



KRVIA-ES

Research & Design Cell

Mapping Aarey

**A Study of the Impacts of Land Use / Land Cover Changes on
Catchment Areas and Ecosystems**

Research and Design Cell, Kamla Raheja Vidyanidhi Institute of Architecture
and Environmental Studies (KRVIA), Mumbai

Cover Image: A stream (tributary) that feeds the Mithi river.



Vihar lake lies in the drainage basin of the Mithi river in the Sanjay Gandhi National Park which is contiguous with Aarey Colony.

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Aarey is a hilly landscape of extensive forest cover, natural ecosystems, numerous adivasi settlements, and primary occupations. Since it was established as a government Milk Colony in the late 1940s, it has been a predominantly low-intensity development zone, forming a much needed buffer area to the Sanjay Gandhi National Park (SGNP). Aarey is a part of Mumbai's ecologically vital hill complex along with the National Park, where streams and tributaries that feed two of four major rivers of the city originate: Oshiwara and Mithi. This report provides a qualitative-spatial analysis to highlight the impacts of past and proposed land use / land cover changes in Aarey on its river catchments and ecosystems.



KRVIA-ES

Research & Design Cell

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Sheema Fatima is a Sociologist with a degree in Urban Planning from CEPT, Ahmadabad. She is an Urban Researcher and Visiting Faculty at KRVI and a PhD scholar at the Tata Institute for Social Sciences (TISS). Her research areas include urban policy, planning and governance.

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Unless specified otherwise, all the maps and photographs have been prepared by the authors of this report.

Maps and Photographs

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Research Assistants

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The views expressed in this report and the accuracy of its findings are matters for the authors and do not necessarily represent the views or confer liability on KRVIA (Kamla Raheja Vidyaniidhi Institute of Architecture and Environmental Studies)

Aquifers Geological formation of high porosity and high permeability that yields significant quantities of ground water

Channelization* Often undertaken for the purposes of flood control, improving land drainage, improving navigation, relocating channels or leveling land, channelization refers to the modification of river channels by engineering

Concretisation The increase in impermeable or hard-paved surface on land, that increases runoff and reduces permeable area or the capacity of land to absorb water

Contours In cartography, contour lines on a map indicate points of equal elevation (or height) relative to other elevations or to a given level. A contour map shows valleys and hills, or the steepness of slopes. Contour intervals show the difference in elevation between successive contour lines

DEM Digital Elevation Model, a digital representation of topography or terrain

Development intensity The amount of built up area on land relative to land area. Intensity of development is usually prescribed or measured through the built-up to land area ratio: Floor Area Ratio (FAR) or Floor Space Index (FSI)

DP Development Plan - the 20 year masterplan of the city prepared by the Municipal Corporation of Greater Mumbai and sanctioned by the Government of Maharashtra under the Maharashtra Regional and Town Planning (MRTP) Act, 1966

Drainage Pattern* River channels erode into the landscape and therefore the pattern of drainage initially developed tends to persist over time. A collection of river channels joined together is called a drainage network, how it is laid out on the ground in plan view is called the drainage pattern, and the channels together with all the land surface that drains to the channel is called the drainage basin or catchment area.

Drainage Basin* A drainage basin is the extent of land that drains storm-water and runoff into a body of water such as a river, lake, wetland or ocean. Drainage basins are erosion created land-forms shaped predominantly by the actions of flowing water, that flows over land or along a branching network of streams and channels of concentrated flow. A drainage basin includes both the network of streams and rivers that conveys water, as well

as the land surface over which water drains. The term is often used interchangeably with 'watershed' or 'catchment.'

EDDP Earlier Draft Development Plan - that was released in 2015 and after opposition from multiple groups, was scrapped by the GoM and comprehensively revised

Elevation In cartography, the elevation of a location is its height above or below a fixed reference point or level (usually the Mean Sea Level)

ELU map Existing Land Use - a map showing the purpose for which land is used

Estuary A semi-enclosed coastal body of water with a free connection to the open sea in which the salinity is diluted by freshwater from a river. The tidal mouth of the river where it meets the sea which is under tidal influence

Evapotranspiration The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants

Ephemeral Streams Are shallow temporary streams that have flowing water for brief periods in response to rainfall or after a flood

First Order Streams Based on Arthur Newell Strahler's "top down" scheme, rivers of the first order are the outermost tributaries of a river system. When two streams of the same order meet, the resulting stream is given a higher number

Flood Plain* A floodplain is generally the relatively flat area of land that stretches from the banks of the parent stream to the base of the valley walls over which water from the parent stream flows at times of high discharge. A floodplain is formed from sediment deposited by a river when it floods

Geomorphology From Greek for geo- "earth" and morphology - "form" - it is the study of the physical features of the surface of the earth and their relation to its geological structures

GIS Geographic Information System - in this case a computer software that helps capture, store, manipulate, analyze, manage, and present spatial or geographic data

