BHARAT OMAN REFINERIES LIMITED

PROPOSED EXPANSION OF CRUDE OIL STORAGE FACILITIES AT VADINAR, DISTRICT JAMNAGAR, GUJARAT

PRE-FEASIBILITY REPORT

M/s Environn Consulting Services C2S2Consulting Engineers

November 2013

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1. INTRODUCTION

1.1 Bharat Oman Refineries Limited (BORL) is a joint venture set up by Bharat Petroleum Corporation Limited (BPCL) with Oman Oil Company S.A.O.C in 1992, and is operating a 6.0 MMTPA Refinery at Bina in Madhya Pradesh, with a Crude Oil Terminal at Vadinar in the Gulf of Kachchh.

1.2 After obtaining requisite clearances from the Ministry of Environment and Forests in 1995, the Crude Oil Terminal was finally made operational for receiving Very Large Crude Carriers (VLCC) of size 300,000 DWT in 2009, after completion of the refinery at Bina. The Terminal finally became functional in 2010, after the cross-country pipeline and the refinery were completed.

1.3 The facilities at Vadinar consisted of a floating type Single Point Mooring (SPM), where VLCCs could connect up in order to pump crude to the Terminal via a submerged pipeline. The SPM is based on a Catenary Anchor Leg Mooring (CALM) Buoy manufactured by SOFEC, Houston, TX USA. The laying of the buoy and associated appurtenances was carried out under the supervision of the manufacturer.

1.4 The CALM Buoy is located at Lat. 22^{o} 33’ 44’’ N, Long. 69^{o} 45’ 38’’ E, about 7 km offshore from the Vadinar coast. A submerged pipeline conveys the crude oil to the Landfall Point. The onshore section of the pipeline is 6.2 km up to the Crude Oil Tanks.

1.5 The crude oil is pumped from the Crude Oil Tanks through a 943 km long pipeline to Bina, where the refinery is located.

1.6 Wherever there is a change in the mode of transport, such as in the instant case, where the first mode is pumping from the VLCC to the Tank Farm, in a matter of a day or so, and the second, a more or less continuous pumping from Vadinar to Bina, a storage capacity is necessary in order to manage the differing rates of transport in the two components of the system.

1.7 BORL had constructed 8 Crude Oil tanks each of capacity 60,000 m^3 in 2009. The experience of the last three years has revealed that in order to utilize the capacity of the existing system to an optimum level, it would be necessary to augment the capacity of the Crude Oil Tanks, increasing the same by constructing additional tanks, so as to avoid or minimize demurrage charges on account of delay in unloading a vessel that has arrived at the anchorage.

1.8 Since the original approval of the Ministry of Environment and Forests No. J – 11011/32/94 – IA.II(I) dated September 20, 1995 specifies inter alia that:

"Any expansion of the storage facilities, change in the pipeline route or location of SPM site etc., can be taken up only with the prior approval of this Ministry"

BORL approached M/s Environn Consulting Services to pilot a request to the Ministry of Environment and Forests for an increased capacity of the COT Tank Farm, taking in to account the requirements of upgrading the facilities at the Terminal to provide flexibility in handling the crude oil imports. All other parameters including the SPM Buoy, the onshore and offshore pipelines, and the overland pipeline to the Bina Refinery **would** remain entirely within the original approved capacity. A copy of the original approval is placed at Appendix 1.

Comment [V1]: Needs to be enclosed.

1.9 M/s Environn Consulting Services, in turn, requested DHI (India) Water & Environment to prepare an EIA report for submission to the Ministry of Environment and Forests. Environn Consulting Services also engaged the services of M/s Cuttack Consulting and Solution Services (C2S2) to examine the need to expand the Tank Farm and determine the optimum number of tanks for minimizing the demurrage charges of VLCCs awaiting unloading at the SPM. This pre-feasibility report has accordingly been prepared on the request of M/s Environn Consulting Services for expansion of the crude oil storage facilities of BORL, at Vadinar, for submission to the Ministry of Environment and Forests, and includes the upgrading of the facilities at the Terminal.

2. TRANSPORTOF CRUDE OILTO THE BINA REFINERY

2.1 General

2.1.1The crude oil requirement of the Bina Refinery in the first phase, as approved by the Ministry of Environment and Forests in 1995, was 6 million tonnes per annum. Though at that time there was a provision in the Feasibility Report of expanding the refinery to 9 million tonnes per annum, this proposal for expansion was not taken up as the refinery was still to come up to capacity on a sustained basis. Recently (2013), the refinery having come up to capacity, there is a parallel proposal for "debottlenecking" of the Bina Refinery to be able to handle a throughput of 7.5 million tonnes per annum.

2.1.2 The BORL refinery has been designed on the basis of crude oil imported from the Middle East. The present mix of imported crude is based on approximately equal quantities of Arab Mix, Basrah Light and Oman Export Blend.

2.1.3 The crude oil was being imported in VLCCs having a capacity up to 273,000 DWT. Since these tankers have a draft in excess of 20 m, allowing for adequate under-keel clearance, the depth requirement is considerable and therefore BORL had proposed to utilize an offshore facility based on a Single Point Mooring in 32 m of water, just east of the Kandla Channel at Vadinar and west of the facilities for reception of crude oil by Reliance Industries Limited, Jamnagar.

