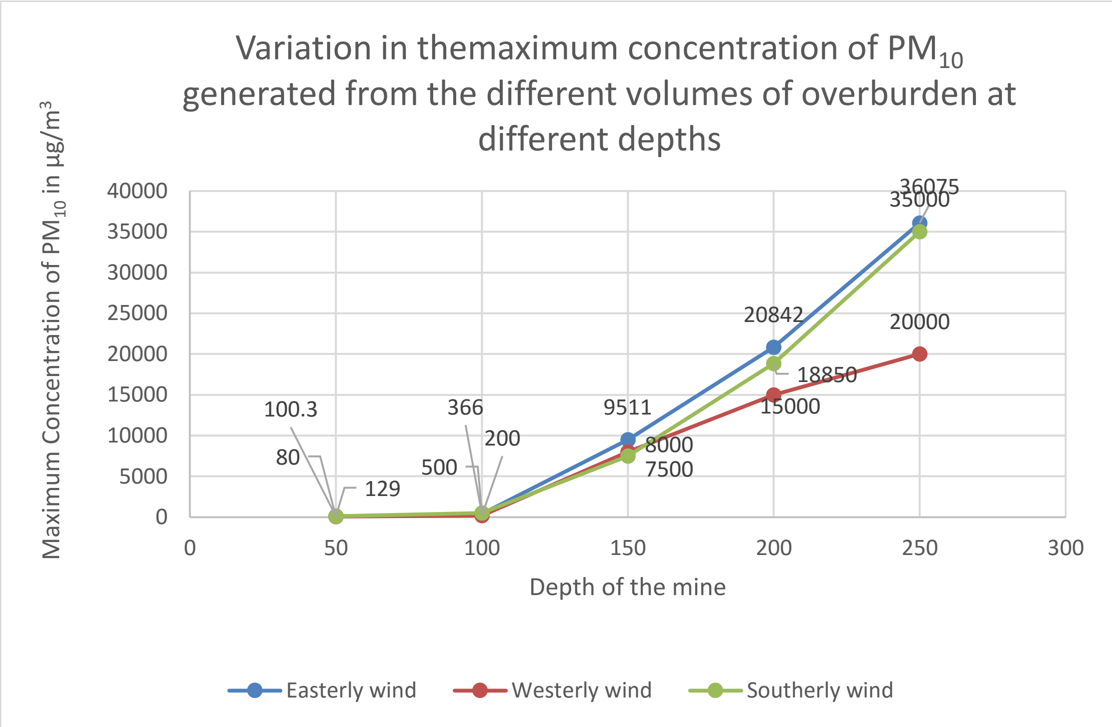

Figure 5.32: Comparative variation of the maximum dust concentration generated from the internal overburden dumps at the different depths of the mine 'B' with the different wind directions

It can be seen from the figure 5.32 that when the internal overburden was made against the wind direction i.e. easterly wind, PM_{10} concentration levels had increased significantly outside the mine with the increase in the depth of the mine. However, when the internal overburden dumps had been made along the wind direction i.e. westerly wind, PM_{10} concentration levels were high outside the region of the mine. These levels were trapped inside the mine itself almost for every depth and these levels were reduced for the each depth in comparison to the easterly wind. When wind was vertically hitting the internal overburden, PM_{10} concentration levels were high in the outside region of the mine. Further, it can be concluded from the preceding discussion, that when the wind direction was against the location of the internal overburden dump, the dust concentration was the highest outside the mine, whereas it was the lowest among three for the westerly wind.

5.3 Dust dispersion due to the haul road with the varying depth and wind direction

The study of dust dispersion with haul road has been carried out at different depth of operation from 50 m to 250 m at an interval of 50 m of mine ‘B’. These haul road are observed at the western side of the mine ‘B’. These are originating from the centre of the mine at the surface and ending at the bottom of the mine. Their dust dispersion has been studied with different wind directions. Results of dust dispersion with varying depth vis-à-vis wind direction has been plotted as contours for the areas outside the mine boundary.

5.3.1 Dust dispersion due to the haul road with the varying depth and the easterly wind

In the western part of the mine ‘B’, haul roads had been observed. The direction of the wind was observed to be easterly for all the five depth variations. The length of the haul road was 917 m when the depth of the mine was 50 m. Figure 5.33 shows the variations in PM_{10} concentration outside the mine boundary for this depth. X and Y axes represent distances in X and Y direction from the centre of the mine ‘B’.

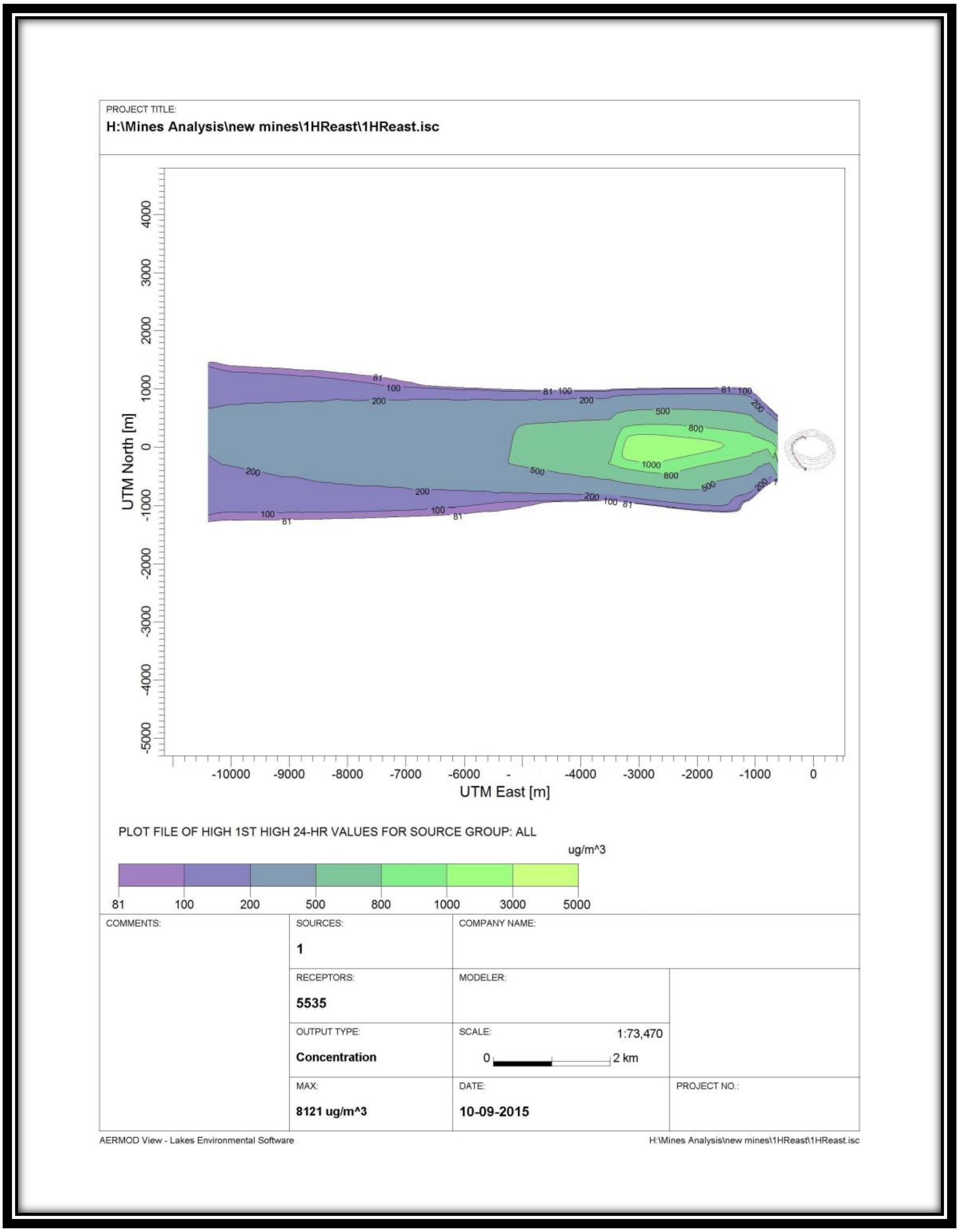

Figure 5.33: Contours of PM_{10} concentrations generated from the haul road at 50 m depth of the mine 'B' with the easterly wind

It may be observed from the figure 5.33 that the maximum concentration obtained during this case was 5,000 µg/m^3. This concentration was for a very small area of nearly 1 km^2 near the mine boundary. As one moves away from the mine boundary, it may be noted that the concentration of the PM_{10} dropped to 1,000 µg/m^3 at the distance of 1,000 m and it reduced to 800 µg/m^3 at a distance of 2,500 m, from the centre of the mine. After this distance the concentration levels of PM_{10} were ranging from 81 to 500 µg/m^3 levels. These levels could be seen up to a distance of 10,000 m, from the centre of the mine. Figure 5.34 shows contours of PM_{10} concentrations generated from the haul road at 100 m depth of the mine 'B' with the easterly wind.