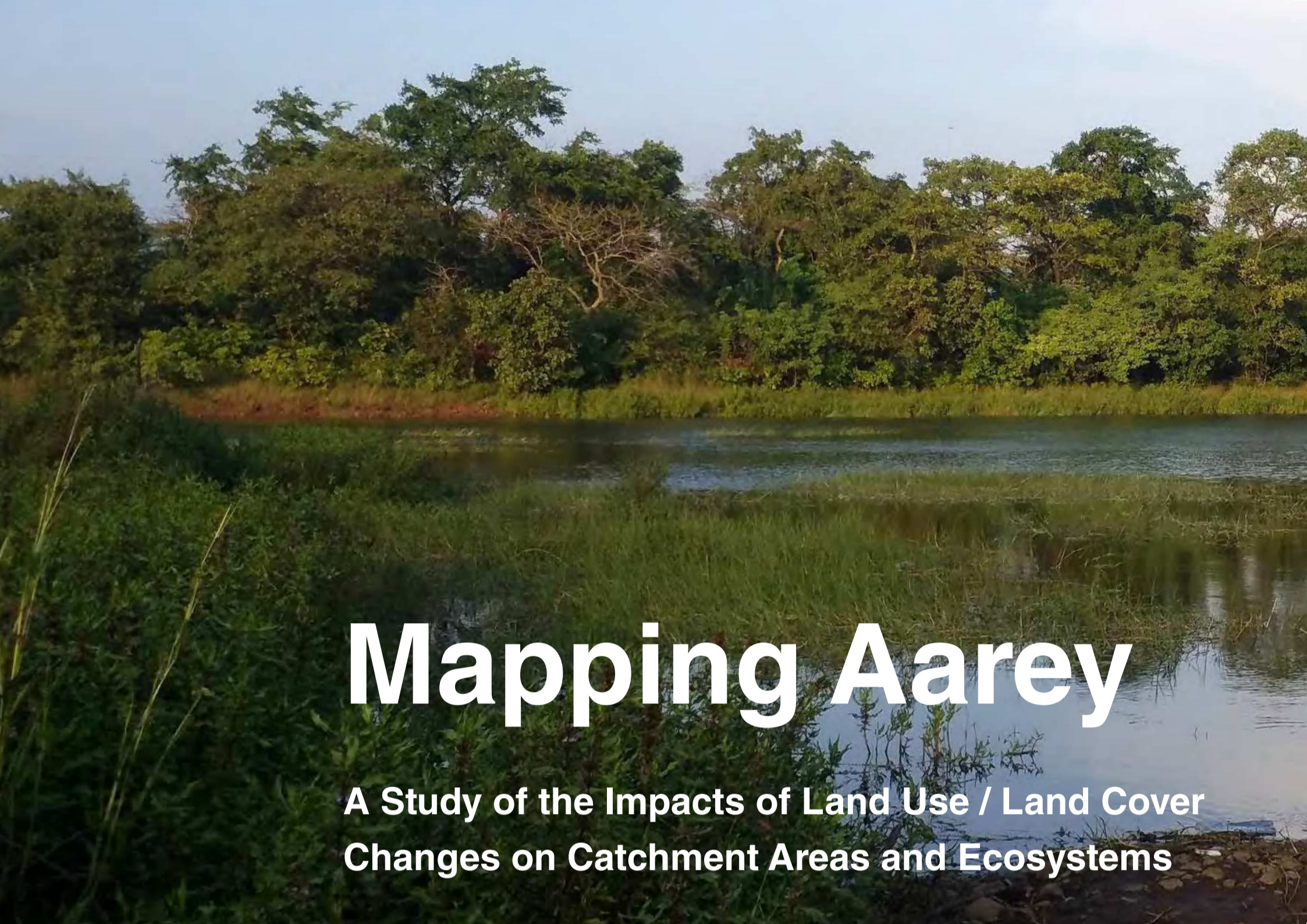
GoM Government of Maharashtra

Groundwater Subsurface water contained in saturated soils or rocks

Ground Coverage	Ground coverage is the percentage of land area or plot covered by a building or covered structure. In dense urban areas, development regulations typically allow higher ground coverage area as compared to suburban areas. Ground coverage can also be expressed as a built to unbuilt ratio indicating the extent of land in a given area that is covered by building as compared to area that remains open to sky. Note: ground coverage does not refer to the type or permeability of the unbuilt ground area	Riparian zone	Is an ecosystem formed at the interface between land and a river or stream usually spread out on both sides of the river banks
GZ	Green Zone - A new zoning category under the 2016-2034 sanctioned Development Plan for Mumbai, that defines it as "a large area predominantly with green cover." However, this zone permits uses such as zoos, resettlement housing and other "uses approved by GoM with permission from the Ministry of Environment and Forest."	RDDP	Revised Draft Development Plan - that was released in 2016 after the earlier (2015) version of Mumbai's Development Plan was scrapped by the GoM and comprehensively revised. This plan was sanctioned in parts between 2018 and 2019
Hydrology	From Greek for hydro- "water" and logos- "study of" is a study of surface and subsurface water, its movement, physical and chemical properties and its relationship with the environment	Runoff	Runoff is the part of the water cycle, including water from rain, snowmelt or other sources, that flows over land surface or drains into a water course, instead of percolating or being absorbed to form groundwater, or being lost through evaporation
Hyporheic zone	Is a region of the stream banks and stream bed that forms a surface and subsurface hydrological exchange zone. These are areas of porous sediment beneath and alongside streams where shallow groundwater and surface water mix.	R&R	Rehabilitation and Resettlement housing
Intermittent Streams	Are streams that have flowing water during the wet season but are usually dry in other seasons	SGNP	Sanjay Gandhi National Park
MCGM	Municipal Corporation of Greater Mumbai	Topography	In cartography, it is the study of the shape and features of the land's surface
MMRCL	Mumbai Metro Rail Corporation Limited. Joint Venture of GoI and GoM	Waterlogging	Waterlogging occurs when water is unable to drain away, or be absorbed due to saturation of soil with water
MoEFCC	Ministry of Environment, Forests and Climate Change	Catchment / Watershed*	A catchment or watershed is the divide that separates one drainage basin from another drainage area or basin (see Drainage Basin). [Note]: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study
MSL	Mean Sea Level	Water table	Water table or groundwater table is the upper level of an underground surface where the soil or rocks are permanently saturated with water
NDZ	No Development Zone - a category of the Mumbai Development Plan that prohibited building activity or restricted it to very low intensity	Wetland	An area where water meets land - forming a distinct ecosystem created around hydric soil permanently or seasonally flooded with water
Perennial Streams	Are streams that have a continuous flow throughout the year. These streams typically have well-defined channels and may have several smaller tributaries that join them		
PLU	Proposed Land Use - a map showing the proposed purpose for which land is to be used		

Glossary of Terms

* Definitions based on Andrew Goudie (ed.), Encyclopedia of Geomorphology: Vol 1, Routledge, 2003.



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Introduction

1. The Socio-ecological Importance of Aarey for Mumbai

The land on which Aarey Milk Colony was established is a predominantly forested land contiguous with the Sanjay Gandhi National Park. It was established in 1949 as a government dairy farm "situated about twenty miles north of Bombay"¹ in order to establish 30 to 40 farms for relocating the cattle sheds and 15,000 cattle from the Island City. According to the Dairy Development Department, 1,287 hectares of land was acquired for the colony. Over the decades, parts of the original Milk Colony have been diverted for other uses.

Aarey Milk Colony when established was intended for dairy farming ('primary' sector activity) away from city limits. Over the years, the urban growth has engulfed the area from three sides, except from the side it shares with the Sanjay Gandhi National Park. As noted above, the 1964 Development Plan reserved this area for the Milk Colony. In the 1981 Development Plan (sanctioned in 1991) the colony was set aside as a 'no development zone' (NDZ) which restricted development activity in the area - however, the NDZ area in the 1981 DP was approximately 23%

smaller than the area reserved in the 1964 DP for Aarey Colony. The No Development Zoning, designation as a dairy farm, contiguity with the National Park as well as its forest cover have all contributed to Aarey's existence as an area that shelters numerous adivasi villages, supports primary sector livelihoods, nurtures a rich biodiversity, as well as provides a very popular recreational destination for city residents.

According to a survey conducted by the Tribal Research and Training Institute (TRTI), Aarey consists of 27 adivasi hamlets (or padas) - though the Dairy Development Records acknowledge only 18 of them. The Colony consists of 30 stable units that accommodated a total of 16,160 cattle in 2013.² The Colony is known for its forest characteristics and biodiversity in terms of plant and animal species. Naturalists report 136 varieties of birds, 85+15 varieties of butterflies and moths, 13 varieties of amphibians, 47 varieties of reptiles, 90+20 varieties of Spiders and other Arachnids, 22+70 varieties of Ants and other Insects, 100 varieties of Bugs and Beetles, 40 varieties of Dragonflies and Damselflies, 19 varieties of Mammals including Leopard, Jungle Cat, Flying Fox and Jackal.³ Many of these species are listed as scheduled species under the Wildlife (Protection) Act, 1972. Furthermore,

in the largely open-space starved suburbs of Mumbai, Aarey offers many popular destinations for naturalists and recreational visitors.

2. The Purpose and Aims of this Study

This mapping study of Aarey intends to highlight the impacts of past and proposed land use and land cover changes in Aarey on its terrain, watersheds and ecosystems.

Mumbai's physical geography has undergone drastic transformations over three centuries - from a landscape that originally composed of a cluster of islands with vegetated hilly cores and surrounded by low lying tidal marshes or estuarine mudflats, to a contiguous land mass, through a series of planned and unplanned land reclamations.⁴ Till the late early 20th century, Salsette continued to exist as the city's rural fringe with very sparse inhabitation. Yet, since Independence, urban settlement in Salsette grew at a rapid pace, and many of the low lying marshlands were drained and filled up for the city's growing trends.

An important feature of the Salsette island is its hill complex in its central portions that trend from the north to the south, eventually merging into the tidal swamps towards the east. This hilly



Vihar Lake is located in SGNP which is contiguous with Landscapes and Natural Ecosystems of Aarey

core - reaching a highest point of 467 meters in the Powai-Kanheri ranges - slopes towards the east and the west, forming a radial drainage pattern, and an important catchment area for the rain-fed rivers that originate there. The city's four major rivers within the city limits, Dahisar, Poisar, Oshiwara and Mithi originate in this hill complex. A large part of this hill complex falls within the Sanjay Gandhi National Park (SGNP), although it extends beyond the SGNP in the south (around Powai Lake) and south-west areas (Aarey). Two of the city's three largest freshwater lakes (Tulsi and Vihar) are part of the SGNP. Over the decades, the pressures of urbanization have gradually eroded the edges of the SGNP and areas around it.

The recent spate of catastrophic floods, landslides and infrastructure failures in Mumbai have their roots in the extensive reclamations in the low lying estuarine regions of these four rivers, as well as due to incautious developments in their catchment areas.⁵ A recent report by a Supreme Court-appointed panel accurately described the Mumbai Metropolitan Regional Development Authority (MMRDA) as the "biggest encroacher" of the Mithi river, for the creation of the Bandra Kurla Complex.⁶ It is evident through dozens of studies and reports on urban floods in Mumbai that developments that disrupt the city's river

systems have led to terrible loss of life and destruction of property in recent decades, and that the consequences of any further disturbance to the city's ecological systems is likely to be even more disastrous in the future.

Aarey Colony is one such ecological landscape in Mumbai. Contiguous with the SGNP and an area where tributaries that feed two of the city's four rivers originate (Oshiwara and Mithi), Aarey fits the criteria of very high ecological significance, and therefore demands conservation and protection. This study aims to show that the original area of Aarey has been reduced systematically since it was established in the late 1940s, that newly proposed public and private projects are likely to sever the Colony entirely from the SGNP and that the new projects will disrupt hydrological processes and drainage patterns in the area. The extent and locations of these new projects will have serious socio-ecological impacts in Aarey itself, and are expected to displace indigenous settlements, communities and their livelihoods, create downstream impacts, possibly increasing the scale and severity of urban floods.

3. Methodology, Scope & Limits

This is a mapping report of Aarey from a multidisciplinary perspective. Its focus is to

provide a qualitative-spatial analysis using the overlay technique to identify impacts of land use and land cover changes on the Aarey ecosystem and in downstream areas. The study has relied on the various existing and proposed land use maps prepared by the Municipal Corporation of Greater Mumbai, which is the planning authority for most of the city. For an analysis of watersheds, terrain, drainage and flooding risk, we have relied on open source geographic analysis (GIS) tools and resources, older Survey of India maps as well as various secondary studies and reports. For an analysis of land cover and vegetation, we have relied on older and latest Google Satellite imagery. We have also made multiple visits to Aarey and interacted with various stakeholders who live and work there. This study adopts visual & descriptive data as well as spatial analysis of land use / land cover and watersheds. The study is evaluative and suggestive in its conclusions. The study does not include statistical data such as hydrological models or tests to evaluate quantitative impacts of land use and land cover changes in Aarey, though it has referred to such studies undertaken by other institutions & individuals.

1. "Milk Colony", The Times of India, March 11, 1949. p.6.