2.2 Single Point Mooring

2.2.1The location of the BORL SPM in the Gulf of Kachchh is shown in Fig.1, extract of IN Chart 203 at Latitude 22^0 33' 44" N, Longitude 69^0 45' 38" E. A zoom in (Fig.2) shows SPMs belonging to Reliance Industries Jamnagar Refinery, located in GMB waters and the IOC SPM located in Kandla waters (Fig. 2).

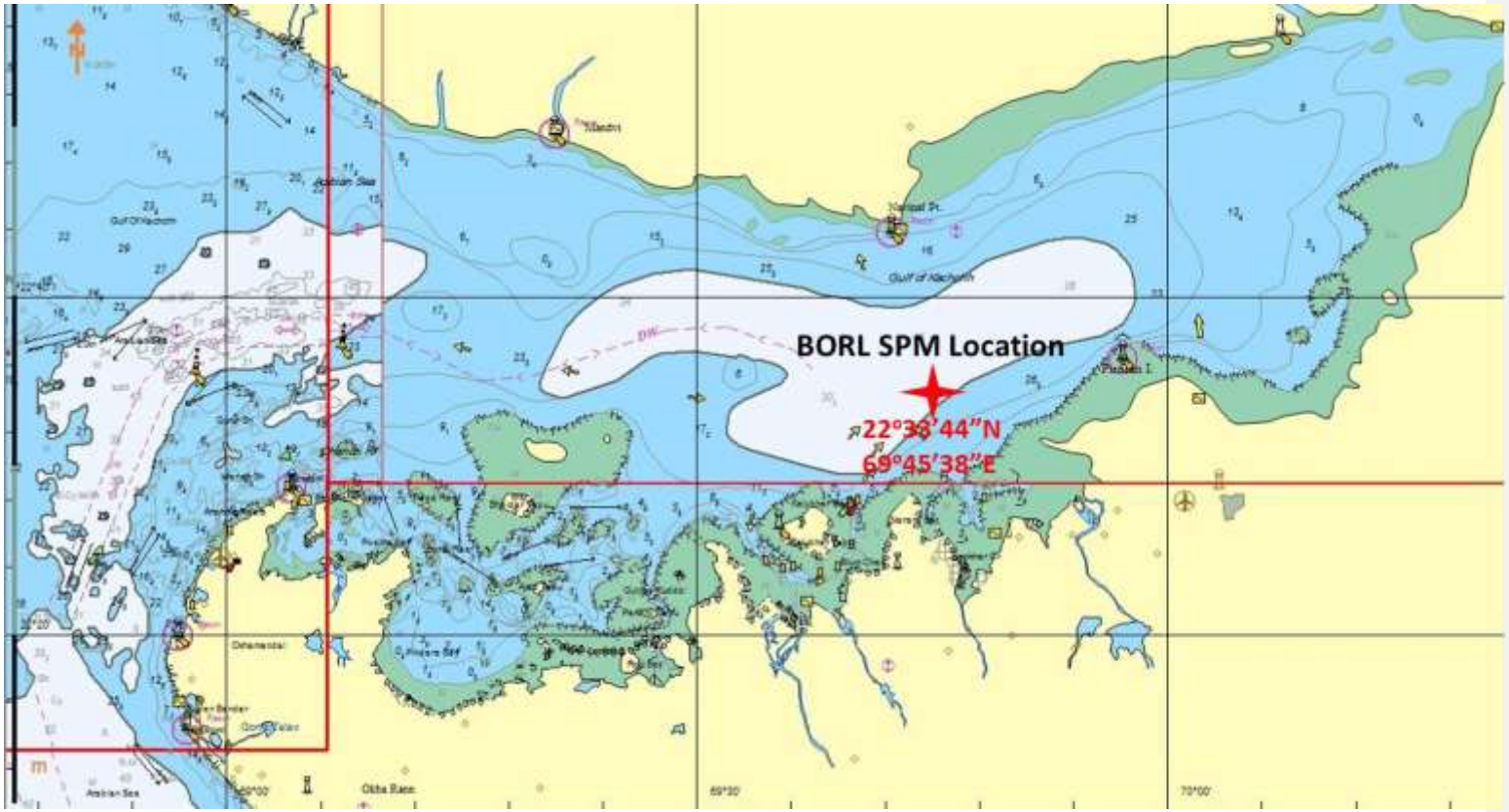

Figure 1 BORL SPM Location in Gulf of Kachchh

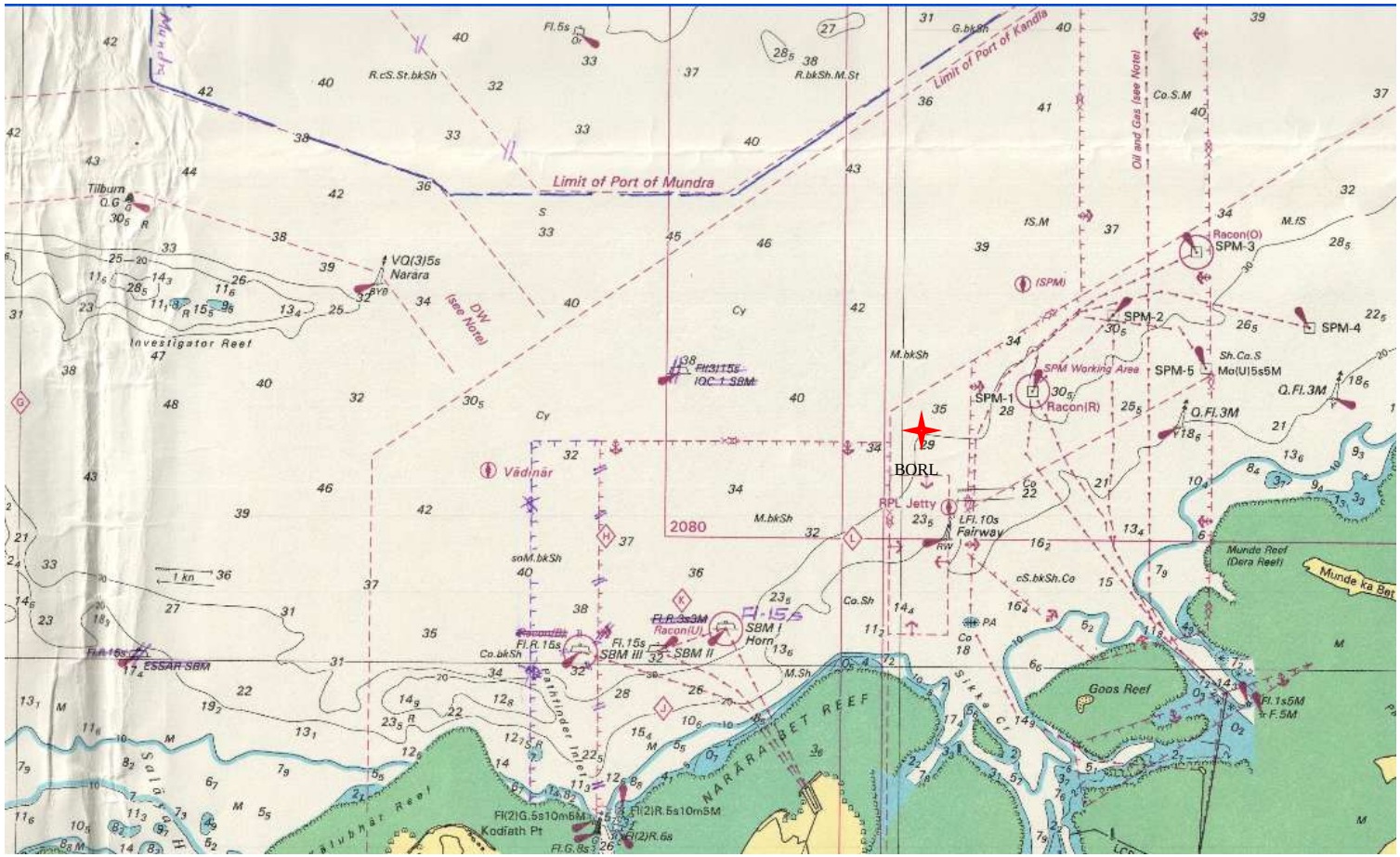

Figure 2 Location of other SPMs in Gulf of Kachchh

2.2.2 The BORL Single Point Mooring is based on a Catenary Anchor Leg Mooring (CALM) Buoy manufactured by SOFEC, Houston, TX USA. The CALM Buoy is designed to take the mooring loads of 320,000 DWT tankers under adverse wind and wave conditions. The buoy supports a turntable which is free to rotate over 360^0, with the help of a three layer roller bearing system. The VLCC is moored on to the turntable, which enables the vessel to "weathervane" adjusting its alignment along the resultant of the forces exerted on the vessel due to the effects of wind, wave and current (Fig. 3).