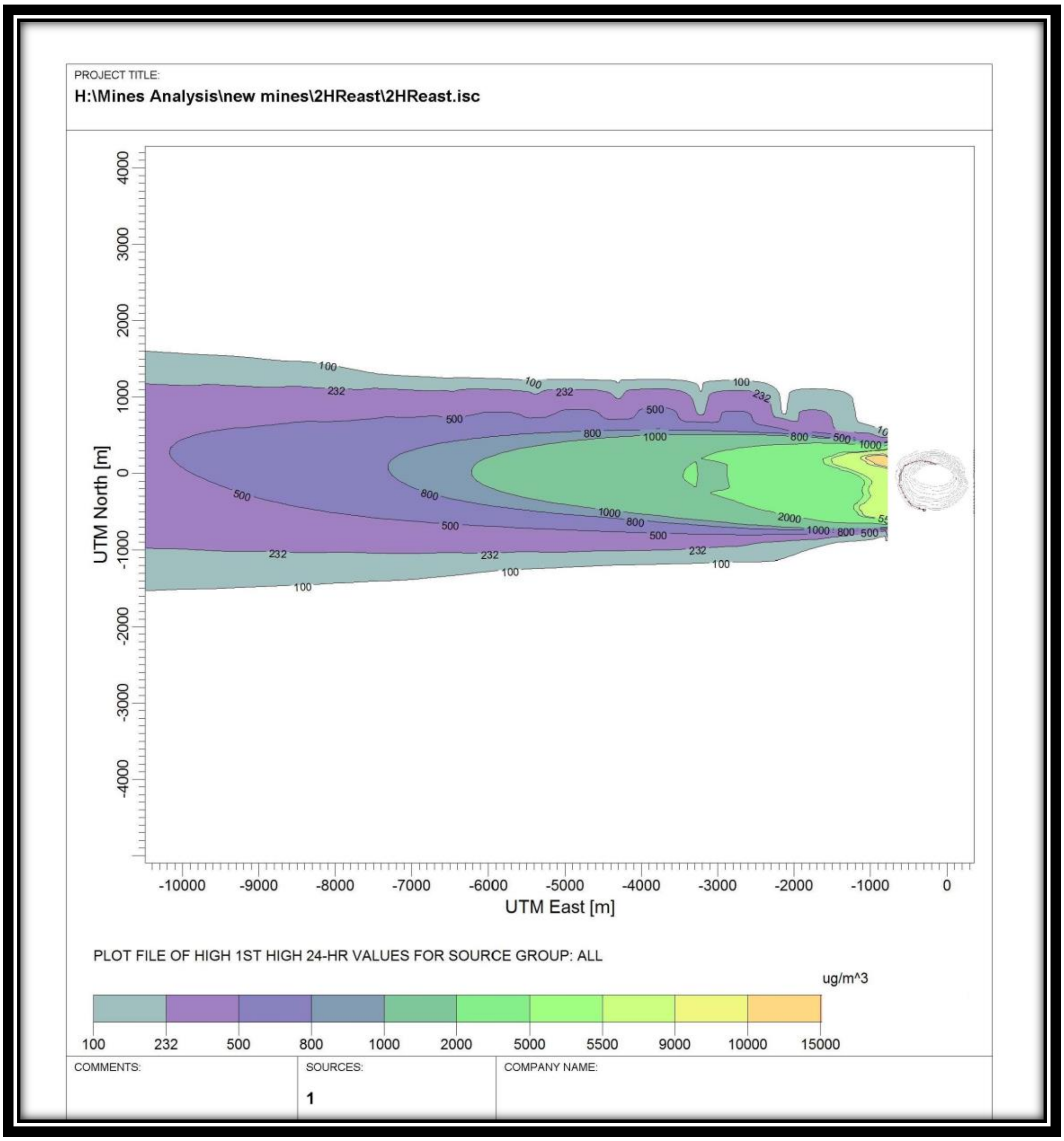

Figure 5.34: Contours of the PM_{10} concentrations generated from the haul road at 100 m depth of the mine 'B' with the easterly wind

The haul road length was of 1604 m at a depth of 100 m. In can be observed from figure 5.34 that the high level of concentration of a range of 1,000 to 15,000 µg/m^3. Concentration levels of 15,000 µg/m^3 was restricted up to a distance of 1,000 m from the centre of the mine 'B'. The concentration levels of 5,000 to 10,000 µg/m^3

were found up to 3000 m. These levels reduced from 800 to 100 µg/m^3 after this distance till 10,000 m. Very serious preventive measures were required up to a distance of 3,000 m, from the centre of the mine 'B', for the depth of 100 m. Figure 5.35 depicts the contours of PM_{10} concentrations generated from the haul road at 150 m depth of the mine 'B' with the easterly wind.

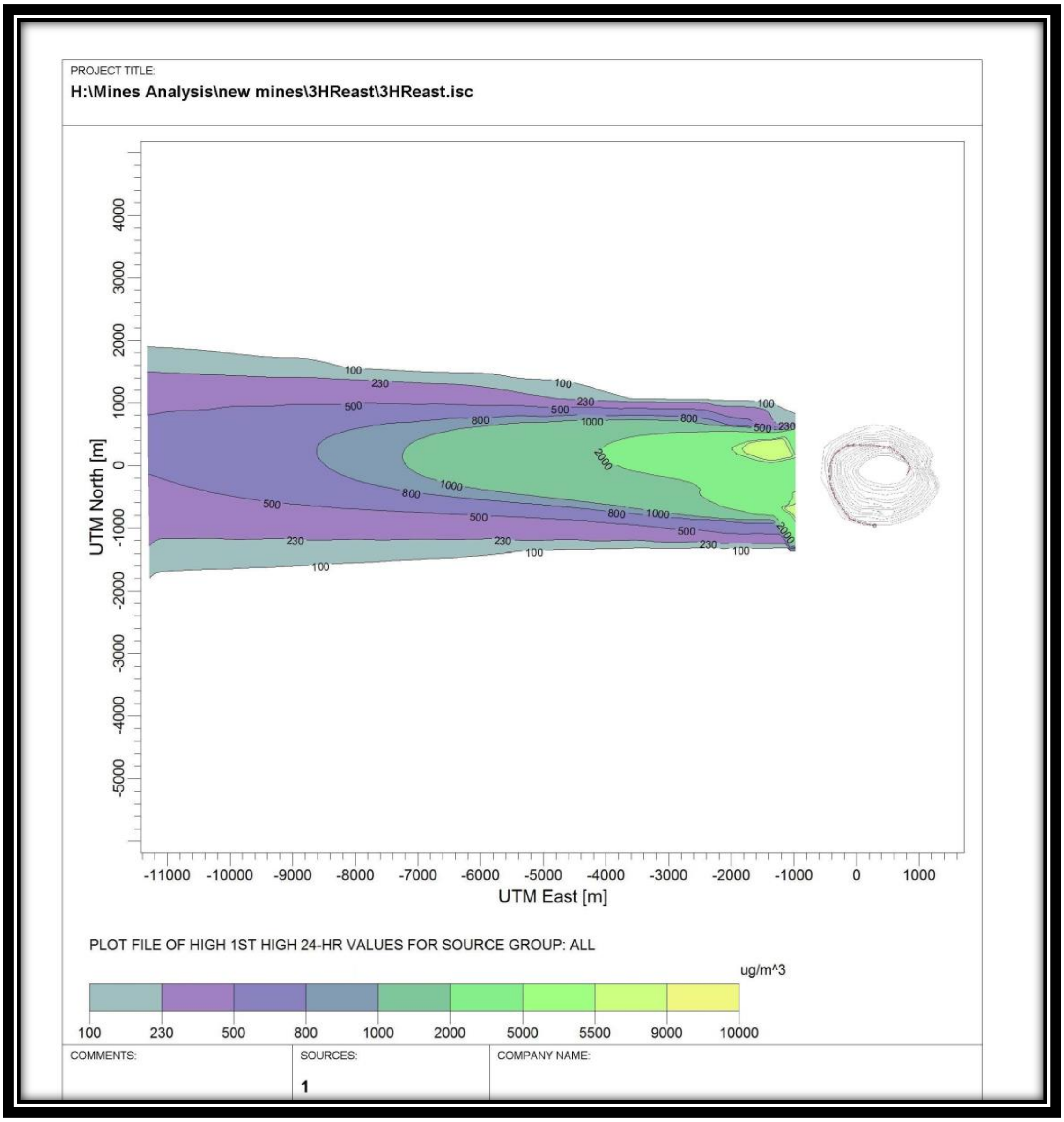

Figure 5.35: Contours of PM_{10} concentrations generated from the haul road at 150 m depth of the mine 'B' with the easterly wind

The haul road length was 2543 m at depth of 150 m. It is evident from figure 5.35 that concentration levels of PM_{10} had reduced between 1,000 to 10,000 µg/m^3 for 150 m depth of mine 'B', up to a distance of 7,000 m from the centre of the mine. These levels has been quite high at the same distance for the depth of 50 m and 100 m respectively. After this distance, up to 10,000 m, these levels suddenly reduced between 100 to 800 μg/m^3. It could be seen from figure 5.33, 5.34 and 5.35 that as the depth become 150 m, the dust was getting trapped inside the mine which is generated from the lower part of the haul road. These concentration levels of PM_{10} had been decreased near as well as far away from the mine boundary. Figure 5.36 shows contours of PM_{10} concentrations generated from the haul road at the 200 m depth of the mine 'B' with the easterly wind.