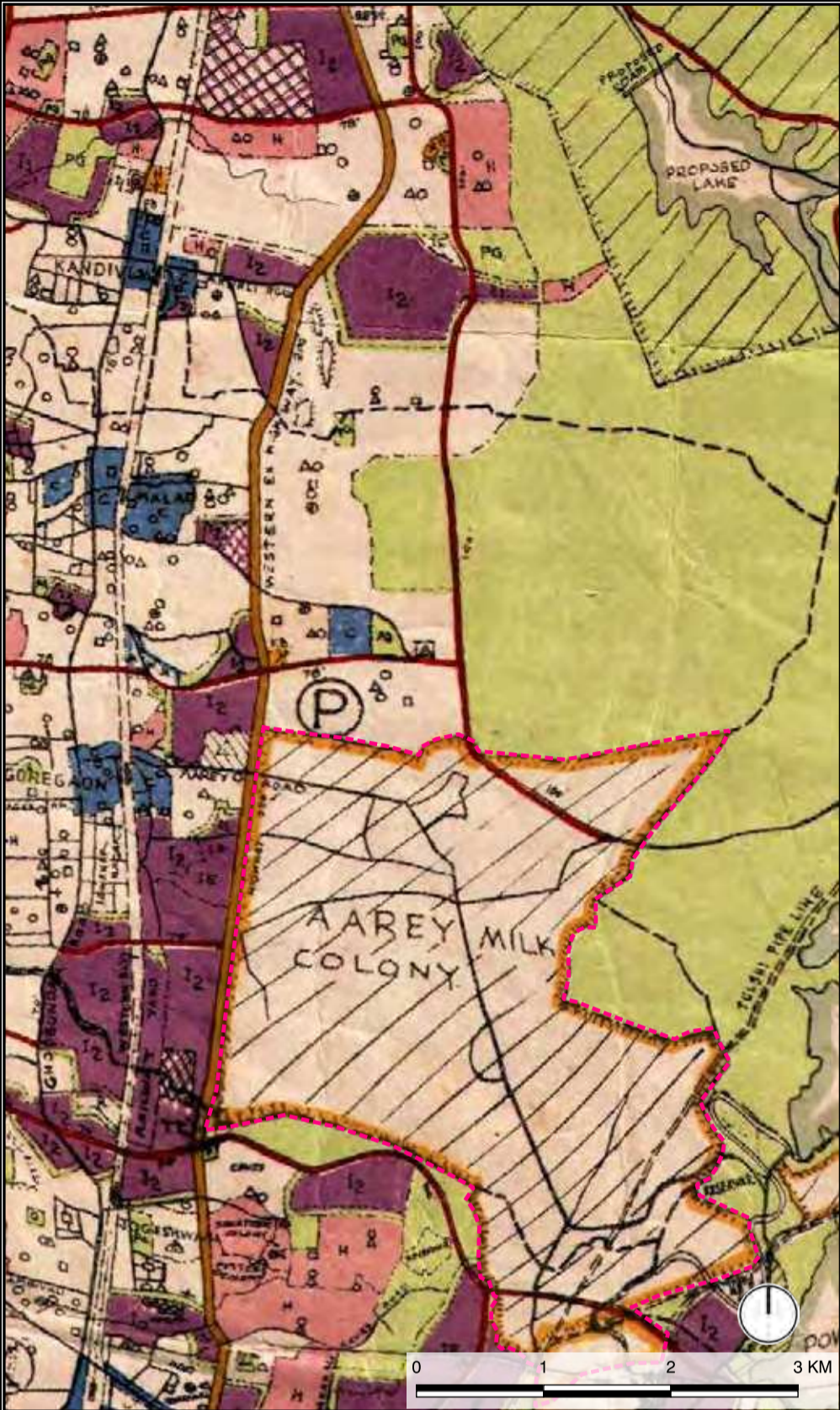
2. Dairy Development Department, Performance Budget 2013-14, Government of Maharashtra, 2013.

3. Zeeshan Mirza and Rajesh Sanap, Biodiversity of Aarey Milk Colony & Film City, A Report Submitted to Government of Maharashtra and Forest Department of Maharashtra, January 2010. Also noted in the judgement of the Bombay High Court in Vanashakti and ors. Vs Union of India and ors. 1487 of 2019.

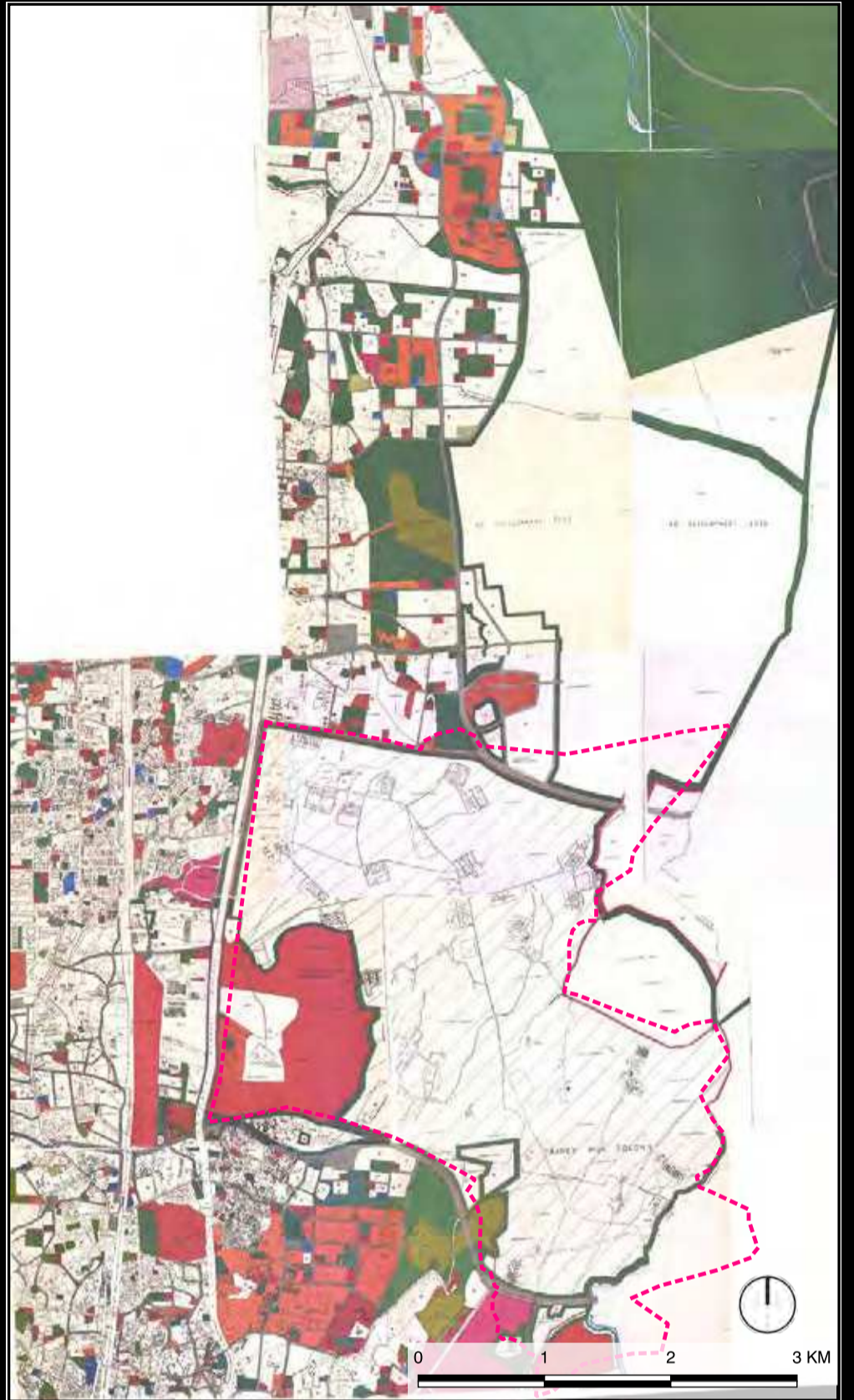
4. Indorewala, Hussain, Shweta Wagh, Uttara Ramakrishnan, and Omkar Nandlaskar (2017), Mumbai City Resume. Report prepared in the BINUCOM (Building Inclusive Urban Communities) project, funded by the Erasmus+ Program of the European Union. KRVA Research and Design Cell, Mumbai.

5. Hussain Indorewala & Shweta Wagh, "Here is Why Mumbai Floods Year After Year", The Wire.in, 20th July 2018.

6. Clara Lewis, "Mithi floods due to 600 acres reclaimed for BKC, SC told", Times of India, 8th September 2019.



DP 1964: This is the 1964 Proposed Land Use (PLU) of the Development Plan that shows the extent of 'Aarey Milk Colony' between the SGNP on the east and the Western Express Highway forming its western edge.



DP 1981: This map of the 1981 Development Plan's Proposed Land Use (PLU) is overlaid with the boundary of Aarey Colony extracted from the 1964 Plan (in pink dotted line). Notice the reservations in the south-west corner for the veterinary hospital and transit housing. Also notice the plots for Film City and an excluded part that would become Royal Palms golf course in the 1990s.