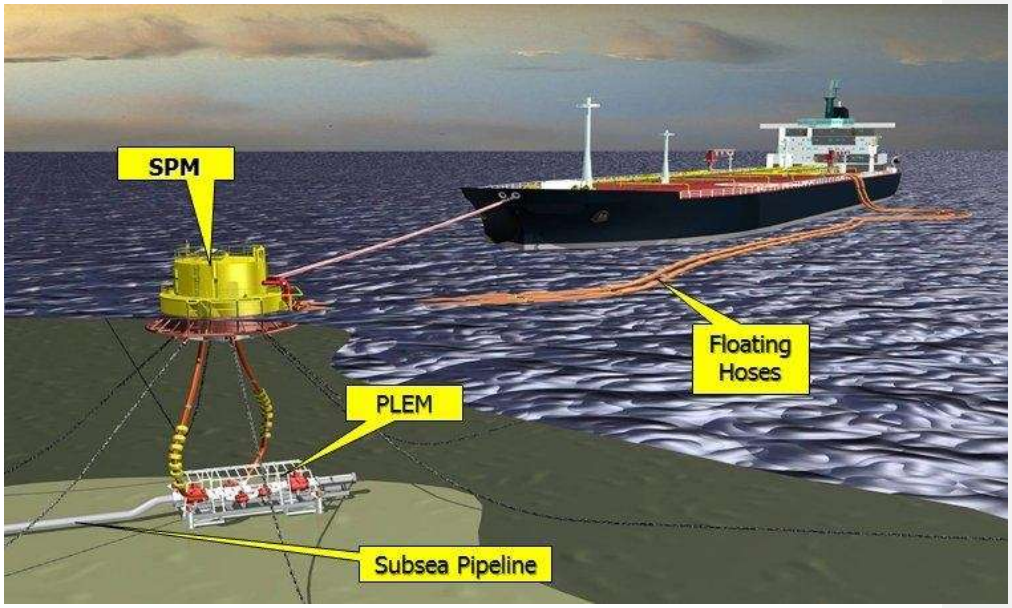

Fig. 3 Depiction of how the vessel "weather-vanes" around the SPM

2.2.3 The buoy has an external or hull diameter of 12.5 m, with a central well of 3.7 m. In order to protect the buoy from damage due to collision with the moored vessel, as can occur at the change of tide, or from any passing vessel, debris etc., a protective skirt of diameter 16.5 m is provided.

2.2.4 The oceanographic conditions at the BORL SPM are quite amenable to round the year operation. The tidal range during spring tides is 3.5 m. The tidal currents are reversing, the flood tide flowing eastwards, while the ebb flows westward. The peak currents experienced in the area are 2.5 knots.

2.2.5 Winds in this area are governed by the monsoon and reach a peak in July of 12 knots. The wind direction is dominantly from the southwest, with west being the second dominant direction.

2.2.6 Wave action in the Gulf is very limited, the Saurashtra Peninsula providing protection from the strong wave action in the monsoon, experienced on the west coast of the Peninsula from Dwarka to Veraval. Waves in the Gulf of Kachchh, particularly on the southern bank are limited to that generated by local winds over a limited fetch, estimated as 1.2 m.

2.2.7While wave action in the area is very mild, cyclonic storms do occur at a frequency of about once in ten years. A severe cyclone crossed over the Saurashtra Peninsula in 1998, from Porbandar towards Kandla, the path crossing over the BORL site. Wind speeds of 44 m/s were reported in this event, with an estimated wave height of 4 m.

2.2.8The performance of the Single Point Mooring as per the manufacturers is guaranteed to wave heights of this magnitude, and it is known that similar buoys are known to operate in even more severe conditions around the world.

2.2.9 It may be mentioned here that no disconnection has been required during the operative duration of the BORL Buoy since its installation in 2008. Similarly, no incident of grounding, collision or other mishap has occurred during this period.

2.2.10The buoy is moored to the sea bed through six anchor chains, 85 mm diameter, spaced equally at 60^0 along the periphery of the buoy, the chains being connected to anchor piles, drilled and grouted in to bed rock.

2.2.11The vessel is moored to the turntable by a single bow hawser via a mooring bridle assembly. The purpose of the bridle assembly is to isolate the fixed components of the buoy from the rotating turntable and associated attachments. Thus the undersea connections from the buoy to Landfall Point through the Pipeline End Manifold (PLEM) are protected from any damage.

2.2.12 A photograph of the BORL SPM as installed is shown below in Fig. 4.

Figure 4 Single Point Mooring of BORL

2.2.13The crude oil is pumped by the ship's power through a 17 km pipeline to the tank farm, the submarine pipeline being 11 km long and the

land pipeline 6 km long. The single submarine pipeline has a diameter of 48 inches, with a connected overland pipeline of the same diameter leading to the Tank Farm. The system is designed to achieve an unloading rate of 16,000 m^3/h, implying thereby that a VLCC can be unloaded in a matter of a day or so.

2.3 Crude Oil Terminal (COT)

2.3.1 The tank farm was originally designed to cater to an average of one 250,000 DWT tanker every 14 days. Allowing for bunching of vessel arrivals and the need to segregate different types of crude oil, it was contemplated in the original Project Report that the capacity should be 780,000 m^3, consisting of thirteen tanks of 60,000 m^3 each. This was also intended to take in to account the slower evacuation rates from the tanks by cross-country pumping from the crude oil tanks to the Refinery at Bina. However, in order to economize on the capital cost, only eight tanks were constructed

2.3.2 Crude Oil is pumped from the Tank Farm to the Bina Refinery through a single pipeline. The pipeline is operated by two sets of pumps, the first to boost the pressure to 7 bar and the second to raise it further to 75 bar. The discharge through the pipeline is approximately 862 m^3/h. There are intermediate online booster pumps along the 943 km pipeline.

2.3.3 The Tank Farm has adequate fire fighting facilities consisting of a fire water supply system, medium velocity water spray facilities, rim seal fire protection system for the tanks, low expansion foam system for the tanks, smoke detection system for the Control Rooms and fire fighting equipment and fire alarm system.