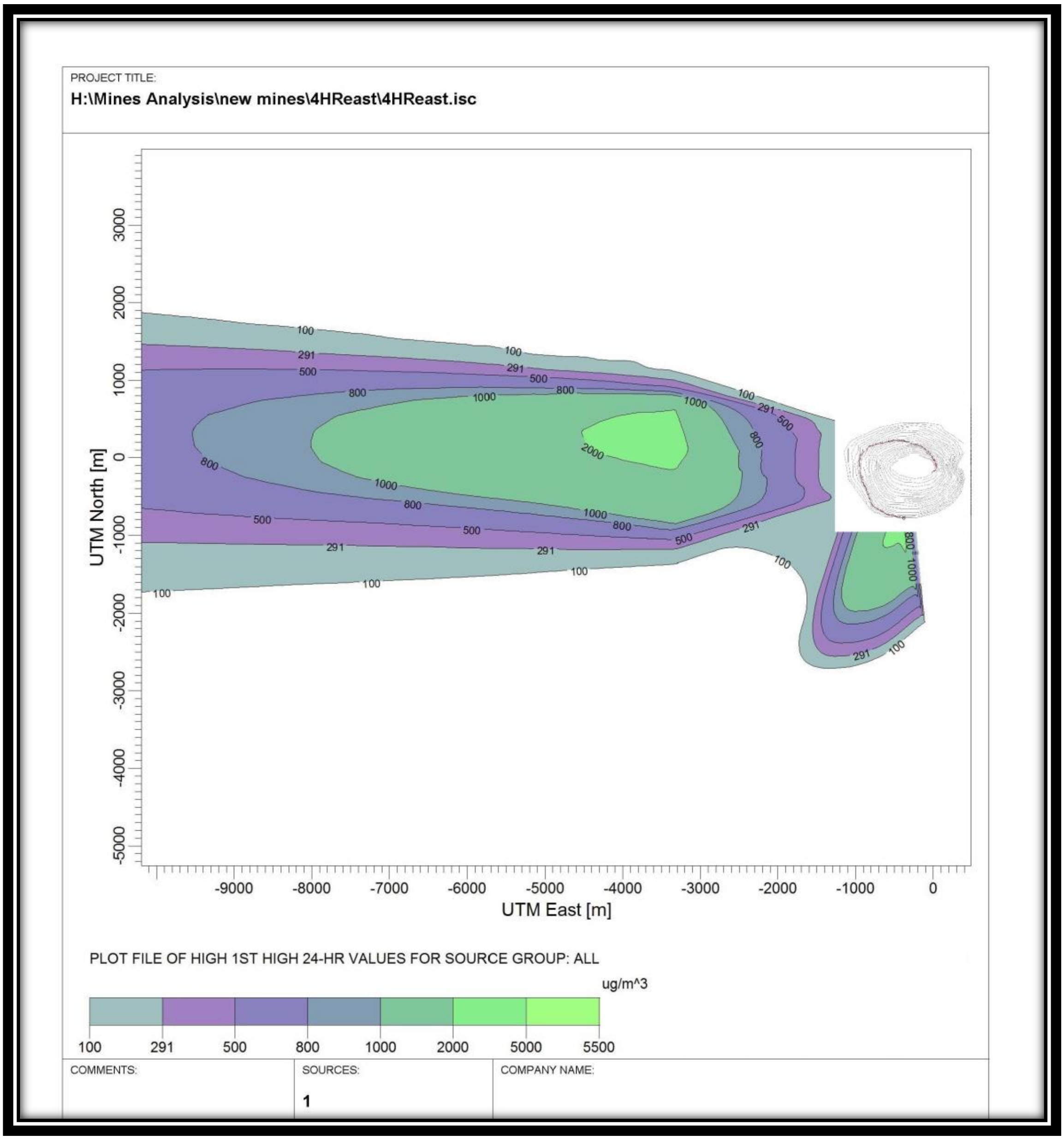

Figure 5.36: Contours of PM_{10} concentrations generated from the haul road at 200 m depth of the mine 'B' with the easterly wind

The length of the haul road was 3279 m at a depth of 200 m. It is obvious from figure 5.36 that the concentration levels of PM_{10} reduced between 1,000 to 5,500 μg/m^3 for the 200 m depth of the mine 'B', up to a distance of 7,500 m from the centre of the mine. These levels had been quite high at the same distance, for the depth of 50 m and 100 m respectively. After this distance up to 10,000 m, these levels suddenly reduced between 100 to 800 μg/m^3. Some contours of the concentration were also visible on the south side of the mine due to interaction of the easterly wind with the upper part of the haul road. It could be seen from the figure 5.33 through 5.36 that when the depth was 150 m, the dust was getting trapped inside the mine which was generated from the lower part of the haul road. The concentration levels of PM_{10} had decreased near as well as far away from the mine boundary. Figure 5.37 shows contours of PM_{10} concentrations generated from the haul road at 250 m depth of the mine 'B' with the easterly wind.

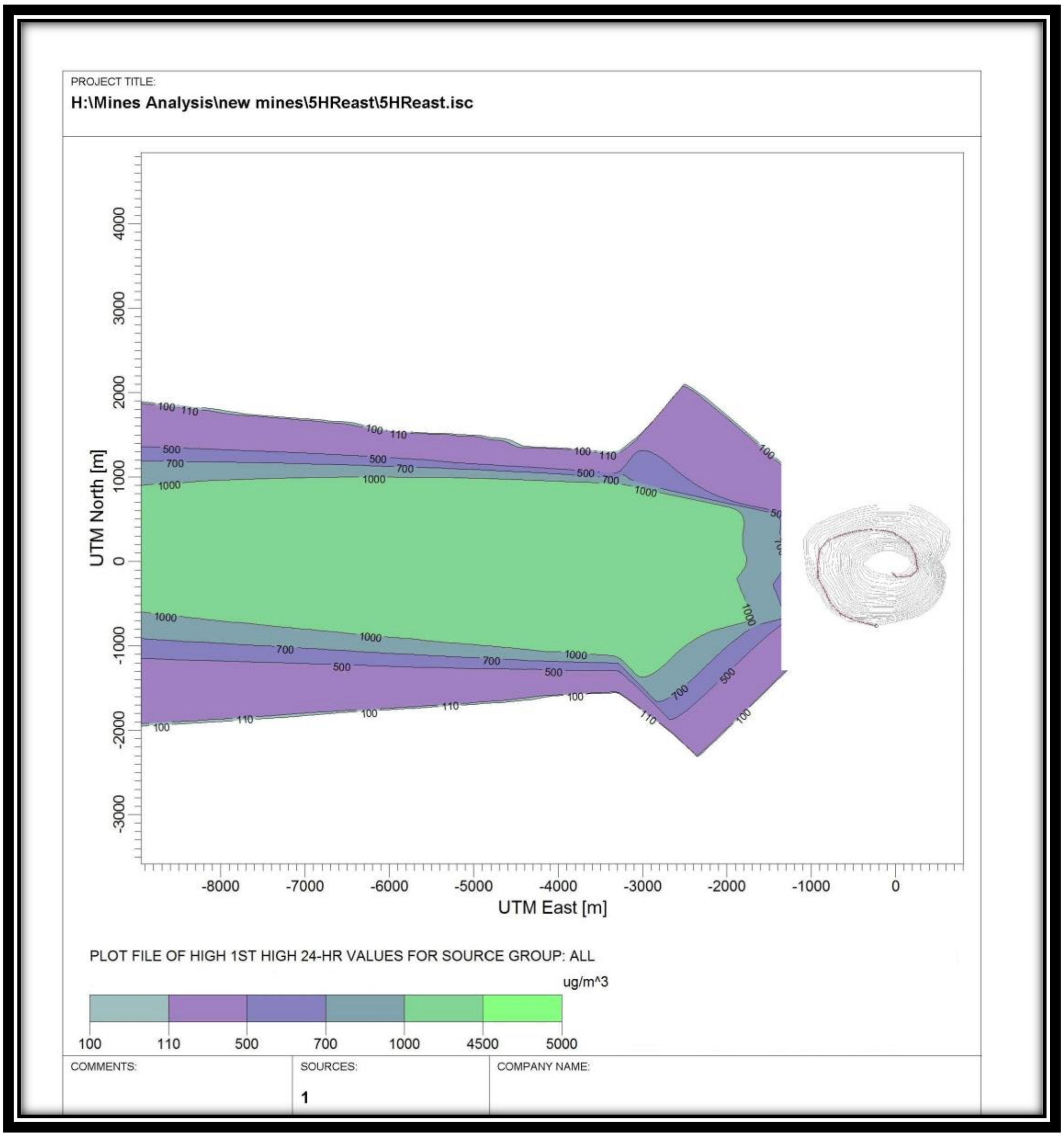

Figure 5.37: Contours of PM_{10} concentrations generated from the haul road at 250 m depth of the mine 'B' with the easterly wind

The haul road of a length 4173 m was at a depth of 250 m. The estimated PM_{10} concentration levels from the haul roads were of the range of 100 to 5,000 µg/m^3 outside the mine as shown in the figure 5.37. The concentration levels of 100 to 1,000 µg/m^3 were spread over the 10,000 m. These can be managed by providing a barricading of trees at the mine boundary itself for mitigating its ill - effects.

PM_{10} concentration levels had increased up to a depth of 100 m but after this depth the concentration of PM_{10} decreased due to lesser air circulation at the deeper part of the mine. This was due to wind direction. As wind was easterly in nature and haul roads were at the west side of the mine, PM_{10} emission could not be trapped inside the mine due to minimum availability of the area inside the mine. Although dust emission rate from haul road is high but area exposed at the top for the dust erosion was less in comparison to internal overburden dump.

5.3.2 Dust dispersion due to the haul road with the varying depth and the westerly wind

Haul road had been observed in the western part of mine 'B' similar to previous case. The direction of the wind was observed to be westerly for all the five depth variations. This had been done in this way to observe that the haul road was on eastern part and wind remained easterly in nature. The length of haul road was 917 m at a depth of 50 m. Figure 5.38 shows the variations in PM_{10} concentrations outside the mine boundary for this depth. X and Y axes represent distances in X and Y direction from the centre of the mine 'B'.

