

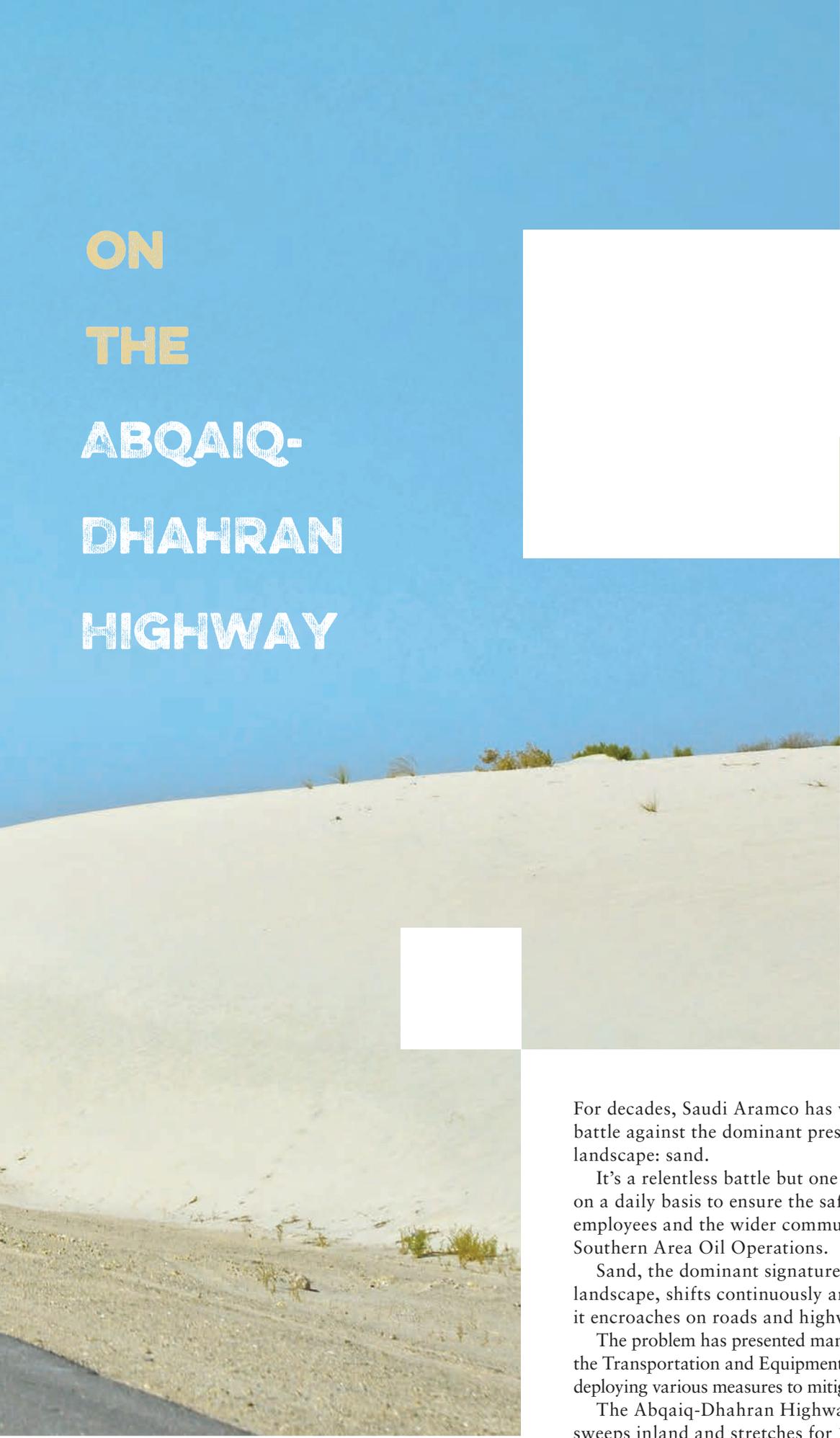
GOING
AGAINST

THE

GRAIN



A sand dune seen along the highway as it starts encroaching on the highway.