2.3.4 The Tank Farm also meets its small requirement of drinking water and for other multi-use, drawn from a bore well, supplemented by water tankers in the area.

2.3.5 The power requirements of the Tank Farm amounting to 4000 KVA is taken from the Gujarat State Electricity Distribution system, catering primarily to the pumping requirements, of the cross-country pipeline, in addition to lighting and other miscellaneous use**s**. The power is drawn from the 66 KV line, stepping down through a transformer and associated switchgear. A stand-by diesel generator provides 2 KVA as back up, in the event of grid failure.

2.3.6 The washings from the Crude Oil Terminal area contain some amount of oil and hence a waste water treatment system is required. This has been implemented by having a Tilted Plate Interceptor (TPI) and a Dissolved Air Floatation (DAF) system for recovery of oil, which is pumped back in to the crude oil tanks. The remaining sludge is dried and disposed off in accordance with MSW Rules 2000.

2.4 Cross Country Pipeline

2.4.1 The transportation of crude oil from the COT to the refinery at Bina is accomplished by a single 24" pipeline having a capacity of approximately 862 m^3/h. As mentioned earlier, the pressure developed at the COT is up to 75 bar, and to overcome the head loss in the 943 km pipeline, two intermediate booster pump **stations** have been provided.

2.4.2 Considering **the** specific gravity of the Arab crude oil of 0.85, the refinery capacity of 6 million tonnes per annum can be achieved by the operation of the transport of the crude oil through the cross country pipeline for 22 hours per day for 365 days a year.

3. PRESENT STORAGE CAPACITY OFTHE CRUDE OIL TERMINAL AND NEED FOR AUGMENTATION

3.1 General

3.1.1 An important feature of intermodal traffic is that at the point of change of mode, it is mandatory to have a storage terminal. This feature is necessary to account for differential rates of movement of cargo, the need for segregation, and the dispatch to various destinations.

3.1.2 In the present case, it has to be recognized that the pumping capacity of modern VLCCs is as high as 16,000 tonnes per hour, depending on the distance to which the oil is to be pumped. On the other hand the capacity of the overland cross-country pipeline is only 862 m^3/h. It is immediately evident that storages would have to be provided to take care of the slower rate of evacuation of the storage tanks, in comparison to the unloading of a VLCC.

3.1.3 Other important reasons for storage, in the event of a modal change, are the need for segregation of different types of crude, allowance for break-down in operation of either mode and the need for blending of various qualities of crude oil.

3.2 Calculation of the Storage requirement of the BORL COT

3.2.1 The annual throughput of the Bina Refinery as approved in 1995 was 6 million tonnes of crude oil per annum. On the basis of an average tanker capacity of 250,000 DWT, the operation requires 24 crude carriers per annum. This gives a spacing of an average of 15 days between ship arrivals. The storages necessary at the BORL COT are now calculated on the basis of various assumptions.

3.2.2 VLCCs range in size from 160,000 DWT to 320,000 DWT. Taking a median value of 275,000 DWT, the volumetric content would be 324,000 m^3, which would be unloaded in approximately 18 or 19 hours. During these 18 hours, the evacuation from the COT to the cross country pipeline would be 890 x 18 = 16,000 m^3, resulting in the

need to store 308,000 m^3, which would require six tanks of 60,000 m^3 to be available. Even in the event of a breakdown in the cross country pipeline for a day or so, the evacuation loss due to breakdown is so small that the storage requirement of six tanks remains the same.

3.2.3 The next assumption is the bunching of vessels. If the vessels are on long term charter, the schedule of delivery of crude oil could be phased with greater efficiency and any bunching would be due only **to** bad weather, lack of tide etc. Assuming a period of five continuous days of disruption due to bad weather, causing the late arrival of a particular vessel and consequent additional storage before the next scheduled arrival, the additional requirement would be about 90,000 tonnes or 106,000 m^3, thus requiring two more tanks, bringing the requirement to a total of eight tanks.

3.2.4 The next consideration is that successive vessels arriving at Vadinar have different qualities of crude oil, which would give rise to the need for segregation, especially considering the limited storage at Bina. In such a case, an additional six tanks would be required bringing the total required number to 14.

4. STORAGE CAPACITY OF THE CRUDE OIL TERMINAL FOR FUTURE REQUIREMENTS

4.1 As mentioned in para 2.1.1, there is a concurrent proposal to increase the capacity of the Bina Refinery from the present throughput of 6 million tonnes per annum to 7.5 million tonnes per annum by what is termed as "debottlenecking". Since the throughput to the Bina Refinery has to be increased by 25%, this has to be achieved by upgrading the pumping capacity of the cross-country pipeline by the use of drag reducing additives and upgrading the pumps, both at the COT, as well as at the intermediate booster stations.