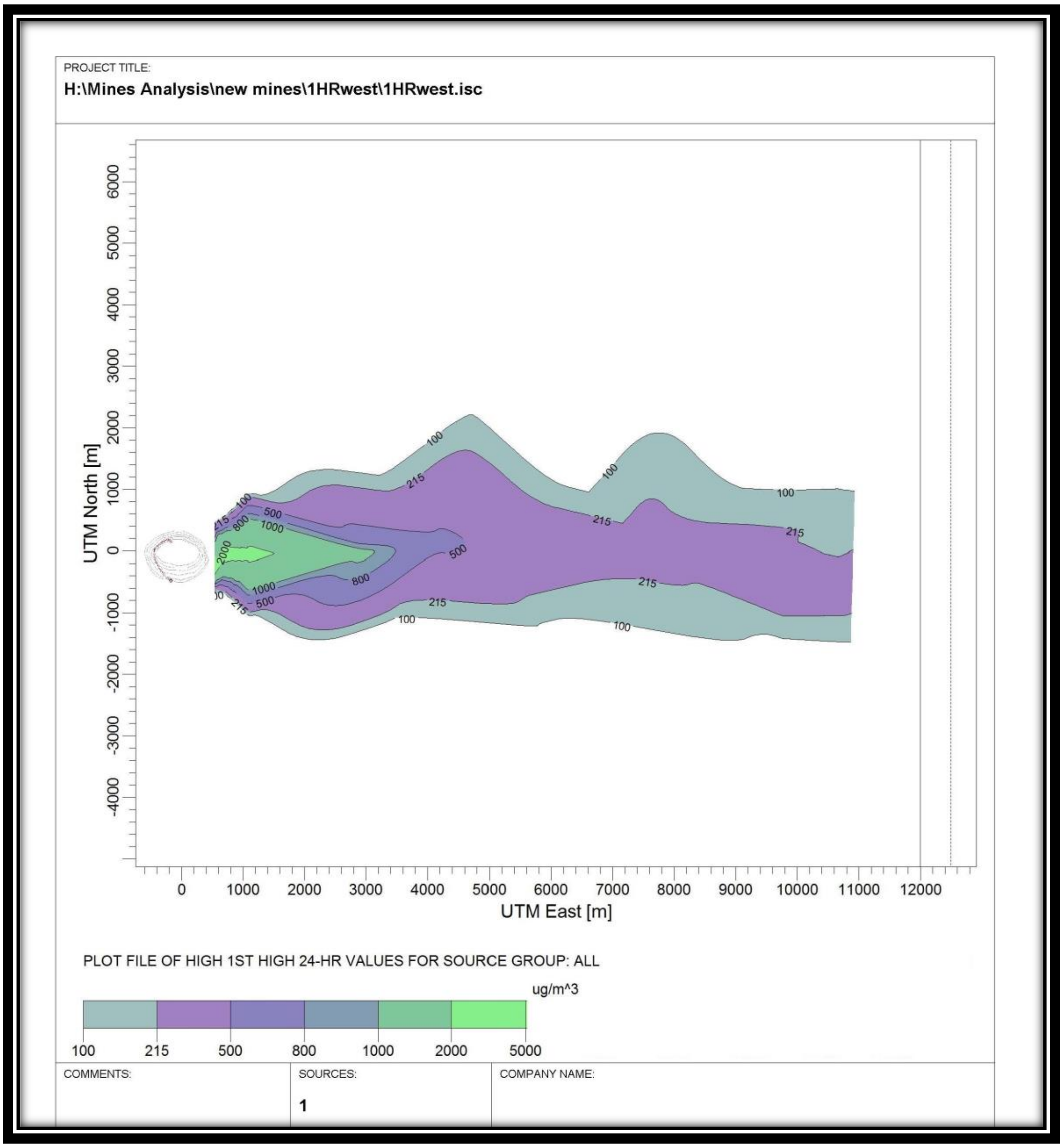

Figure 5.38: Contours of PM_{10} concentrations generated from the haul road at 50 m depth of the mine 'B' with the westerly wind

It is clear from the figure 5.38 that the maximum concentration obtained during the case when the depth was 50 m was 5,000 $\mu g/m^3$. This concentration was for a very small area of nearly 0.5 km^2 near the mine boundary. It may be noted that these concentrations are almost lethal. It is advisable that effective remedial measures were to be taken for mitigating it. As one moves away from the mine boundary, it may be noted that the concentration of the PM_{10} dropped to 1,000 $\mu g/m^3$ at the distance of 3,500 m and it reduced to 800 µg/m^3 at a distance of 4,000 m from the centre of the mine. After this distance, the concentration levels of PM_{10} ranged from 100 to 500 µg/m^3 levels which were near the threshold values of it. These levels could be seen up to a distance of 11,000 m from the centre of the mine. Figure 5.39 shows the contours of the PM_{10} concentrations generated from the haul road at the 100 m depth of the mine 'B' with the westerly wind.

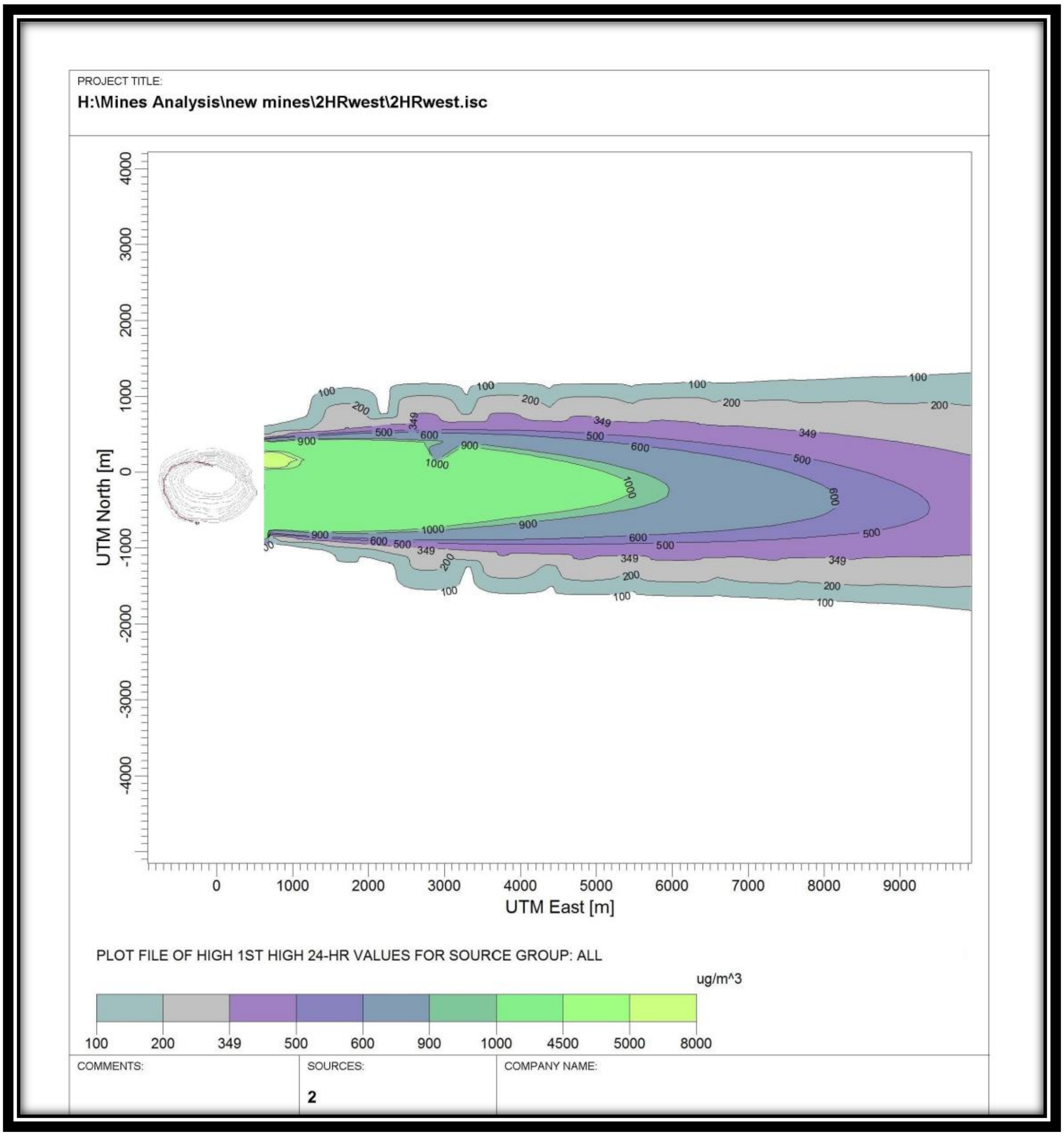

Figure 5.39: Contours of PM_{10} concentrations generated from the haul road at 100 m depth of the mine 'B' with the westerly wind

The haul road length was 1604 m at a depth of 100 m. In can be observed from figure 5.39 that higher levels of the concentration of a range of 1,000 to 8,000 µg/m^3. The concentration levels of 8,000 µg/m^3 was restricted up to a distance of

1,500 m from the centre of the mine 'B'. The concentration levels of 1,000 µg/m^3 was restricted up to a distance of 3,800 m. These levels ranged from 100 to 300 µg/m^3 after this distance till 10,000 m. Very serious preventive measures were required up to a distance of 3,000 m from the centre of the mine 'B' for the depth of 100 m. Figure 5.40 shows the contours of the PM_{10} concentrations generated from the haul road at 150 m depth of the mine 'B' with the westerly wind.