1

Location, Adjacencies and Administrative boundaries

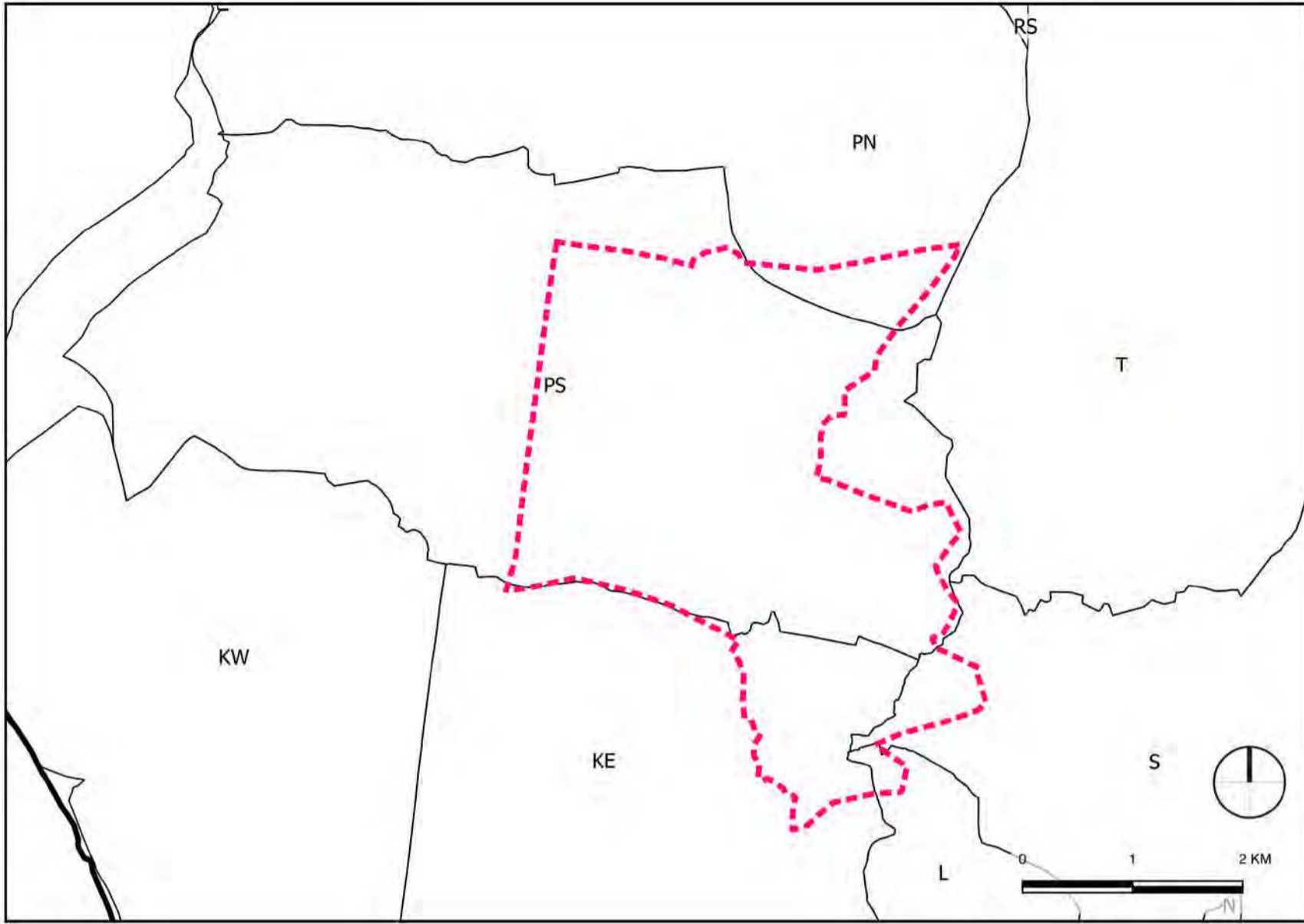
Faced with acute milk shortage and problems of poor quality, in 1945 a Milk Department was created by the Government of Bombay. An area of 1,100 acres "about 20 miles north of Bombay" was acquired from the village of Aarey in November 1945 to set up a Government dairy farm for 1,000 buffaloes. A few months later, the Government issued a directive to expand the Colony by 2,000 acres in order to establish 30 to 40 farms for relocating the cattle sheds and 15,000 cattle from the Island City.⁷

Aarey Colony is located towards the south-western edge of the Sanjay Gandhi National Park. The map above (left) shows the Aarey Colony boundaries as per the 1964 Development Plan of Greater Mumbai. According to the Dairy Development Department, 1,287 hectares of

land was acquired for the colony originally, but 430 hectares were subsequently allocated to other institutions for other uses.⁸ The map above (right) is the 1981 Development Plan, showing Aarey Colony as a No Development Zone (NDZ) with some of the earlier land parcels diverted for other uses. GIS mapping suggests that the PLU of the 1981 DP zoned approximately 990 hectares of Aarey as NDZ. On the facing page (above), the 1964 Aarey extent is overlaid on the administrative wards of Greater Mumbai, and it can be seen falling into the PN, PS, KE, S, L wards. On the facing page (below) is the Aarey 1964 boundary overlaid on the revenue villages of Suburban Mumbai, showing that Aarey falls within most of Aarey village, Pahadi Goregaon East, Marol Maroshi, Prajapur, Marol, Tungwe and Paspoli.

7. Brissenden, C. H. "The Bombay Milk Scheme." International Journal of Dairy Technology 5, no. 2 (1952): 108-114.

8. Dairy Development Department, Performance Budget 2013-14, Government of Maharashtra, 2013.



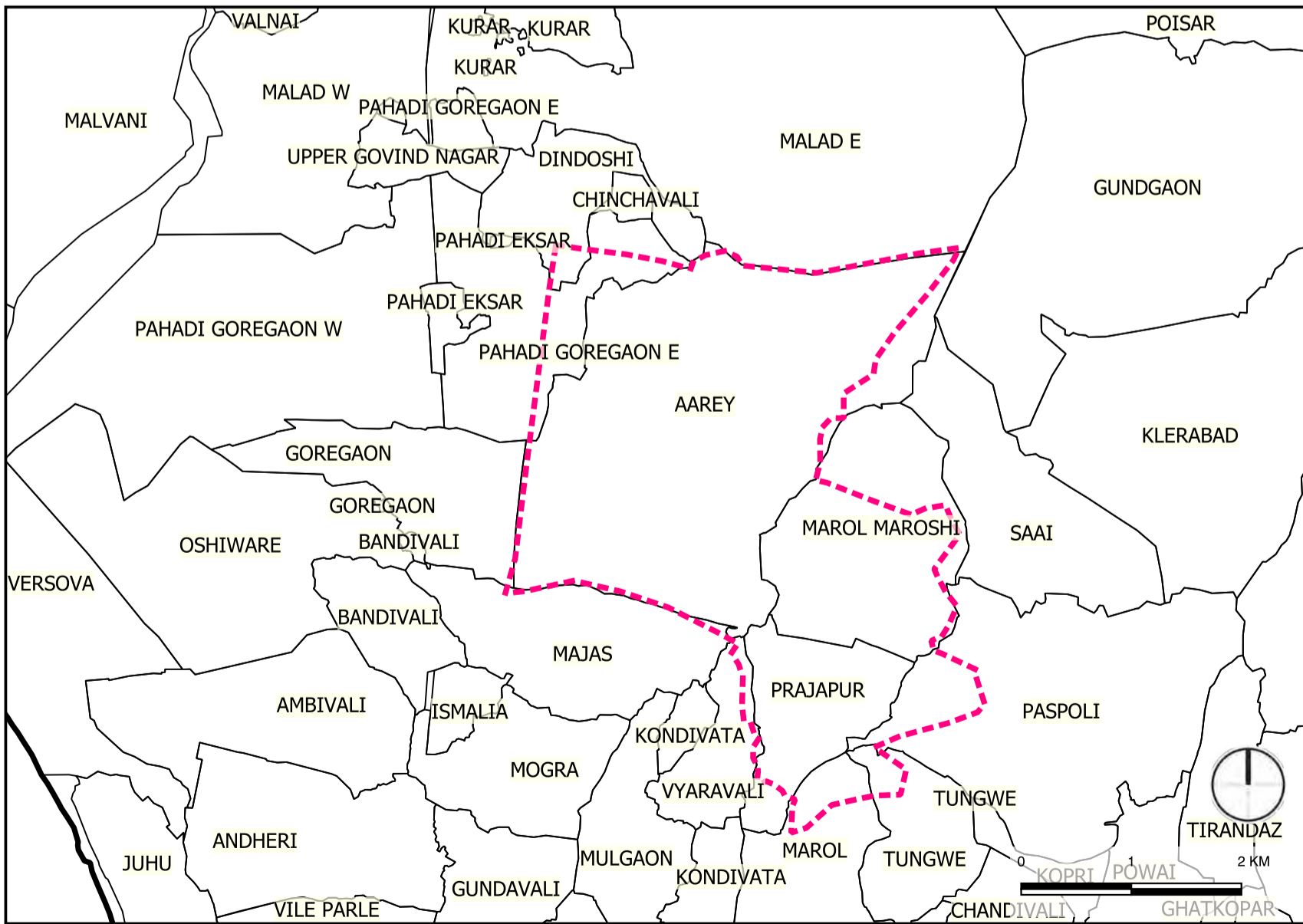
Note: This map of the administrative ward boundaries of Greater Mumbai is overlaid with the boundary of Aarey extracted from the 1964 Development Plan. When established, Aarey Milk Colony was part of PS, KE, L, S, and PN wards.

Suggested Reference:
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Administrative Ward Boundaries

Source: (1) Administrative Ward Boundaries extracted from Proposed Land Use Map, Revised Development Plan 2018-34 for Greater Mumbai, MCGM. (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.



Note: This map of the revenue villages of Mumbai is overlaid with the boundary of Aarey extracted from the 1964 Development Plan. When established, Aarey Milk Colony was part of Aarey village, Dindoshi, Pahadi Goregaon East, Marol Maroshi, Prajapur, Paspoli, Tungwe, and Marol villages.