4.2 It may be pointed out here that the increased requirement of 7.5 million tonnes of crude per annum for the Bina Refinery after "debottlenecking" has no impact on the requirements of storage at the COT, because the only parameter requiring change is the carrying capacity of the cross-country pipeline. Of course the number of arrivals of crude vessels mentioned in para 3.2.1 has to go up by 25% from 2 arrivals a month to 5 arrivals every two months, which is well within the SPM capacity. As mentioned in para 3.1.2, the crude from the VLCC is pumped ashore by the ship's pumps, which have the capacity to discharge the full cargo of a VLCC in a matter of less than a day. Even if the throughput of crude is increased to 15 million tonnes per annum, the arrival of VLCCs would go up to 5 arrivals a month. Thus the proposed increase in the number of tanks to a total of 14,as mentioned in the previous chapter, would still be able to handle a throughput of 15 million tonnes per annum of crude, as and when it is required in the future by the Bina Refinery.

4.3 Therefore, while the main objective (in terms of meeting the requirements of staggered arrivals due to bad weather and the need to provide segregation of different qualities of crude) is to augment the number of tanks to meet current difficulties, BORL also proposes to

augment other facilities, (at a fraction of the cost of the storage tanks), in order to provide flexibility, as explained in the following paragraphs.

4.4 Blending Unit

As mentioned in para 1.2.2 supra, BORL is presently importing three different categories of crude, the segregation of which requires the additional tanks as mentioned in Para 3.2.4. There is often a requirement of blending these crudes as required by the refinery production. The limitation of space at the Bina Refinery can be overcome by having the Blending Unit at the Vadinar COT. The blending unit is a series of pipelines from various tanks brought to the Blending Unit which has a set of control valves, which can produce the required blended mix. The blended crude, of course, has to be stored in separate tanks for pumping to Bina. This would imply increasing the number of tanks required from the 14 mentioned in para 3.2.4, to 16.

It would thus be seen that for efficient operation of the COT, that is to keep the refinery fully operational, it is necessary to have fourteen operational tanks at the Vadinar end. For storage of blended crude another two tanks are required and allowing for one tank outage at a time, due to regular maintenance/major repairs, it is necessary to have *seventeen* tanks in the COT complex to allow for combined eventualities of an early arrival of a tanker by 5 days, the need for segregation of different mixes of crude, and the storage of blended crude.

This scheme of seventeen tanks would ensure against heavy demurrage on a VLCC having to wait for emptying of a tank through the cross-country pipeline. However, this proposal has to be weighed against the probability and frequency of a waiting VLCC at the SPM. Allowing for minimal demurrage of three days a year, one tank could be reduced, thereby bringing down the capital cost to an acceptable level. It is therefore recommended that only eight additional tanks be

constructed, bringing the total number of tanks at the Vadinar COT to 16.

Plate I attached shows the layout of the COT, indicating the location of the existing tanks and also the proposed additional tanks.

4.5 Inter-connection to the neighboring IOC Terminal

As mentioned earlier, the BORL SPM lies in the waters of the Gujarat Maritime Board, whereas the neighbouring IOC SPM is in the waters of the Major Port of Kandla (see Fig. 2 above). A satellite Google Image below (Fig.5)shows the proximity of the two terminals and the possibility of providing an inexpensive land link.

Fig. 5 Satellite Image showing IOC and BORL Terminals

The objective of the link is to provide as much security as possible to a vital sector of the economy, which depends to a very large extent on crude oil imports from the Middle East. In the event that there is a mishap at the SPM, or the BORL SPM is down for routine inspection/periodic maintenance at a dry dock, the refinery at Bina has

the option of drawing its supplies from the IOC SPM. Surplus capacity at the BORL SPM can be utilized by IOC if required. These are but a few of the various advantageous options available to both parties which are in the Public Sector.

Various alignments were considered for the inter-connection and the Preferred Alignment between the Tank Farms of BORL and IOC is shown in Fig. 6 below.

Fig. 6 Preferred Alignment of the Inter-connection BORL to IOC

4. RISK ASSESSMENT

4.1 General

It is brought out at the outset that there is no change in the Risk Environment as a result of the proposal to expand the number of tanks at the Crude Oil Terminal, **if** the throughput remains as originally approved at 6 million tonnes per annum, which is the present capacity of the refinery at Bina. This is because the major risks pertain inter alia to the heavy traffic of VLCCs in the Gulf of Kachchh, in addition to the general cargo traffic to the Port of Kandla. The risks pertain to ship collision, ship grounding, and structural failures at the unloading terminals, which are the Single Point Moorings belonging to ESSAR, IOC, Reliance Industries and the BORL SPM. As mentioned earlier, the BORL arrivals are very few in number, twice a month to be precise, and if these remain the same there is no *additional risk* due to the increase in the number of storage tanks from 8 to 16 at the BORL COT, the justification for which has been given even for the present throughput of 6 million tonnes per annum.

It has however been pointed out earlier that the Bina Refinery has at present a separate proposal for "de-bottlenecking", which would increase the throughput to 7.5 million tonnes per annum. This would only require the augmentation of the evacuating capacity through the cross-country pipeline, and has no bearing on the number of storage tanks required, namely 16. This increase in evacuation capacity is within the capacity of the existing pumping systems, where in addition, the increase in power consumption can be minimized with the introduction of drag reducing additives.

It may also be pointed out here that any future expansion to a throughput of 15 million tonnes per annum, would still not impact the number of tanks required, being governed only by the evacuation rate.