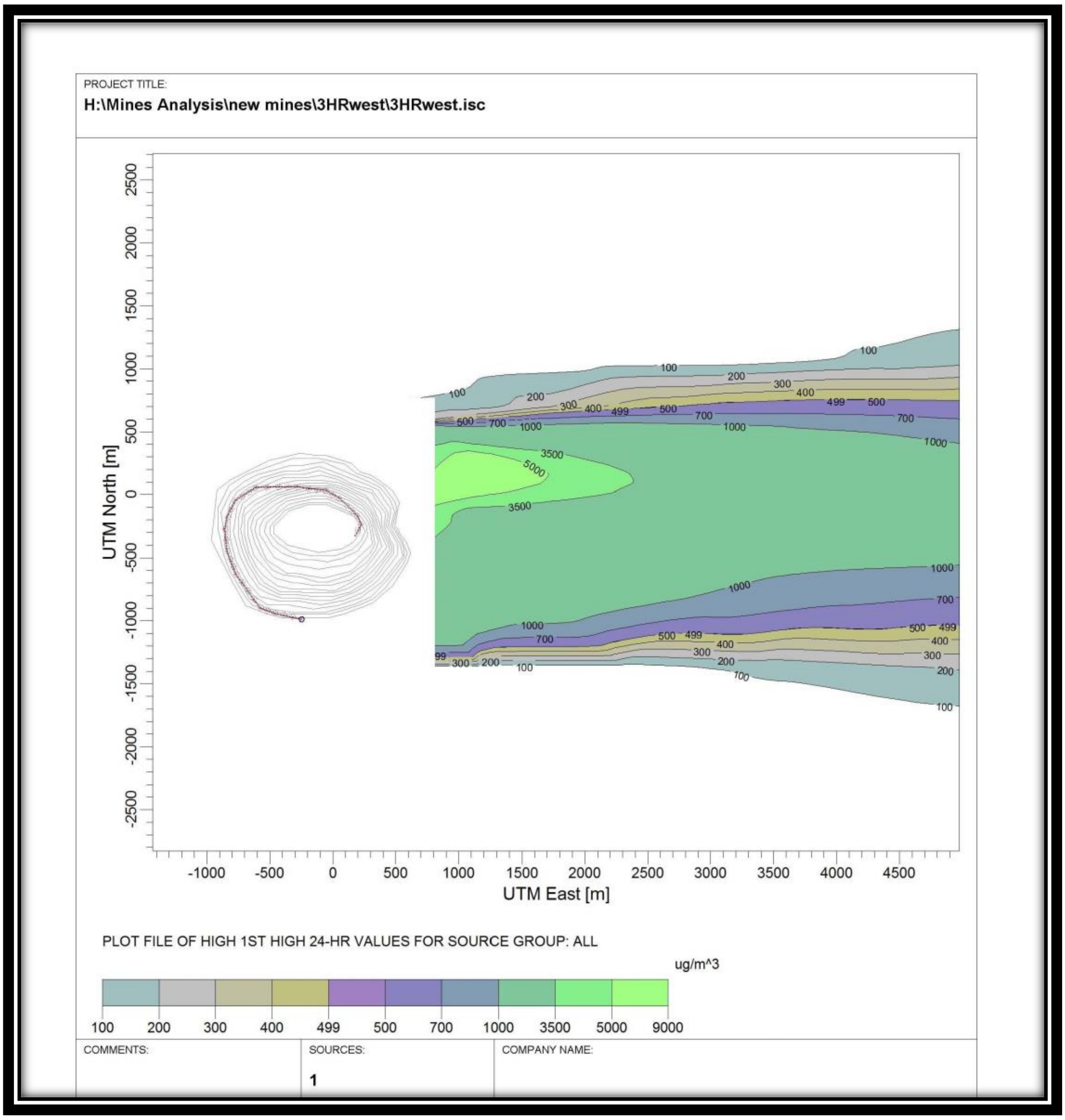

Figure 5.40: Contours of PM_{10} concentrations generated from the haul road at 150 m depth of the mine 'B' with the westerly wind

The haul road length was 2543 m at depth of 150 m. It is obvious from figure 5.40 that the concentration levels of the PM_{10} ranged from 1,000 to 9,000 µg/m^3 for 150 m depth of mine 'B' up to a distance of 1,700 m, from the centre of the mine. These levels spread over a large area for the depth of 50 m and 100 m, respectively. After this distance up to 11,000 m, these levels reduced suddenly to range from 100 to

700 µg/m^3. It could be seen from the figure 5.38 through 5.40 that as the depth reaches 150 m, the dust starts getting trapped inside the mine, which were generated from the lower locations of the haul road. These concentration levels of PM_{10} decreased near as well as far from the mine boundary. Figure 5.41 shows contours of PM_{10} concentrations generated from the haul road at 200 m depth of the mine 'B' with the westerly wind.

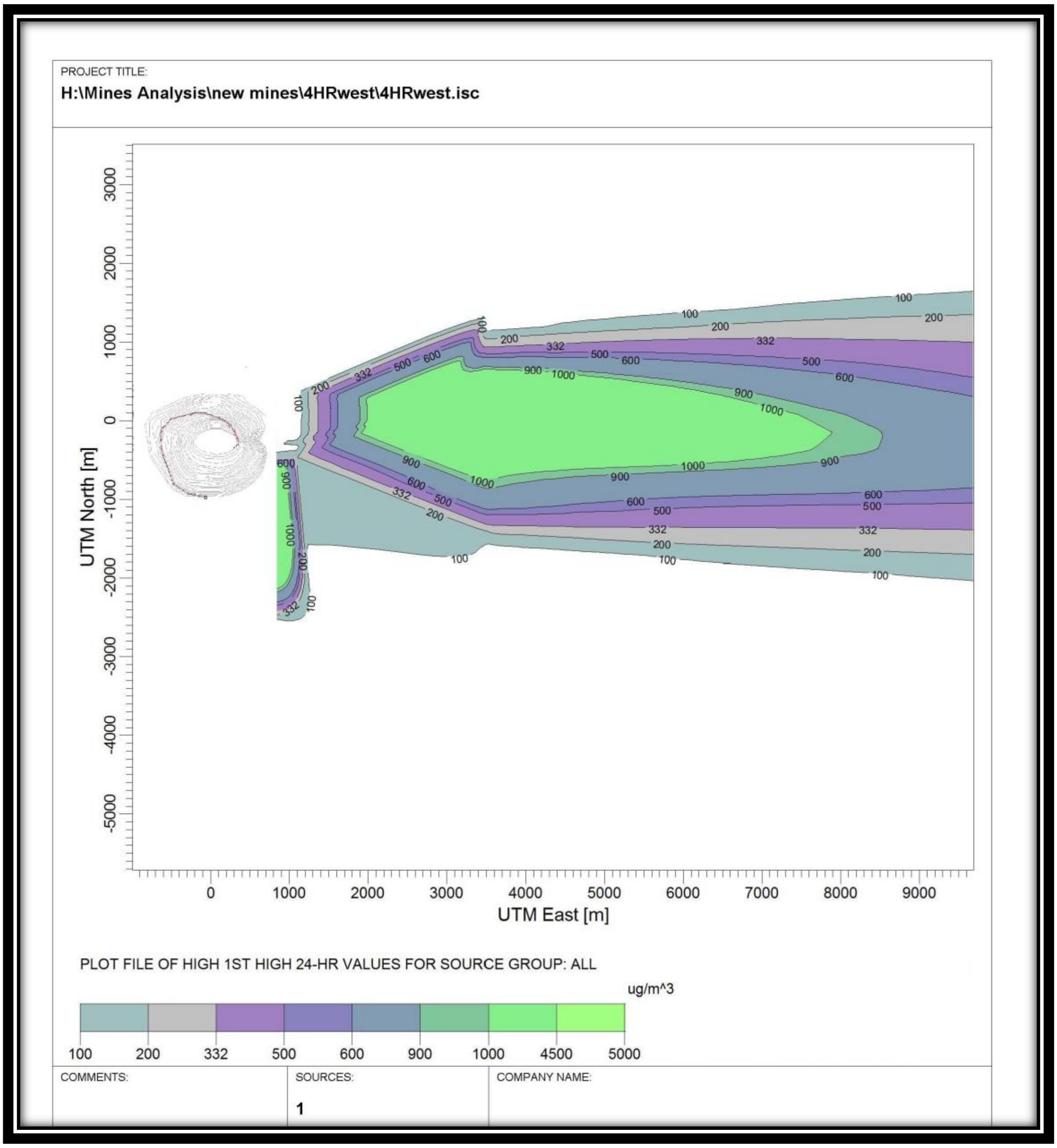

Figure 5.41: Contours of PM_{10} concentrations generated from the haul road at 200 m depth of the mine 'B' with the westerly wind

The haul road had reached to a length of 3279 m when the mine was at a depth of 200 m. It is obvious from figure 5.41 that concentration levels of PM_{10} reduced and ranged from 1,000 to 5,000 µg/m^3 for 200 m depth of the mine 'B', up to a distance of 7,500 m from the centre of the mine. These levels had been quite widely dispersed for the depth of 50 m and 100 m respectively. After this distance, up to 10,000 m, these levels had suddenly flatter and ranged from 100 to 600 µg/m^3. Some contours of concentrations were also visible on the south side of the mine due to the interaction of the westerly wind with the upper section of the haul road. It could be seen from the figure 5.38 through and 5.41 that when the depth reached 150 m, the dust was getting trapped inside the mine (generated from the lower part of the haul road). The concentration levels of PM_{10} had decreased near as well as far away from the mine boundary. Figure 5.42 shows contours of the PM_{10} concentrations generated from the haul road at 250 m depth of the mine 'B' with the westerly wind.

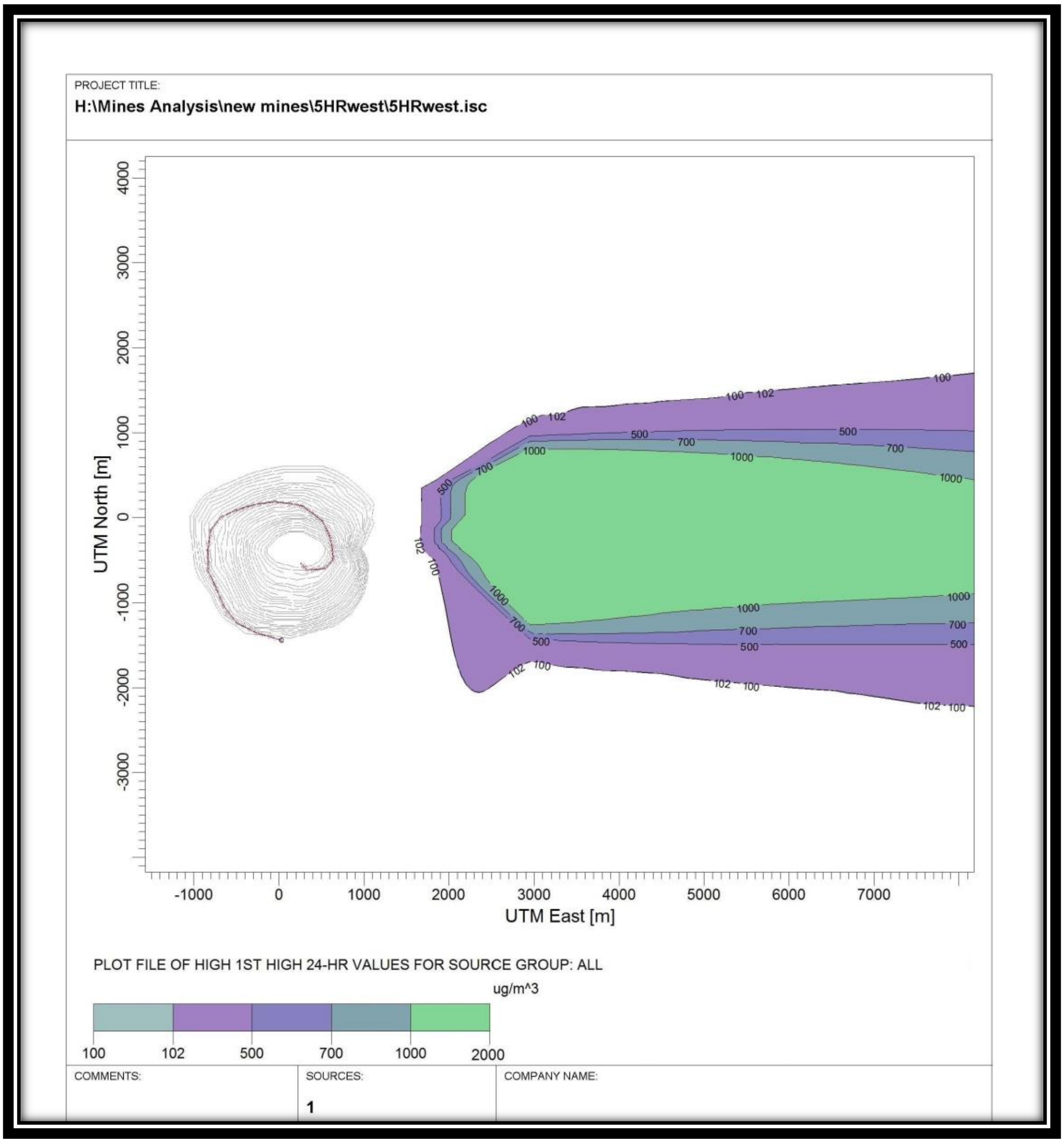

Figure 5.42: Contours of PM_{10} concentration generated from haul road at 250 m depth of mine 'B' with westerly wind