Suggested Reference:
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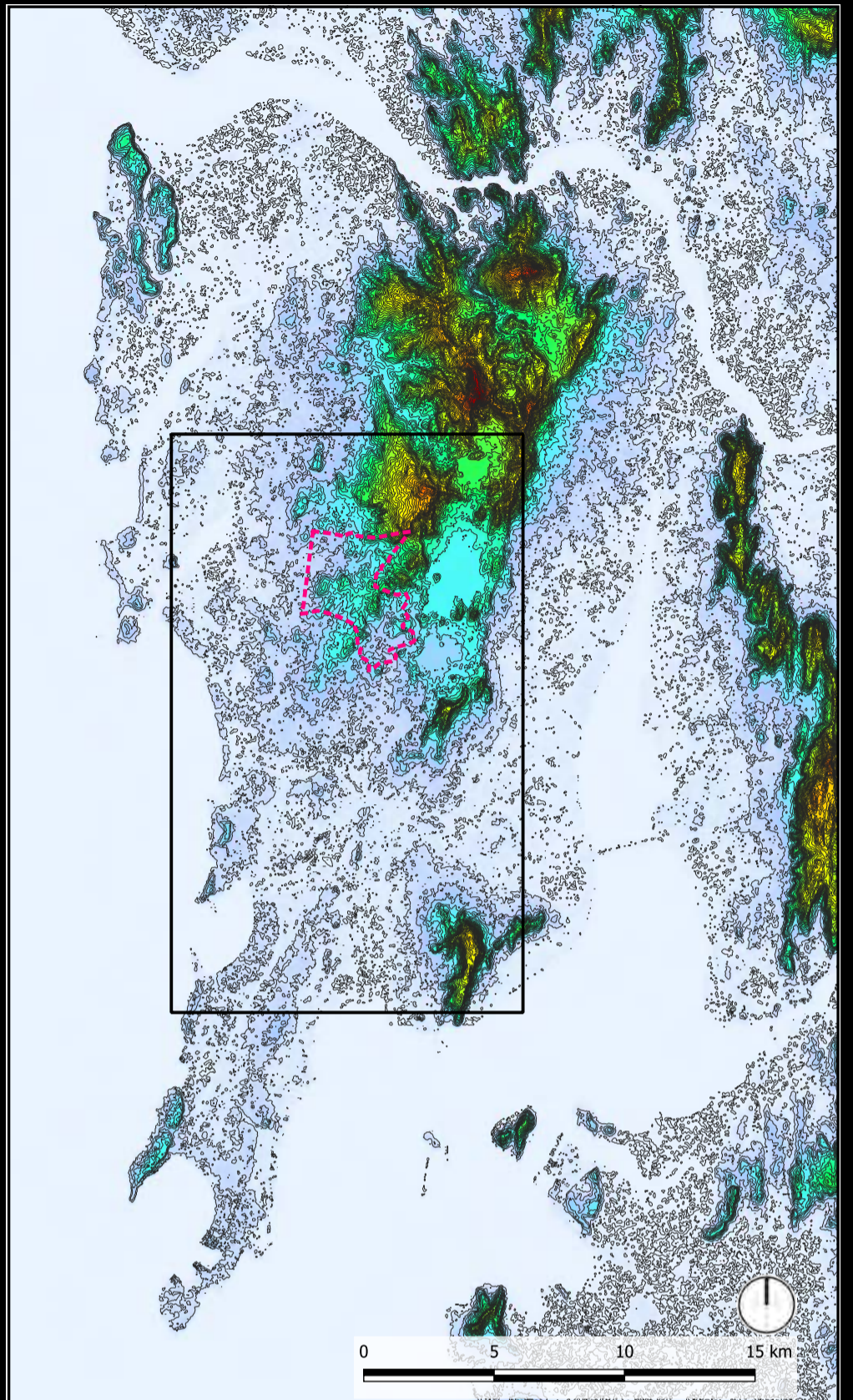
Revenue Village Boundaries

Source: (1) Revenue Village Boundaries extracted from Proposed Land Use Map, Revised Development Plan 2018-34 for Greater Mumbai, MCGM. (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.





Location of Aarey Milk Colony: This map indicates the study area (white box) on a satellite image of Mumbai. The boundary of Aarey Colony (as per the 1964 Development Plan) is shown as a dotted pink outline. The map shows the contiguity of Aarey with the Sanjay Gandhi National Park and proximity to the Powai and Vihar lakes.



Elevation Map of Mumbai: This map shows the elevation of land in Greater Mumbai (higher elevations are in warmer colors and low lying areas in cooler colors). The study area is highlighted as the black box. The boundary of Aarey (as per the 1964 Development Plan) is shown as the dotted pink outline. The map shows the hill complex at the center of Salsette, that slopes downward on all sides towards the Arabian sea in the west, the Ulhas estuary in the north, the Thane creek in the east and the Mahim bay in the south.

2

Mumbai Satellite image and Terrain Map

The Map to the left shows a Google image of the city and indicates the location of the study area. The study area comprises of the catchment areas of the Mithi and Oshiwara rivers which originate in Sanjay Gandhi National Park and Aarey. The area of Aarey as designated in the 1964 development plan has been indicated on the Google map.

To the right is a terrain/elevation map of the city. At the centre of Salsette there is a hill complex that runs north-south reaching 467 m at its highest point. From here the land slopes downward on all sides -towards the tidal swamps and Arabian Sea in the West, the Ulhas estuary in the north, Thane creek in the east and Mahim bay in the south. Two spurs running south enclose a wide valley, the higher western one extending till

Jogeshwari and the lower eastern one extending upto Ghatkopar and Kurla. In addition there is the coastal hill system of Uttan-Dongri towards the North West and the Trombay hill towards the south. The average elevation of the city is 14 meters. The highest point in Salsette is about 450 mts located in Powai-Kanheri ranges.⁹

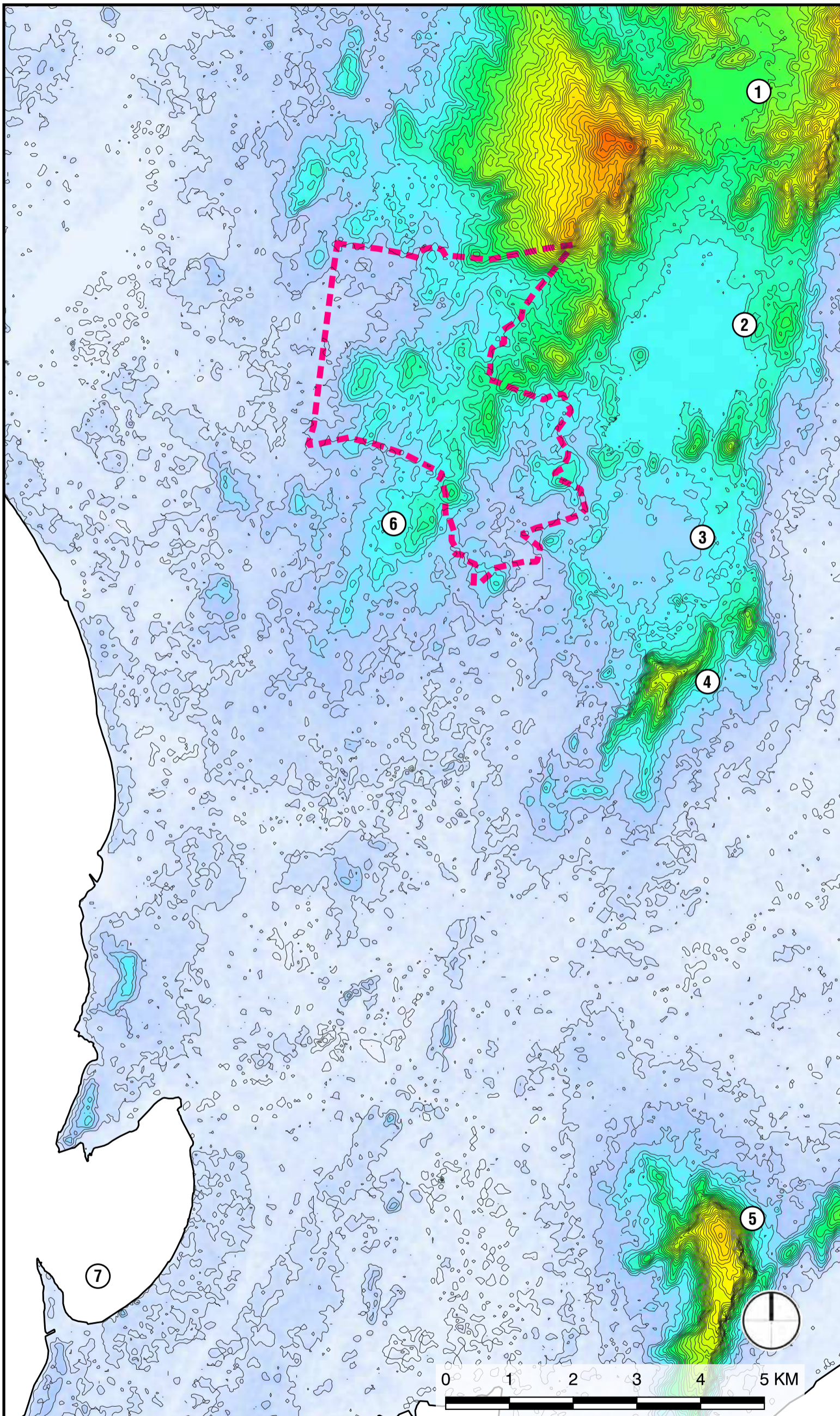
The map on the opposite page has a detailed elevation map showing elevation of the study area. The area of Aarey Milk Colony has an elevation approximately ranging from 25mts to 200mts.

The landforms present in Mumbai are carved out by a combination of denudational, fluvial and marine processes. Most of the hills of the Borivali National Park can be described as Cuestas which

are landforms of denudational origin with gentle dip slope on one side and an escarpment on the other.*

9. Sudha Srivastava and Dipti Mukherji, "Emerging Cityscape and Environmental Issues", from Rohan D'Souza ed. Environment, Technology and Development, Orient Blackswan Private Limited & Economic and Political Weekly, 2012.

* Rani, V. R., H. S. Pandalai, K. S. Sajinkumar, and A. P. Pradeepkumar. "Geomorphology and Its Implication in Urban Groundwater Environment: Case Study from Mumbai, India." Applied Water Science 5, no. 2 (June 1, 2015): 137–51.