As brought out earlier, the requirement of augmentation of the Tankages at the COT are governed only by the need to segregate different qualities of crude, the need to store blended crudes and the

need to minimize demurrages incurred due to late arrivals of a particular consignment due to bad weather.

The present pre-feasibility report is put up as a supporting document for Form 1, in order to seek approval for increasing the number of tanks from the present eight to sixteen, so that large demurrages are avoided with regard to vessels awaiting emptying of tanks. Thus the risks involved in the approaches, at the SPM, through the subsea pipeline, the overland pipeline to the Tank Farm, and the cross-country pipeline, are to be considered only as a consequence of the increased throughput from 6 million to 7.5 million tonnes per annum, or to 15 million tonnes per annum as may be required in the future.

Because of its proximity to the oil resources of the Middle East and the protected climate of the Gulf of Kachchh, 70 % of India's imports of oil are in this area. In addition the deep waters of the Gulf (see the 20 m contour in Fig. **7** below).The sensitive habitat in the Gulf, consisting of coral reefs and mangrove mudflats,has been protected through the declaration of the area as a Marine National Park and Sanctuary in 1982.

Some 2500 vessels transit the Gulf of Kachchh each year. In order to manage this traffic, the Government of India has installed an Interactive Vessel Traffic Management System (VTMS) which controls traffic in the Gulf ensuring safety of vessels and thereby protecting the sensitive environment. The traffic is broadly divided in to three parts, that bound for the major port of Kandla, that proceeding to and from the Adani Port at Mundra and the oil traffic that comes to the southern shore of the Gulf where the refineries are located between Salaya and Jamnagar.

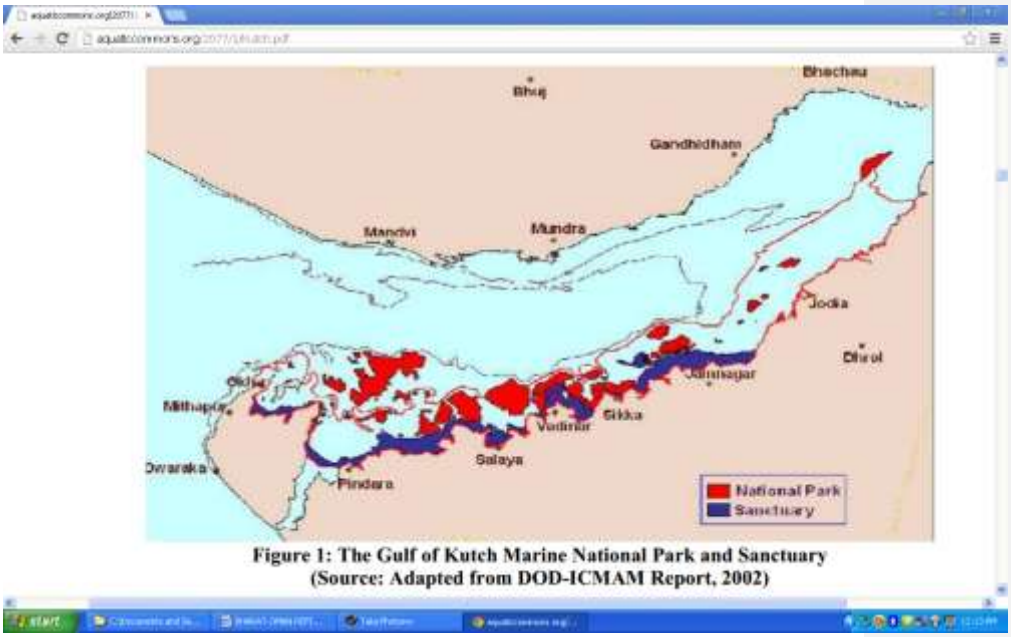

Figure 1: The Gulf of Kutch Marine National Park and Sanctuary
(Source: Adapted from DOD-ICMAM Report, 2002)

Fig. 7 Marine National Park and Sanctuary – Gulf of Kachchh

4.2 Risk Assessment at the BORL Facility

The major threat to the environment comes from potential oil spills. Global statistics indicate that potential oil spills result from three major sources, viz. collisions (28%), groundings (27%) and structural failures (21%).

The probability of collisions in the Gulf has been worked out as 10^{-5}. It may be mentioned that over the years there has been only one collision in the Gulf of Kachchh, between a container vessel bound for Mundra and an empty tanker leaving Kandla Port, and that before installation of VTS.

There have been no groundings in the Gulf, because of the large depths available, especially up to the Oil Facilities on the southern bank, where depths in excess of 30 m are available, the unloading SPMs being located in these deep waters. Some grounding of Handymax vessels have been known to occur in the approaches to Kandla Port, at the Kaladara Shoal, about 70 km north-east of the

BORL SPM. The recent installation of a Vessel Traffic Management System in the Gulf of Kachchh further ensures safety of navigation, as well as emergency response in the event of collision/grounding.
Structural failures include damage to the under-sea hoses below the SPM connecting to the Pipeline End Manifold, as well as the undersea pipeline to the shore terminal. Preventive measures are in place as required by the Insurers for annual inspection of underwater components and replacement thereof. In the event that an oil release in to the environment does take place, sensors are installed which immediately actuate closure of valves to minimize the release of oil in to the environment.
Though provision has been made to isolate and clean up any possible release of crude oil in to the environment, it may be mentioned that no incident has taken place during the operation of the BORL facility.