**ON
THE
ABQAIQ-
DHAHRAN
HIGHWAY**

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For decades, Saudi Aramco has waged a largely unnoticed battle against the dominant presence on the Saudi Arabian landscape: sand.

It's a relentless battle but one that has to be maintained on a daily basis to ensure the safety of Saudi Aramco's employees and the wider communities of the company's Southern Area Oil Operations.

Sand, the dominant signature of the Saudi Arabian landscape, shifts continuously and as nature takes its course, it encroaches on roads and highways.

The problem has presented many challenges for decades, and the Transportation and Equipment Services Department has been deploying various measures to mitigate sand enveloping highways.

The Abqaiq-Dhahran Highway, also known as Route 615, sweeps inland and stretches for 109 kilometers (km). The



road is busy day and night due to the sheer scale of oil and gas operations in the Southern Area of the Eastern Province. Tons of equipment are transported along the route every day, as well as an army of human manpower.

Busy roads are inherently dangerous, but added to this the fact, they can disappear under sand in inclement weather conditions.

Among the areas most affected and vulnerable are stretches of roads servicing both Saudi Aramco and local communities in the Southern Area. Dealing with the encroaching sand drift and sand dune migration amounts to something of a science.

Large scale sand movement can be classified into two types of hazards. Sand may drift as individual grains through the winds' action across sand sheets or inter-dune areas, or it may migrate in bulk in dune form.

The bulk of sand movement takes place close to the ground and understanding how sand is transported is the key to controlling it.

Sand movement consists of three modes behavior:

- Surface creep, in which the sand grains roll or slide along the ground.
- Saltation, discontinuous movement in which the sand grains are briefly lifted and then re-deposited.
- Suspension, in which the sand grains are transported for long distances by the wind.

Sand control techniques are deployed to either reduce the volume of wind-blown sand arriving at a specific location or to prevent sand buildup by facilitating the free movement of sand through the area.

The planting of vegetation along highways has helped the company in its continuous battle with keeping sand from drifting on company maintained roads, which can be a significant hazard on roads and highways Kingdomwide.



Some techniques can be used to accomplish either goal. For example, surface stabilization can prevent the erosion of loose sand from a dune or sand sheet, and additionally, it can enhance sand transport through the area by creating a smooth surface over which moving particles can maintain their momentum.

There are three main tactics that can be deployed to battle encroaching sand.

- The first focuses on the strategic design and siting of facilities before they are built, keeping sand movement in mind. Saudi Aramco employs established best practices in its deployment of sand control methods, starting with

the design, right through to the construction of facilities. The type of facility requiring protection will help to determine the overall approach. For example, some sites, such as airports, may not be able to tolerate even low

volumes of sand flux, so only those techniques that can limit sand flow into the area will be effective.

- Sand fences are a second option. The idea of a “sand fence” is to reduce the wind speed as it passes through the fence, thereby causing the wind to deposit the sand load around the fence. The latest geogrid technology is currently being used by Saudi Aramco. The fencing material can include a high density polyethylene mesh material with holes distributed to provide a 50% porosity to maximize sand deposit volume.
- The third option is surface stabilization through the planting of vegetation. This is regarded as the most desirable and the only permanent sand control system and involves the application of biological science. There are various considerations that help determine the choice of suitable vegetation, including the quantity and quality of available

water, the percentage of salts in the soil, wind speed and direction and the root system of the plant. The plants and trees that perform best are *Conocarpus*, *Tamarix aphylla*, *Acacia*, *Salvadora* (Toothbrush Tree), *Prosopis* and *Penisetum*. These species are hardy, have good foliage cover, are of varying heights and can flourish even in the exacting conditions of the arid desert climate. They represent the most effective barrier to the ever shifting sands.

An additional element in Saudi Aramco’s armory to push back the movement of sand is the constant manual sand control measures carried out on a daily basis by contractors operating on results driven agreements.