NOTE: This map shows the elevation of land in the study area (higher elevations are in warmer colors and low lying areas in cooler colors). The thin black lines indicate contours at 10 meter intervals. The outline of Aarey (as per the 1964 Development Plan) is shown as the dotted pink outline. The Aarey colony has an elevation that ranges from 25 meters to 200 meters above Mean Sea Level.

LABELS:

1. Tulsi Lake
2. Vihar Lake
3. Powai Lake
4. Ghatkopar Hills
5. Trombay Hills
6. Jogeshwari Hills
7. Mahim Bay

Suggested Reference:

Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Contours at 10m interval

Elevation Heights

- 0m
- 0 - 25m
- 26 - 50m
- 51 - 100m
- 101 - 150m
- 151 - 200m
- 201 - 250m
- 251 - 300m
- 301 - 350m
- 350 - 400m
- 401 - 450m
- 451 - 500m

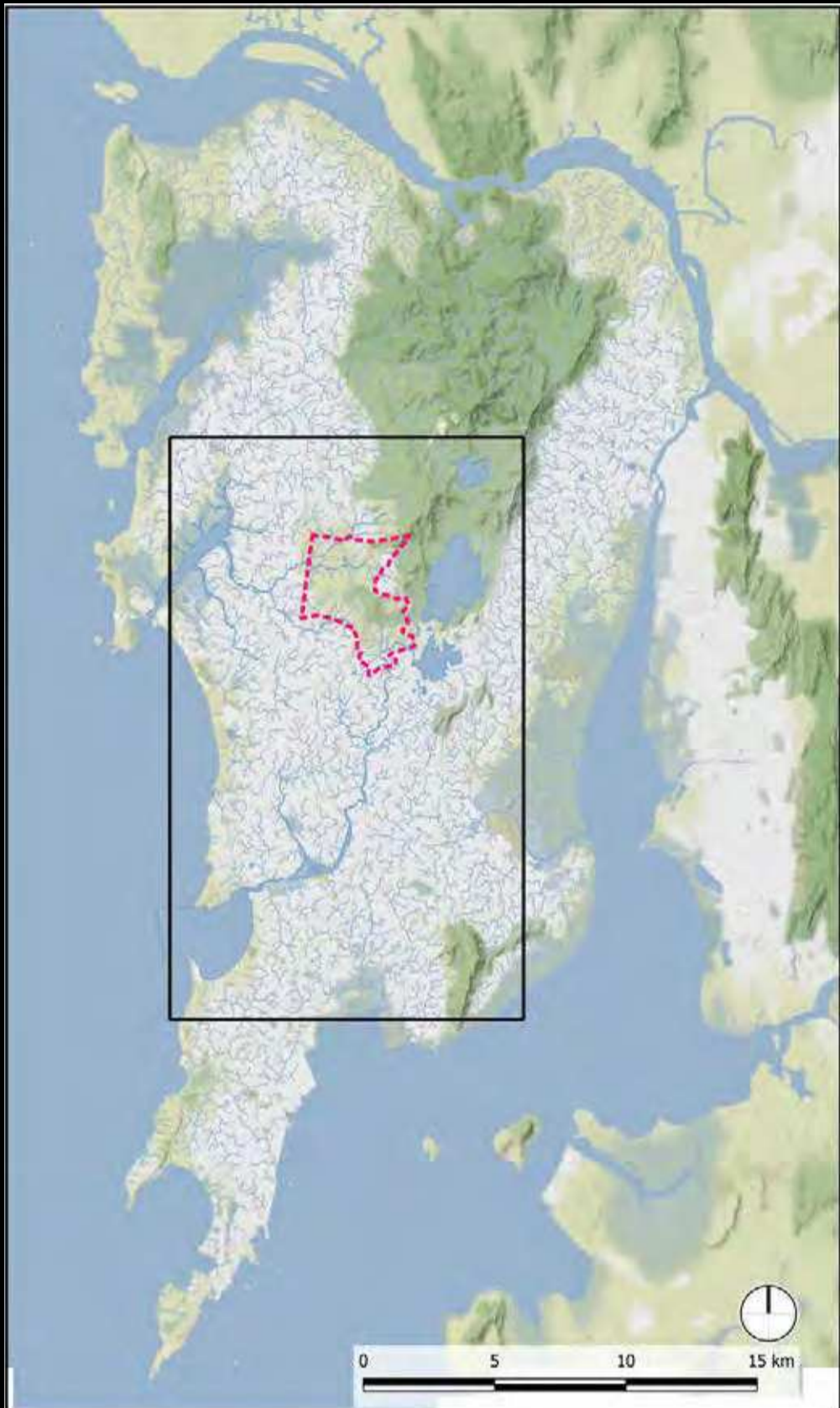


KRVIA Research and Design Cell

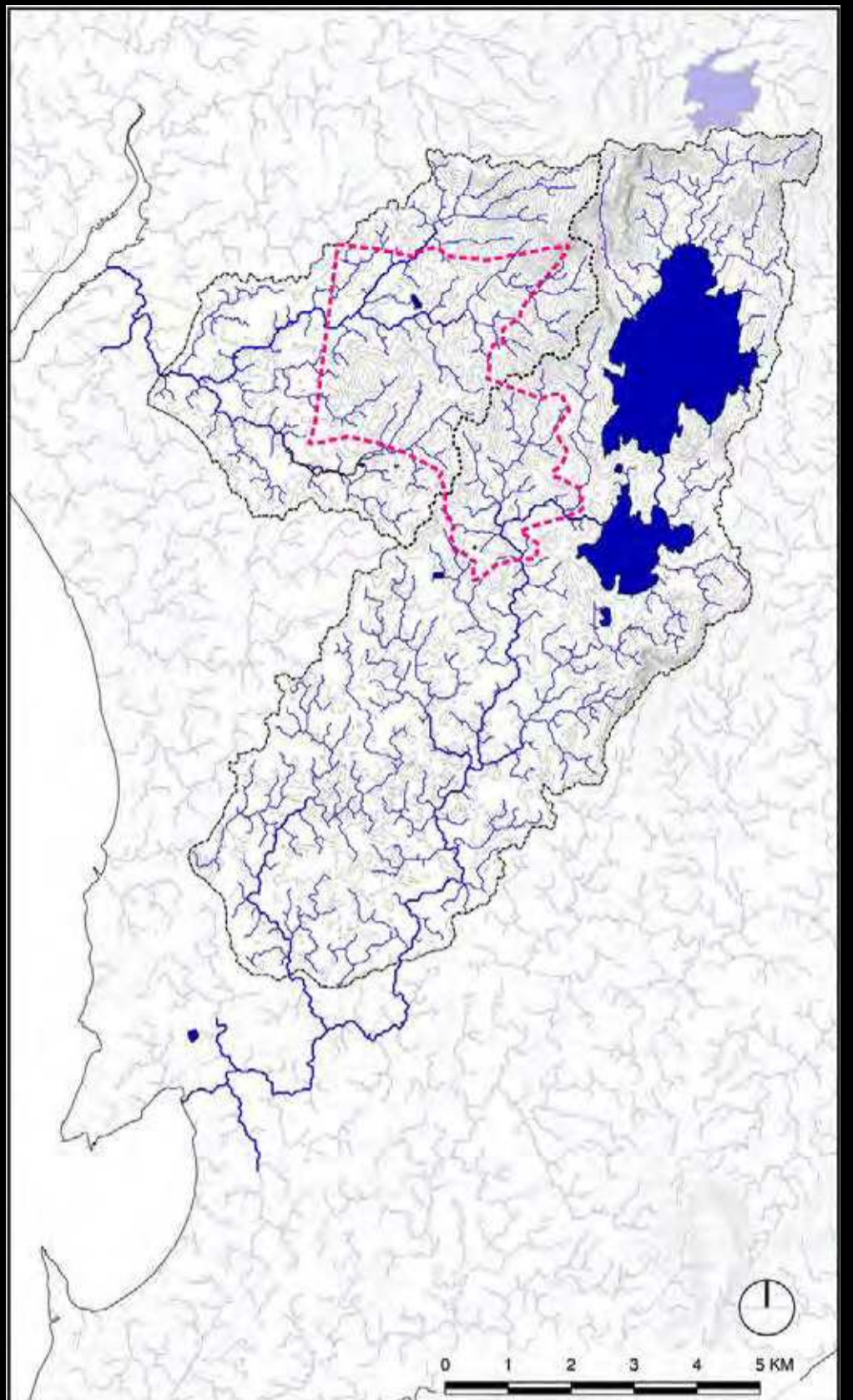
Elevation Map of Study Area

Source: (1) Contours extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/F7PR7TFT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.





Terrain and Surface Drainage of Mumbai: This map shows the terrain of Greater Mumbai and the surface drainage (streams and rivers) of the rain-fed rivers that originate from the hill complex in and around the Sanjay Gandhi National Park. The black box indicates the study area, and the pink dotted line indicates the outline of Aarey (as per the 1964 Development Plan).



Drainage Basins of the Oshiwara and Mithi Rivers: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with a contour map of the study area at 10 meter intervals. The Mithi river (that runs diagonally from top right to bottom left) and Oshiwara river (top right to left) can be seen. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown with stream networks (indicated in deep blue) that feed the two rivers. The ridge line that cuts diagonally through Aarey (emphasised by the dotted black line) separates the two basins. The Vihar & Powai lakes can be seen on right (deep blue).