The haul road had reached to a length of 4173 m at a depth of 250 m. The estimated PM_{10} concentration levels from this haul road were at a range of 100 to 2,000 µg/m^3 outside the mine, as shown in the figure 5.42. The concentration levels of 100 to 1,000 µg/m^3 were spread over 9,000 m. These could be managed by providing a barricading of trees at the mine boundary itself.

Overall PM_{10} concentration levels had increased up to a depth of 150 m but for 200 m and 250 m, the overall concentration of PM_{10} decreased due to lesser air circulation at the deeper sections of the mine. Almost all higher level of PM_{10} concentrations were trapped inside the mine. This was due to greater area available in the mine itself for the westerly wind than the easterly wind. Hence, the settlement of the high PM_{10} concentration largely took place inside the mine.

5.3.3 Dust dispersion due to the haul road with the varying depth and the southerly wind

Haul road had been located in the western part of the mine 'B'. The direction of the wind being observed was westerly for five depth variations under consideration. The haul road length was 917 m at a depth of 50 m. Figure 5.43 shows the variations in PM_{10} concentrations outside the mine boundary for this depth. X and Y axes represented distances in X and Y direction from the centre of the mine 'B'.

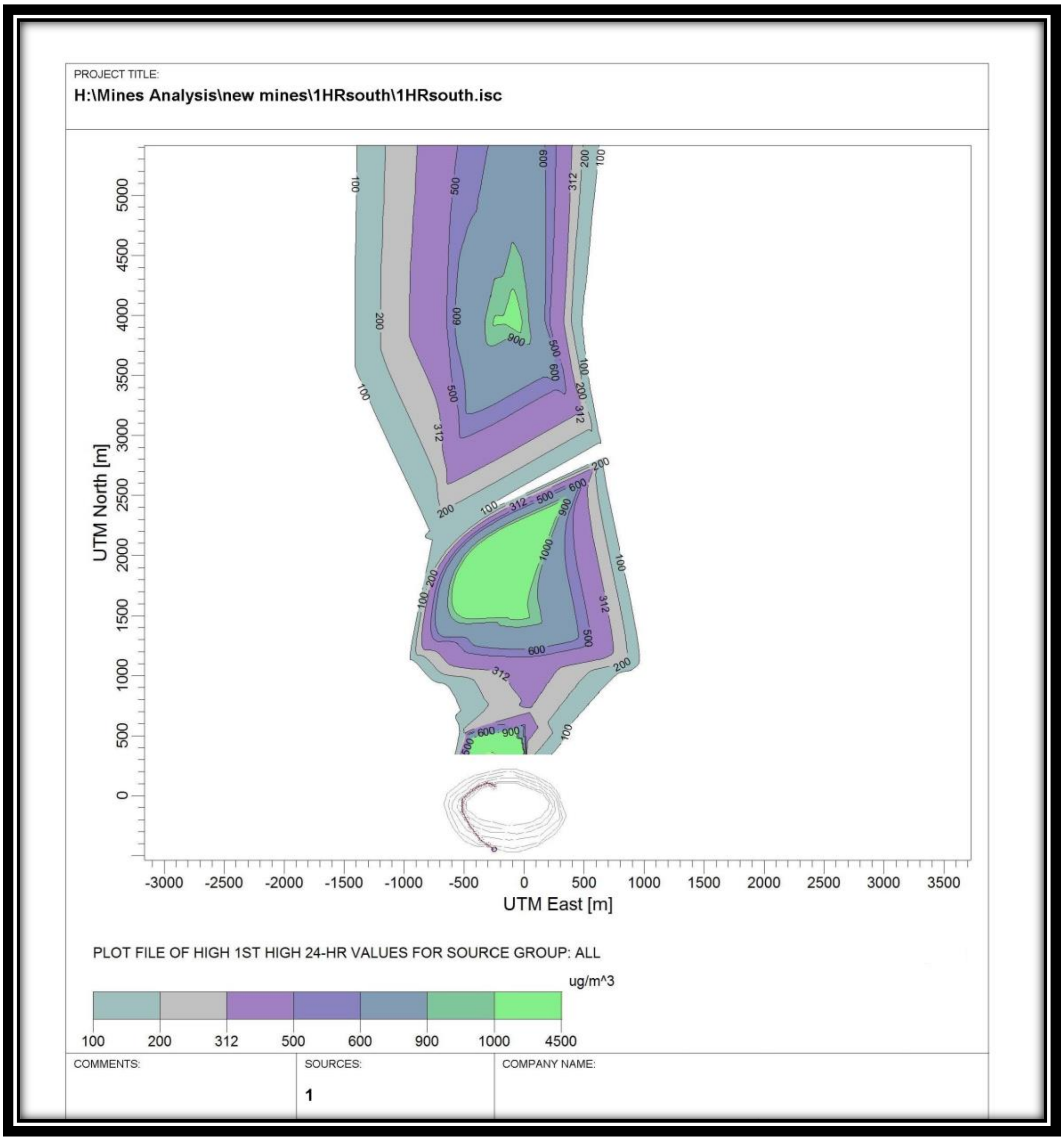

Figure 5.43: Contours of PM_{10} concentrations generated from the haul road at 50 m depth of the mine 'B' with the southerly wind

It has been seen from the figure 5.43 that the maximum concentration obtained during this case was 4,500 µg/m^3. This concentration was for a very small area of nearly 0.25 km^2, near the mine boundary. It may be noted that these concentrations are almost lethal. It is advisable that the effective remedial measures were to be taken for it. On moving away from the mine boundary, the concentration of PM_{10} dropped to 1,000 µg/m^3 at the distance of 2,500 m and it reduced to 900 µg/m^3 at a distance of 4,500 m from the centre of the mine. After this distance the concentration levels of PM_{10} lowered and ranged from 100 to 500 µg/m^3 levels. These were near the threshold values of it. These levels could be seen up to a distance of 11,000 m from the centre of the mine. Figure 5.44 shows contours of PM_{10} concentrations generated from the haul road at 100 m depth of the mine 'B' with the southerly wind.

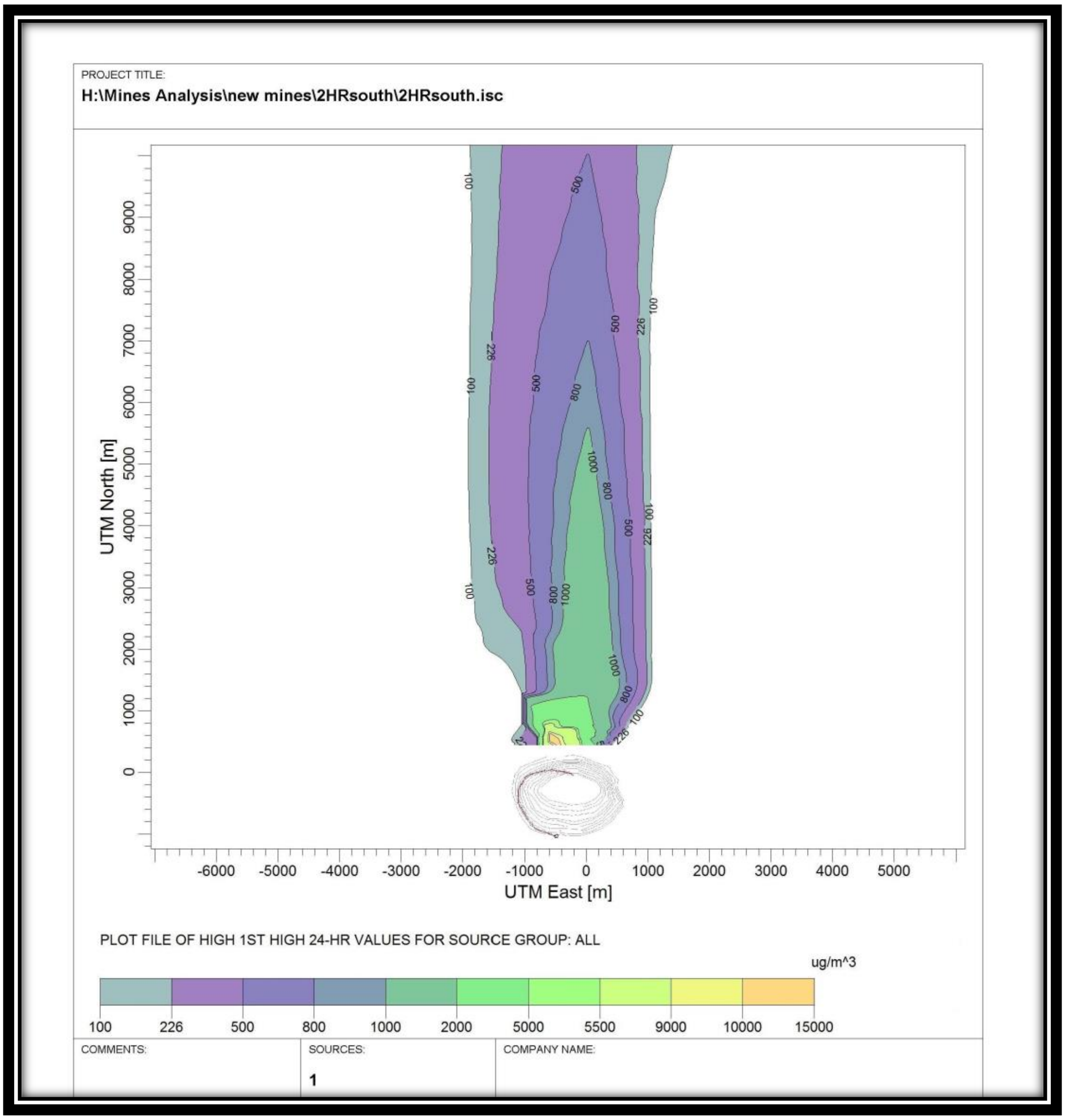

Figure 5.44: Contours of PM_{10} concentrations generated from the haul road at 100 m depth of the mine 'B' with the southerly wind