Saleh Al Abdulgader of the Transportation and Equipment Services Department explains that the Saudi Aramco strategy involves a combination of all of the above.

“The history of sand control in the areas where Saudi Aramco operates started when asphalt roads were first constructed by the company in the early 1950s. Back then, sand dunes were removed outside the road limits on an emergency basis,” Abdulgader says.

“Techniques have evolved over the years until we started using the current systems for checking sand,” adds Al Abdulgader. “All efforts to keep sands off the roads and highways involve a variety of jobs and techniques that are both short-term and long-term solutions.

“The three main phases are sand fencing, sand removal and sand stabilization. Essentially, we are fighting shifting nature.”

The latter, sand stabilization — the long-term and preferred solution — is visible 25 to 30 meters from the

THE COMPANY EMPLOYS

THREE MAIN PREVENTATIVE TACTICS TO ADDRESS ENCROACHING SAND, INCLUDE THE STRATEGIC PLACEMENT OF NEW FACILITIES AT AREAS OF LESSER IMPACT; THE DEPLOYMENT OF SAND FENCES ALONG VULNERABLE STRETCHES OF ROAD; AND THE PLANTING OF VEGETATION TO STABILIZE THE SURFACE AREA NEAR HIGHWAYS AND ROADS.

A BRIEF HISTORY OF SAUDI ARAMCO'S EFFORTS TO EFFECTIVELY MANAGE SAND



THE 1950s AND 1960s:

- When asphalt roads were constructed by the company in the early 1950s, sand dunes were removed outside road limits on an emergency basis until the company's Maintenance Department took charge of sand removal through the deployment of the company's own equipment and operators.

THE 1970s:

- When the Roads Division was established in the late 1970s, it took charge of the sand removal activities of Saudi Aramco's roads through the division's equipment and operators.
- Front-end loaders, bulldozers and dump trucks were the main items of equipment used to remove sand from asphalt roads.

THE 1980s AND 1990s:

- Early use of sand stabilization techniques beside roads included using crude oil, a tactic commonly deployed in the early 1980s.
- Fences made up of wooden slats fabricated in the company's carpentry shops were used to control sand movement during the mid-1980s.
- By the late 1980s, contractors were hired to handle sand control activities.
- Sand was removed from asphalt surfaces on an emergency basis and from roadsides on a regular basis through the use of heavy equipment.

THE 2000s TO THE PRESENT DAY:

- A new type of sand fence using geogrid membranes has significantly improved results and is currently used in the place of wood slats.
- Performance-based contracts are now in place as part of a long-term solution to control sand on Saudi Aramco roads in the Southern Area.
- Plantations of carefully chosen tree species along the sides of highways are now viewed as the most effective long-term solution to sand encroachment.

Opposite far right: Part of the team that tackled the challenging task of restricting sand movement on area highways include, from left, Ali Al Ismail, roads construction engineer; Rashid Al Hajri, roads supervising inspector; Khaleel Al Ibrahim, roads construction engineer (PDP); Saleh Al Abdulgader, supervisor of the Southern Area Roads Engineering Unit; Abdulrahman Al Mulhim, Abqaiq Area Roads lead engineer; and Khalid Al Hajri, roads inspector. Opposite right: The first tactic to battle encroaching sand is to build facilities in areas that won't be impacted by blowing and drifting sand. Below: A key tool in the fight to restrict blowing and drifting sand is the erection of a sand fence, which helps reduce wind speeds.



roadsides. Vegetation, the planting of scientifically chosen plants and trees, is the most desirable and the most enduring tactic. Five rows of three types of trees are being planted along a 30 km stretch of the Abqaiq-Dhahran Highway.

Agriculturist Abdulla Alnaimi is in the business of identifying the best trees and plants to do the job.