3

Natural Drainage Basins and Catchment Areas

Rivers and streams are an important part of the hydrological cycle, and are contiguous ecological systems that connect source regions and estuarine regions. Drainage basins are erosion created landforms sculpted predominantly by the actions of flowing water. A drainage basin (or catchment / watershed) is separated from other drainage basins by its drainage divide, a boundary that encircles a basin along its highest outermost ridgetops. The drainage basin is recognised as a fundamental geomorphological unit and is frequently used as the primary landscape unit for hydrological watersupply and ecological investigations for land management activities.¹⁰

The map to the left above shows the major lakes and surface drainage systems overlaid on a 3D model of the terrain of the city. The major rivers

in Mumbai originate in the Hilly core of Salsette island. A radial drainage pattern is observed around the hill complex of Salsette which forms an important catchment area for the rivers that originate here.¹¹ The study area which comprises of the drainage basins (catchment areas) of the Mithi and Oshiwara rivers is also indicated.

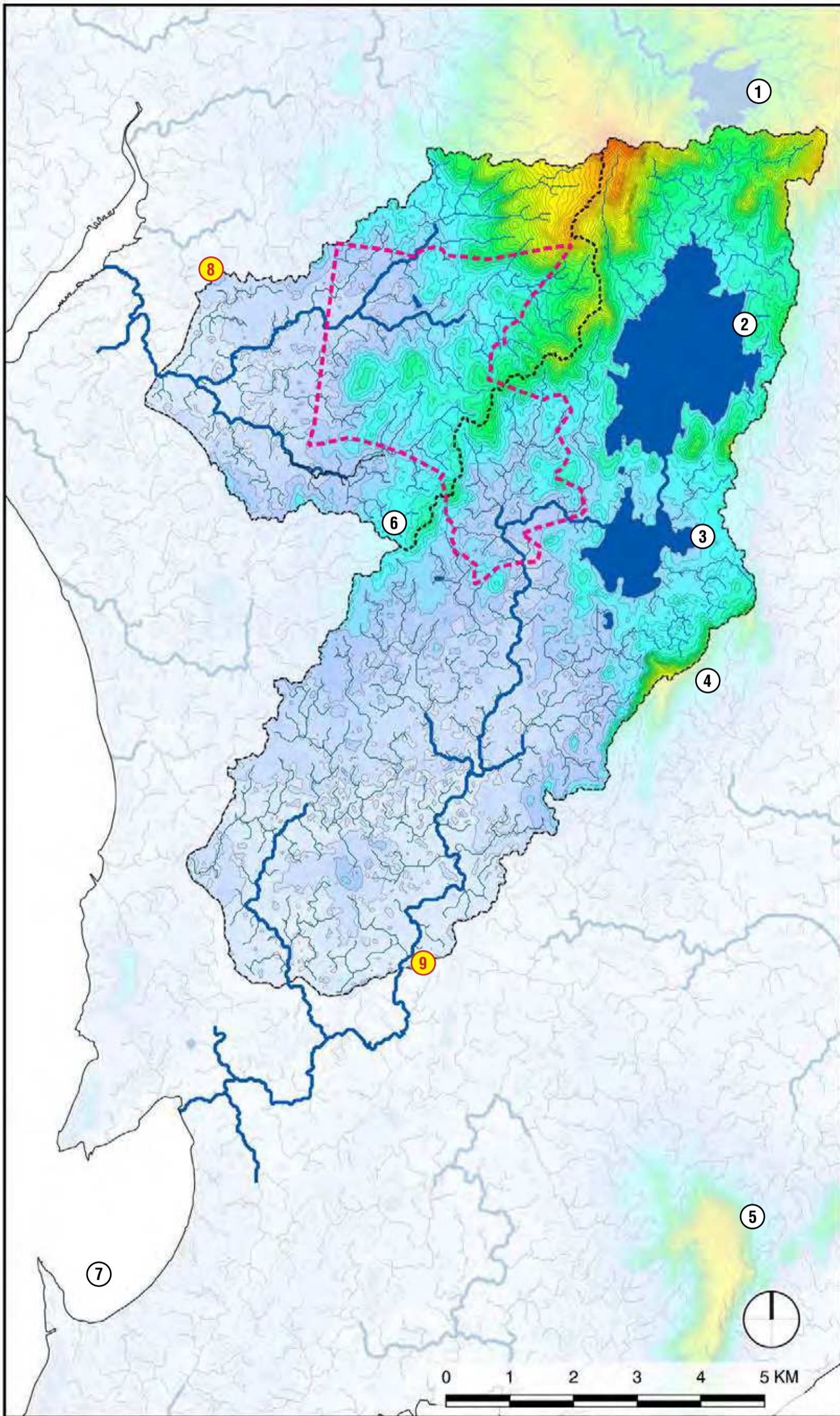
The map to the above right shows the contours, streams (channel flow) and the drainage basins (catchments) of the Mithi & Oshiwara rivers. The map on the opposite page shows the contours, streams and catchment areas overlaid on the elevation map. Tulsi, Vihar and Powai lakes are located within the hill complex in the Upper Salsette region and were created by damming the rivers that originate here. Overflow from the Vihar and Powai lakes now flows into the

Mithi river. The streams and tributaries that feed the Mithi river originate in the Sanjay Gandhi National Park and Aarey. The streams that feed the Oshiwara river largely originate in Aarey Colony. Aarey therefore constitutes an area where tributaries that feed both these rivers originate. The Pranab Sen Committee Report prepared in 2000 identifies "areas where rivers originate" as "so compelling in terms of...ecological significance that they do not require any other justification for protection and conservation."¹²

10. *ibid.*

11. A catchment or a watershed is the area which drains stormwater and runoff into a surface water body such as a river, lake or wetland. For the purposes of this study, areas of the river under tidal influence have not been included as part of the catchment area.

12. Pranab Sen, et. al, Report of The Committee on Identifying Parameters for Designating Ecologically Sensitive Areas in India, Ministry of Environments and Forests, Gol, September 2000.



NOTE: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with an elevation map of the study area with contours at 10 meter intervals. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown indicating the natural drainage channels and stream networks that feed the two rivers. The ridge line that cuts diagonally through Aarey (emphasised by the dotted black line) separates the two basins. The Vihar and Powai lakes can be seen on the right (deep blue).

- LABELS:**
- | | |
|---------------------|-----------------------|
| 1. Tulsi Lake | 7. Mahim Bay |
| 2. Vihar Lake | 8. Oshiwara Catchment |
| 3. Powai Lake | 9. Mithi Catchment |
| 4. Ghatkopar Hills | |
| 5. Trombay Hills | |
| 6. Jogeshwari Hills | |

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

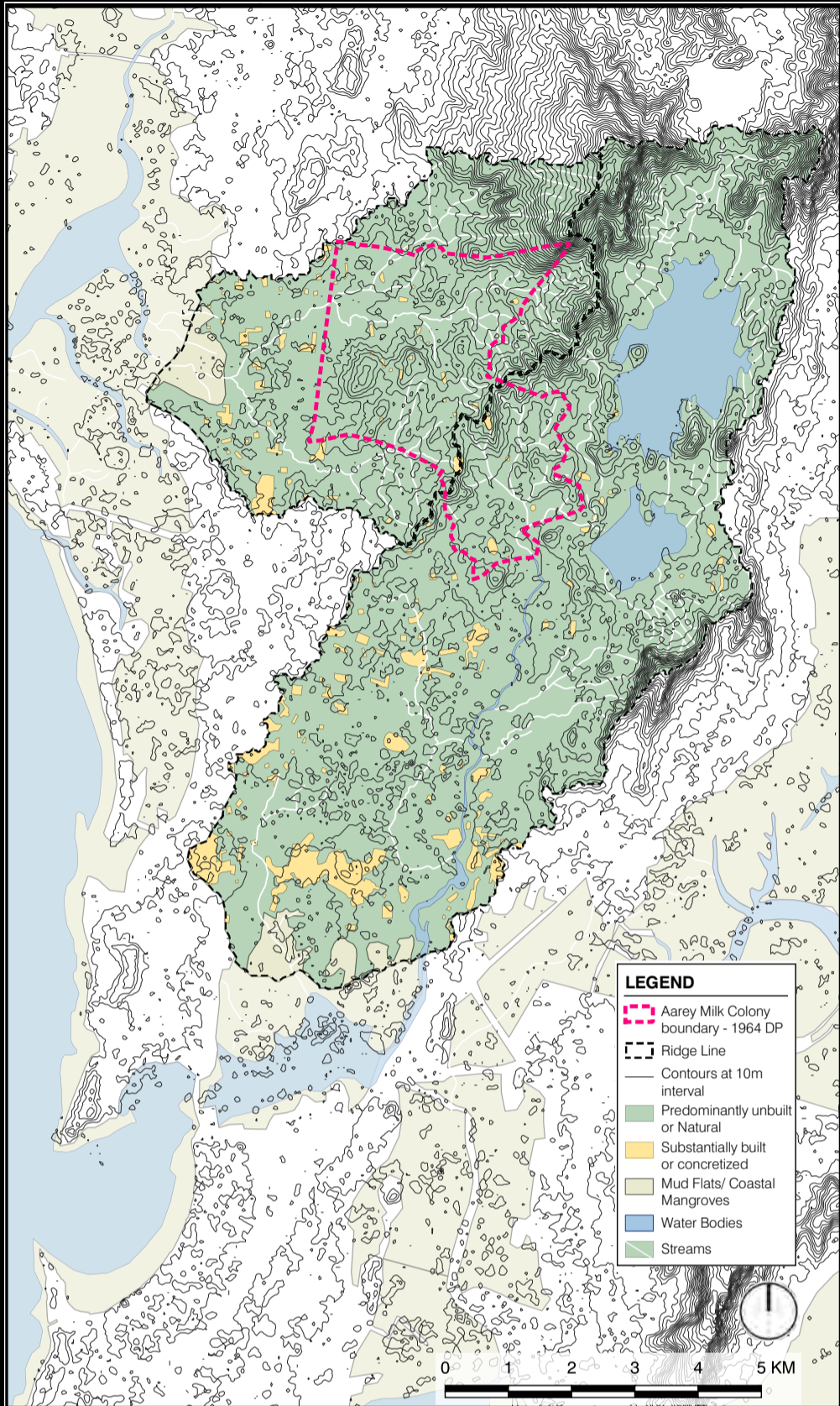
Suggested Reference:
 Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