The haul road had reached to a length of 1,604 m at a depth of 100 m. It was depicted from the figure 5.44 that the high level of concentration was ranging from 1,000 to 15,000 $\mu g/m^3$. The concentration levels of 15,000 $\mu g/m^3$ were restricted up to a distance of 800 m from the centre of the mine ‘B’. The concentration levels of 1,000 $\mu g/m^3$ was found up to a distance of 5,800 m. These had come down from 100 to 300 $\mu g/m^3$ levels after this distance till 10,000 m. Figure 5.45 shows the contours of PM_{10} concentrations generated from the haul road at the 150 m depth of the mine ‘B’ with the southerly wind.

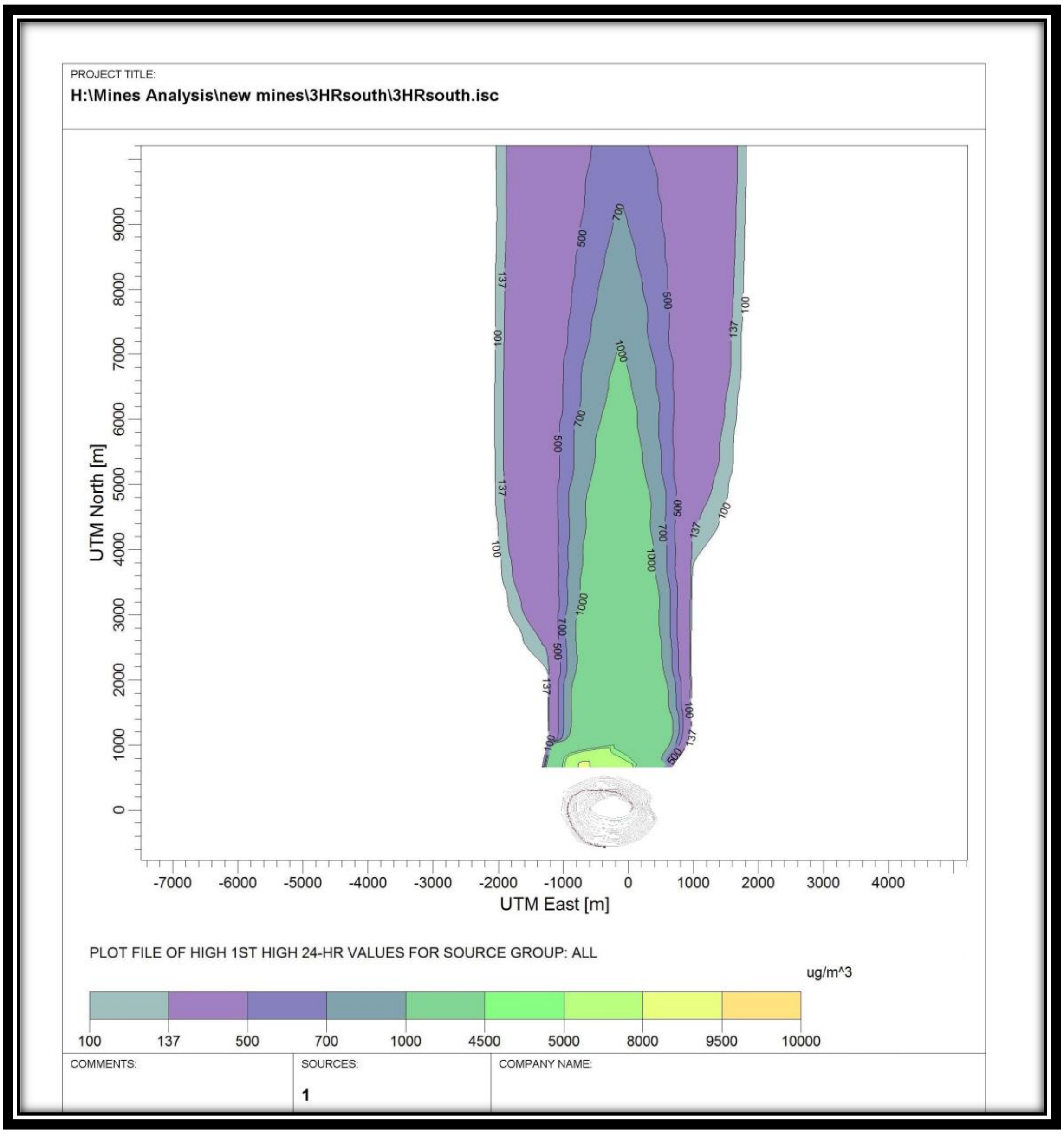

Figure 5.45: Contours of PM_{10} concentrations generated from the haul road at 150 m depth of the mine ‘B’ with the southerly wind

The haul road length has reached to 2543 m at the depth of 150 m. It is observed from the figure 5.45 that the concentration levels of the PM_{10} had ranged from 1,000 to 10,000 µg/m^3 for 150 m depth of the mine 'B' up to a distance of 1,000 m, from the centre of the mine. These levels had been spread over the large area at the depths of 50 m and 100 m respectively. From this distance up to 11,000 m, these levels had suddenly ranged from 100 to 500 µg/m^3. It could be seen from figure 5.43, 5.44 and 5.45 that when the depth reached 150 m, the dust was getting trapped inside the mine (generated from the lower sections of the haul road). These concentration levels of the PM_{10} decreased near as well as far, away from the mine boundary. Figure 5.46 shows the contours of the PM_{10} concentrations, generated from the haul road at 200 m depth of the mine 'B' with the southerly wind.

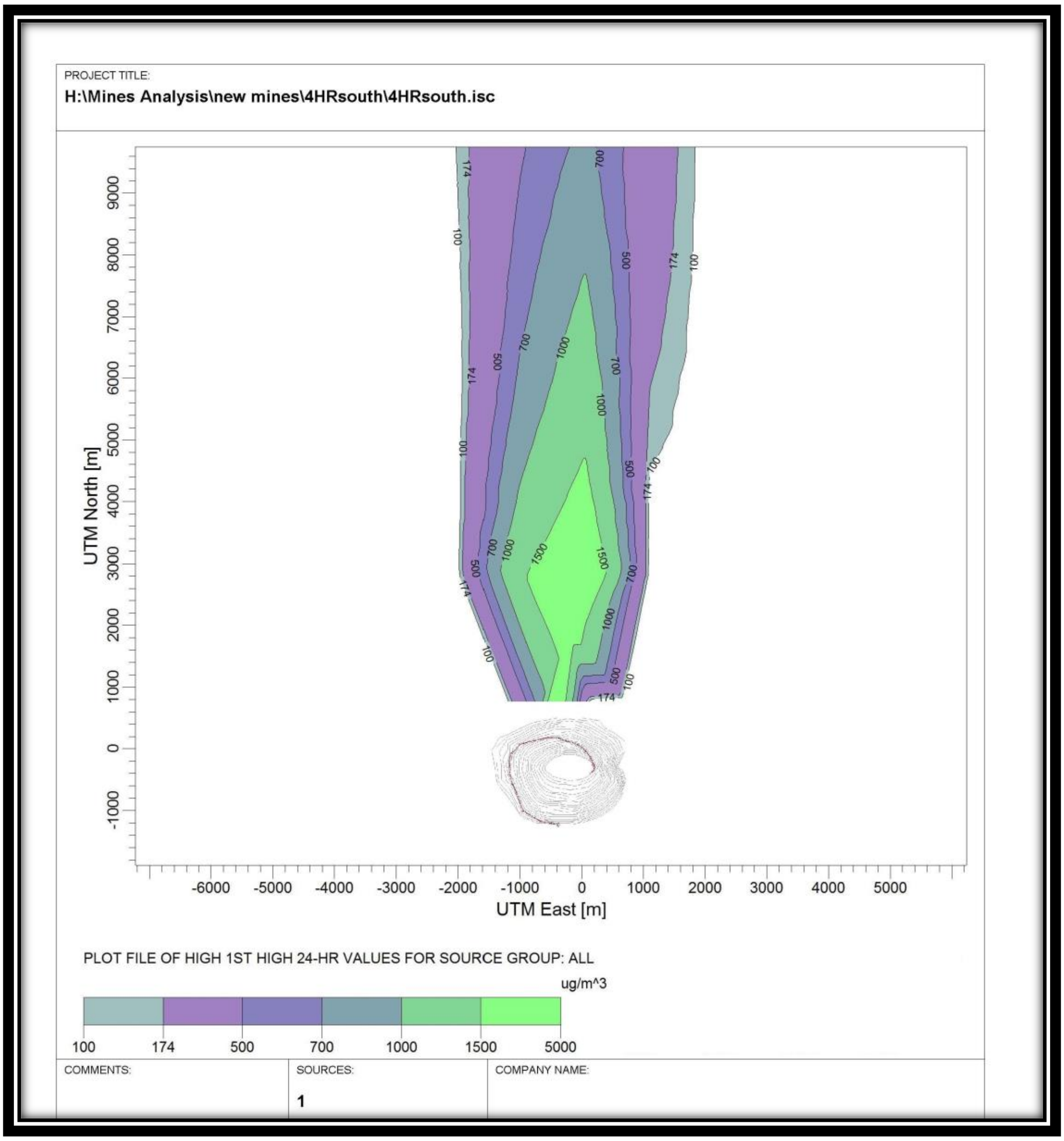

Figure 5.46: Contours of PM_{10} concentrations generated from the haul road at 200 m depth of the mine 'B' with the southerly wind

The haul road was reached to a length of 3279 m at a depth of 200 m. It is evident from figure 5.46 that the concentration levels of PM_{10} had ranged from 1,000 to 5,000 µg/m^3 for the 200 m depth of the mine 'B' up to a distance of 5,000 m from the centre of the mine. These levels had been quite widely dispersed for the depths of 50 m and 100 m respectively. After this distance up to 10,000 m, these levels had suddenly reduced between 100 to 500 µg/m^3. It could be seen from the figure 5.43 through 5.46 that at 150 m depth, the dust was getting trapped inside the mine (generated from the lower part of the haul road). The concentration levels of PM_{10} had been decreased, near as well as far away from the mine boundary. Figure 5.47 shows the contours of the PM_{10} concentrations generated from the haul road at 250 m depth of the mine 'B' with the southerly wind.