The present crude oil traffic in the Gulf of Kachchh is about 120 million tones, of which the BORL traffic has barely reached 5%. The "de-bottlenecking" of the Bina Refinery, raising the throughput from 6 to 7.5 million tonnes per annum, would only mean raising the same to a little over 6%. In terms of shipping the increase would be from two shipments a month to five every two months. The impact on collisions and groundings would therefore remain at the same probability, encompassing as it does the entire traffic in the western part of the Gulf of Kachchh.

The only additional risk is therefore due to the small increase in throughput at the BORL SPM. Even in the foreseeable future the throughput at the BORL Terminal could go up to as much as 15million tonnes per annum, which is well below the safe operating limits of the SPM.

A recent study has shown the extent of oil spills due to collision/grounding to be about 25,000 tonnes. The corresponding spill due to malfunction at the SPM is about 500 tonnes. Similarly the spill from leakages in the sub-sea pipeline would be restricted to 45 tonnes. The extent of spread has been modeled due to each of these

spills, on the basis of which response mechanisms have been put in place. BORL is a participant in the Disaster Management Plan, which caters to the large spills in the event of collisions, there is a need to consider the local and small leakages that could take place at the Pipeline End Manifold and along the sub-sea pipeline. Small undetected discharges of oil can also have a detrimental effect on the sensitive ecology of the area. To this end a service jetty, enabling continuous monitoring and rapid response within the BORL alignment have been provided.

In conclusion, it is brought out once again that there is no increase in the risks involved in the navigation through the Gulf of Kachchh, due to the present project and only marginal increase due to the 25% additional throughput at the SPM and the undersea pipeline. These risks can be obviated by a focused response program at the BORL COT.

5. Environmental Impact

In accordance with the conditions laid down in the MoEF approval dated September 20, 1995, BORL is periodically monitoring the marine environment as well as the waste disposal at the Crude Oil Terminal. Since the area is adjacent to other larger Crude Oil Terminals, data pertaining to the land and air environment are also being collected through various agencies. Based on these recent data, an Environmental Impact Assessment has been separately prepared by BORL in support of the present proposal to expand the Terminal capacity by increasing the present number of tanks from eight to fourteen.

As mentioned earlier, the impact on the marine environment remains unchanged with the proposed expansion of the COT, and hence the impacts are not repeated here. With the throughput proposed to be increased by 25%, for the "de-bottlenecking" of the Bina Refinery, the impact on the land, noise and social impacts are also marginally affected and remain well within the prescribes standards. There is only change due to increase in the number of tanks from 8 to 16 and that is to the air environment

The impact on the air environment from a Crude Oil Terminal stems from the possible evaporation of hydrocarbons in to the atmosphere. The sources are two: first, the evaporation from the exposed walls of an empty tank, of oil adhering to the walls. This has been estimated as 0.0328 g/s from each empty tank.

The second source is the capillary flow between the outer side of the seal ring and the inner wall of the tank. These losses tend to be significant if the seal has an improper fit, thereby allowing air to circulate through the openings. It was estimated by the National Environmental Engineering Institute (NEERI) that this release would be 1.05 g/s from each tank.

Based on these assumptions, it was predicted that the maximum impact on ground level concentrations (during summer) would be up to 40 $\mu g/m^3$ at a distance of 500 m from the compound wall. In order to obviate the same, the tanks have been provided with double seals as shown in Plate II. This single measure has reduced the fugitive emissions of hydrocarbons to a tenth of the values predicted by NEERI.

It may be mentioned here that there are no standards prescribed by the Central Pollution Control Board (CPCB) for the ground level concentration of hydrocarbons in or around refineries. A scan of global literature reveals concentrations of the order of 200 $\mu g/m^3$ around refineries.

Considering the fact that the BORL Tank Farm is serving the refinery at far away Bina in Madhya Pradesh, it can be concluded that the expansion of the Tank Farm from 8 to 16 tanks would have a negligible impact on the air environment at Vadinar.

6. Project Cost

As mentioned in the earlier chapters, the prime objective of the Project is the construction of eight additional tanks of 60,000 m^3 capacity, which forms the bulk of the cost. The cost break up of each taqnk is given below:

Particulars	Estimated Cost (Rs. in Crores)
Plates, Piping & Misc Material	13.10
Construction & Erection	11.67
Valves	0.82
Instrumentation	0.21
Safety Equipments	0.81
TOTAL	26.62

The total cost estimate including other items is given below:

Sl. No.	Item	Unit Rate Crores, Rs	Cost Crores, Rs
1	Eight Crude Oil StorageTanks	26.62	213
2	Blending Unit	L.S.	8
3	Inter-connection with IOC	L.S.	20
4	ETP Plant	L.S.	6
5	Administration Building	L.S.	3
	GRAND TOTAL		250