"Preventing sand movement has many techniques," he explains. "From my side, I am responsible for the plantation project — it's the permanent solution for the sand movement — and therefore we wanted to make sure it was going to be a success. Three issues were to be considered. First, choosing the right types of trees that meet the requirements of the sand fence; second, good foliage cover and low water consumption; and the third important consideration is finding them in the market in good shape and condition."

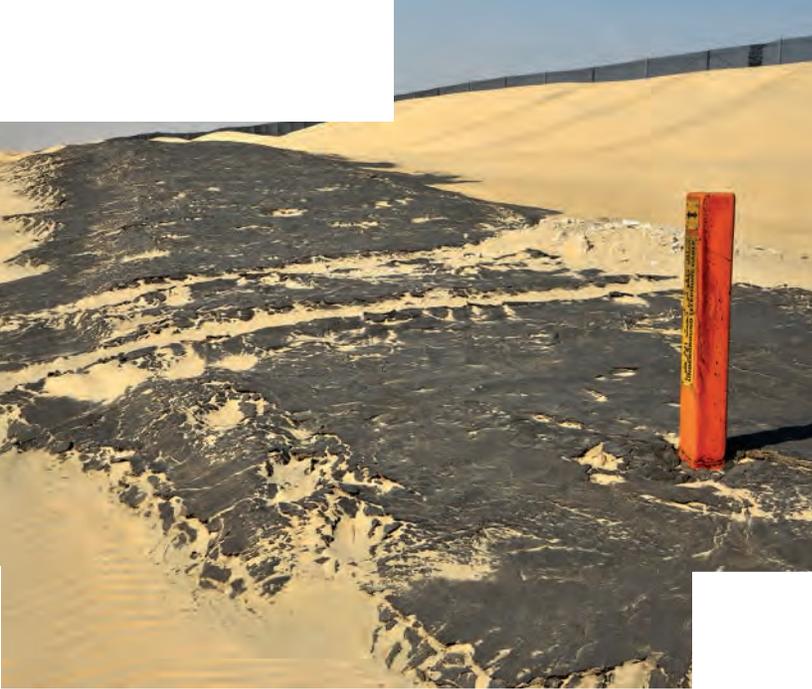
Providing water for the plantation requires a lot of innovation and effort, Alnaimi says.

"To feed 28 km of five rows of trees required a lot of work, especially with regards to the excavation of wells in sandy areas. It was a lot of work to construct road access points and platforms for the rigs to enable effective well excavation.

"Maintaining the plants for the first few months until they starting growing in the windy and sandy areas required daily inspections," he says.

The battle against the sand involves the application of detailed planning.





For example, Al Abdulgader adds: “One or two rows of geogrid sand fences should be installed at an appropriate distance from the facility. The first row of fences should be installed approximately 70 meters upwind of the site and should extend a minimum of 25 meters beyond the edges of the site to be protected.

“The second row of fences, if required, should be installed approximately 140 meters upwind of the site and should extend a minimum of 50 meters beyond the edges of the site to be protected. Fences should be aligned perpendicular to the prevailing wind direction. The selection of the number of fence rows depends on the annual drift area. Two rows of fences are recommended in areas with large volumes of annual drift rates.”

Sand management and control in the Southern Area is all about mitigating the adverse and often dangerous effects of nature’s behavior. It’s a relentless battle, but one that Saudi Aramco pursues diligently to help keep its employees and the wider community safe. 🌍



1,300

KM

is the total length of roads subject to sand encroachment in the Southern Area.

3.6

MILLION CUBIC METERS is the quantity of sand removed from beside company roads in 2014 in the Kingdom.

302

KM is the total length of company roads from which sand is removed.

18,600

LINEAR METERS is the length of geogrid type sand fence installed beside company roads.

12,100

LINEAR METERS is the length of geogrid type sand fence installed beside the Abqaiq-Dhahran Highway.

850,000

CUBIC METERS is the quantity of sand removed from beside the Abqaiq-Dhahran Highway in 2014.

46,600

is the number of **TREES PLANTED** beside the Abqaiq-Dhahran Highway.