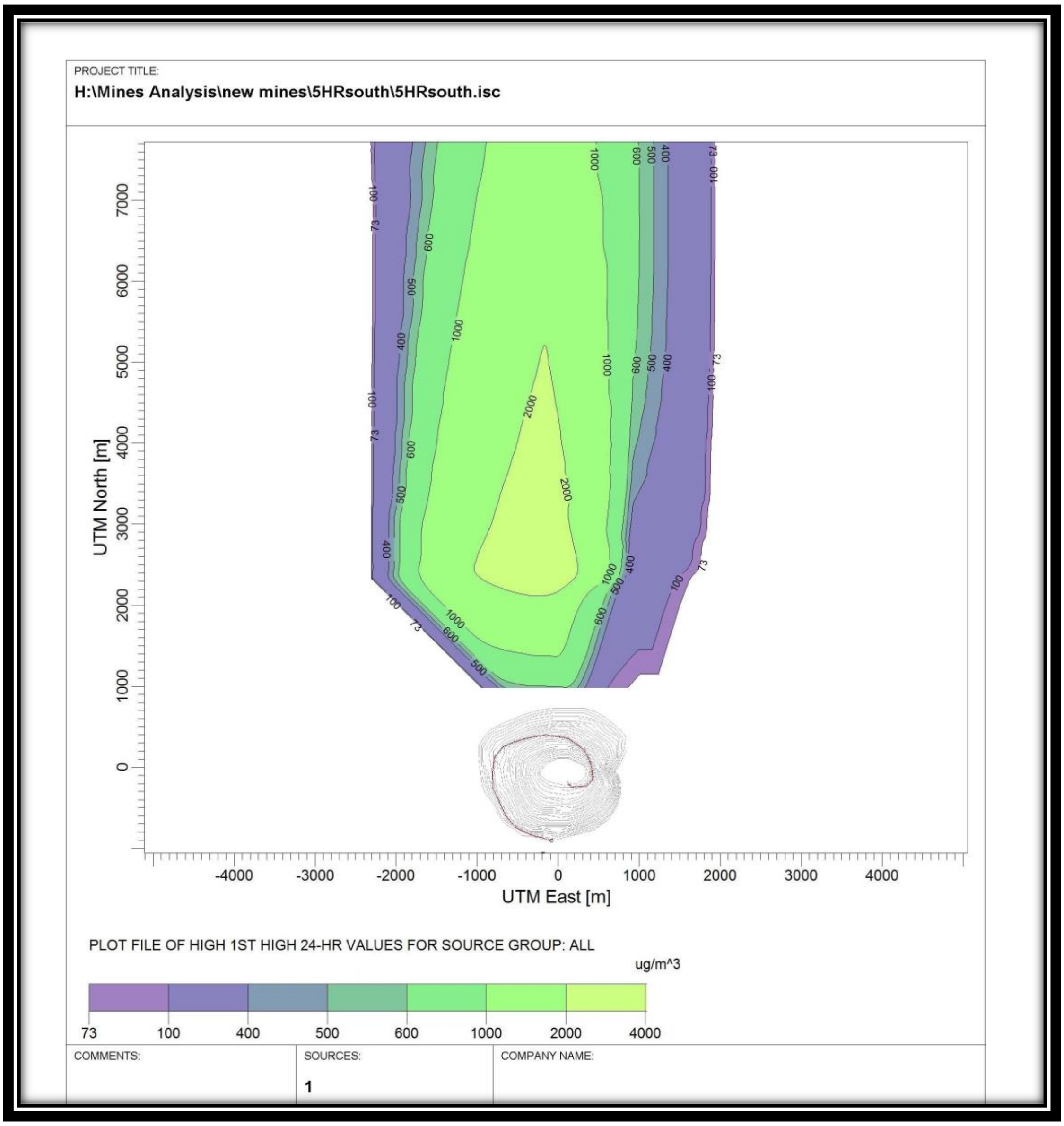

Figure 5.47: Contours of PM_{10} concentrations generated from the haul road at 250 m depth of the mine 'B' with the southerly wind

The haul road had reached to a length of 4173 when mine was at 250 m depth. The estimated PM_{10} concentration levels from this haul road were of the range of 100 to 4,000 µg/m^3 outside the mine as shown in the figure 5.47. These levels of concentrations were visible up to a distance of 5,000 m. The concentration levels from 73 to 1,000 µg/m^3 were spread over 9,000 m. These could be managed by providing a barricading of trees at the mine boundary itself.

PM_{10} concentration levels had increased up to 150 m depth of the mine 'B'. This was due the extension of the haul road from the south and going deeper at the northern boundary of the mine. Further, the wind was southerly in nature. Due to all this the haul road interactions with the wind had decreased as the depth increased. This further reduced the PM_{10} dispersion from the haul road. Although there was some interaction between the wind and the haul road but due to availability of the larger area inside the mine, the higher level of PM_{10} emission was trapped within the mine.

Figure 5.48 shows the comparative variations of the maximum dust concentration generated from the different lengths of the haul roads at different depth of the mine 'B' with the different wind directions.

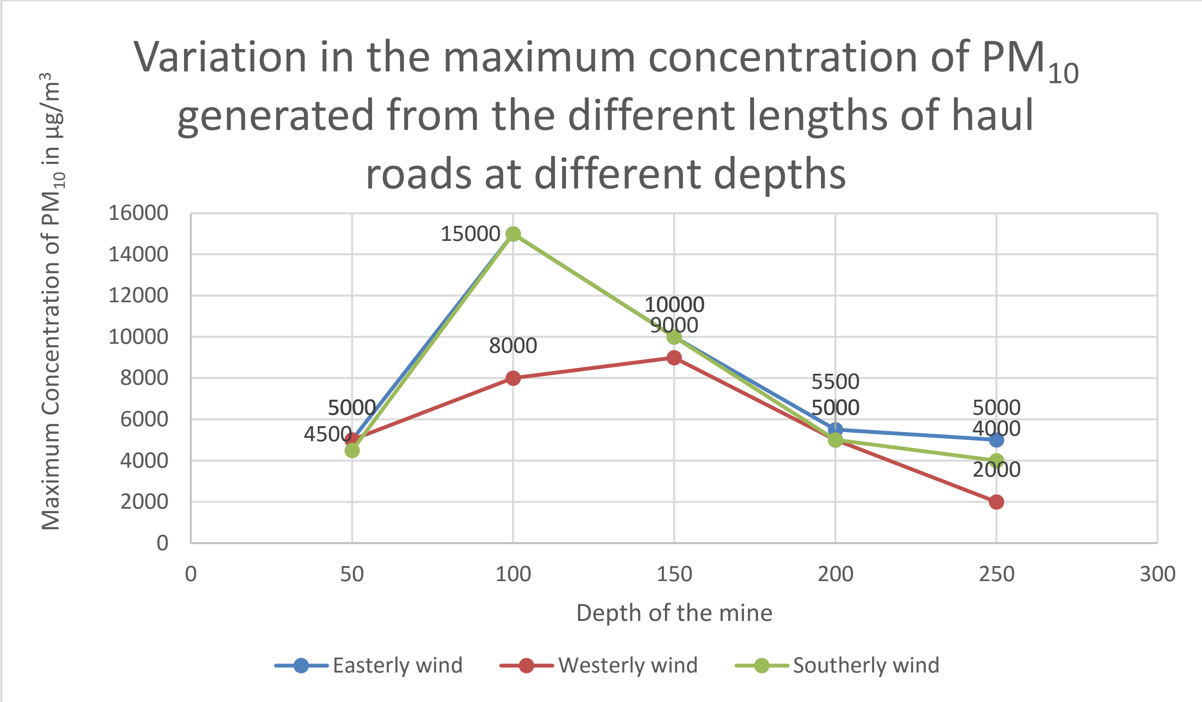

Figure 5.48: Comparative variations of the maximum dust concentration generated from the haul roads at the different depth of the mine 'B' with the different wind directions

The haul roads were located on the west side of the mine. The wind directions were easterly and westerly in nature, then the dust concentration levels were increased up to 100 m depth and thereafter decreased with the subsequent deepening of the mine. The decrease in the concentration was more with the westerly than the easterly wind. Further, these levels reduced for the depths of 200 m and 250 m, significantly. When the wind direction was southerly, the interaction of the wind with the haul road was vertical. In this condition, the estimated PM_{10} levels were higher outside the mine, up to a depth of 150 m. Further, these levels reduced significantly beyond depth of 150 m. It may also be inferred when the wind direction is against the location of the haul road, the dust concentrations were the highest outside the mine for all the depths of the mine, whereas these levels were less for the condition when the wind direction was along or vertical to the location of the haul road.