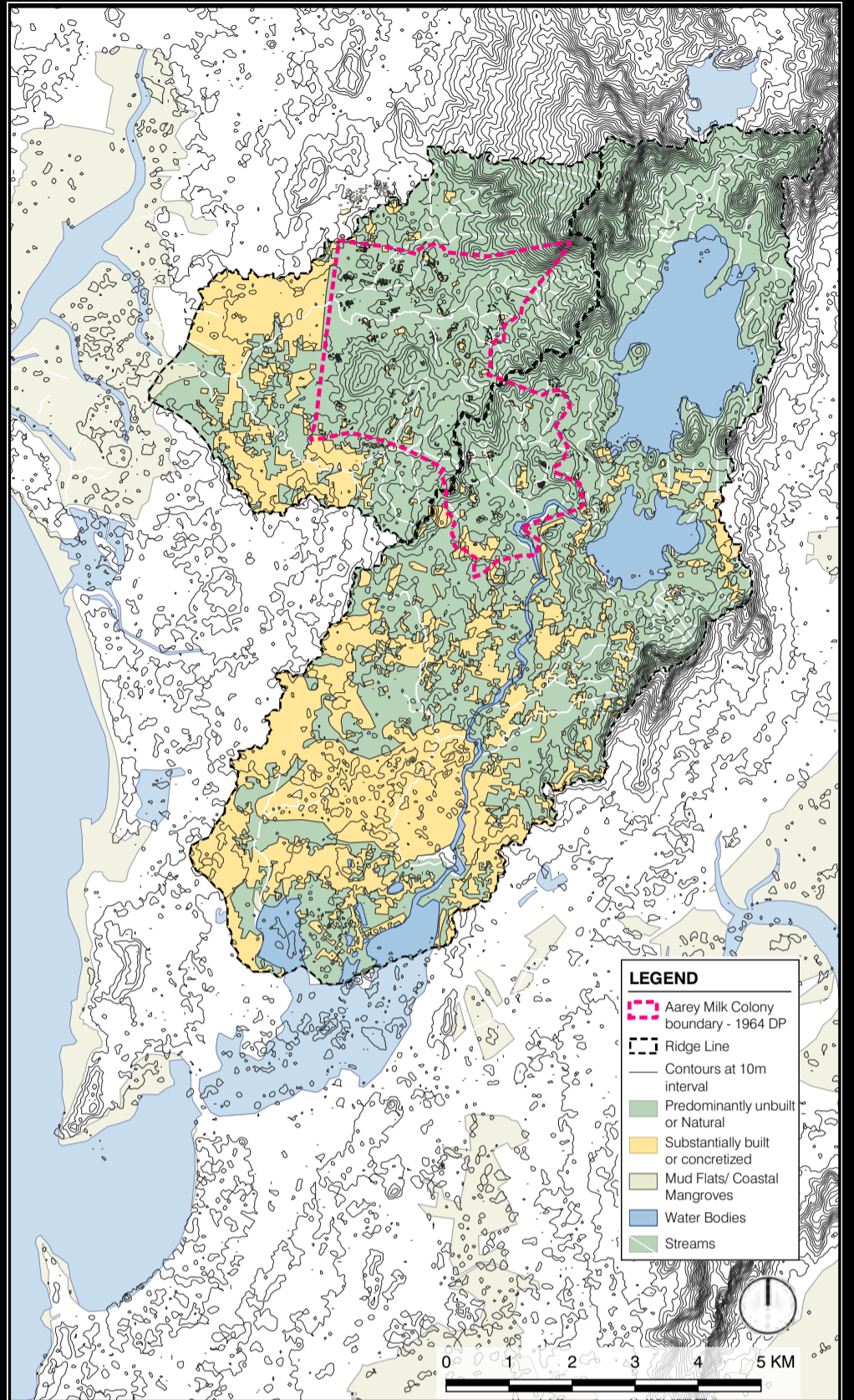
- - - Aarey Milk Colony boundary - 1964 DP
- Ridge Lines
- Lakes
- Major streams
- Contours at 10m intervals
- Minor streams

Elevation Heights

 0m
 0 - 25m
 26 - 50m
 51 - 100m
 101 - 150m
 151 - 200m
 201 - 250m
 251 - 300m
 301 - 350m
 350 - 400m
 401 - 450m
 451 - 500m



Land Cover Map of Aarey and its Surroundings (1926): This map shows the broad land cover of 1926 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or natural areas, and yellow denotes substantially built or concretised areas. Aarey Milk Colony did not exist in 1926 - the pink outline of Aarey extracted from the 1964 Development Plan is shown here for orientation only.



Land Cover Map of Aarey and its Surroundings (1966): This map shows the broad land cover of 1966 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or natural areas, and yellow denotes substantially built or concretised areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line.

4

Land Cover Change in the catchment

The four maps on this spread indicate the broad landcover change in the catchments of the Mithi and Oshiwara rivers between the years 1926 and 2019. The boundary of Aarey Milk Colony as per the 1964 development plan has been shown in a pink dotted line.

The land-cover map of 1926 shows that the catchment areas of the Mithi and Oshiwara rivers are predominantly unbuilt or natural and very few areas in the catchments are substantially built-up or concretised. These largely include pre-urban settlements inhabited by agrarian and forest dwelling communities.

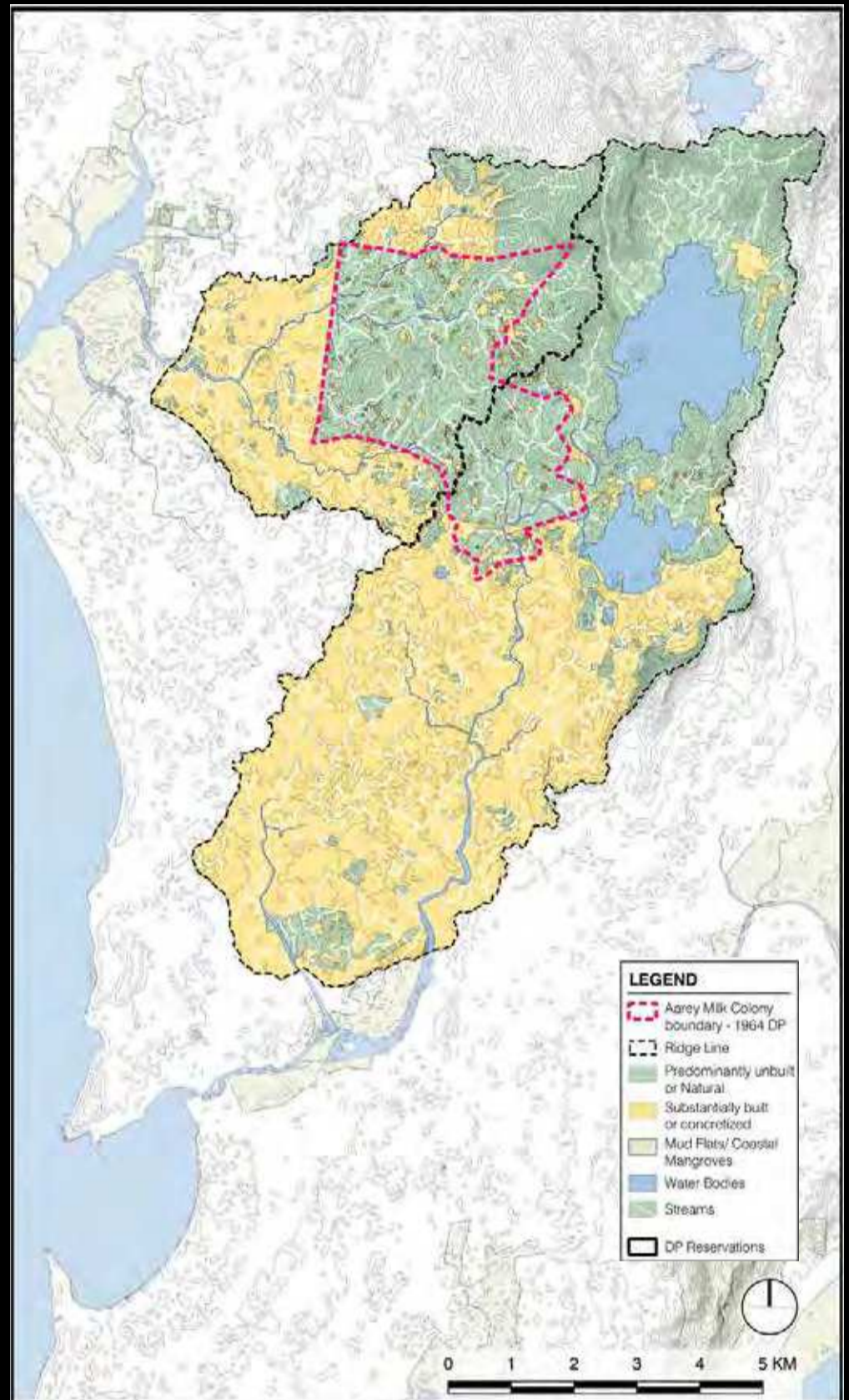
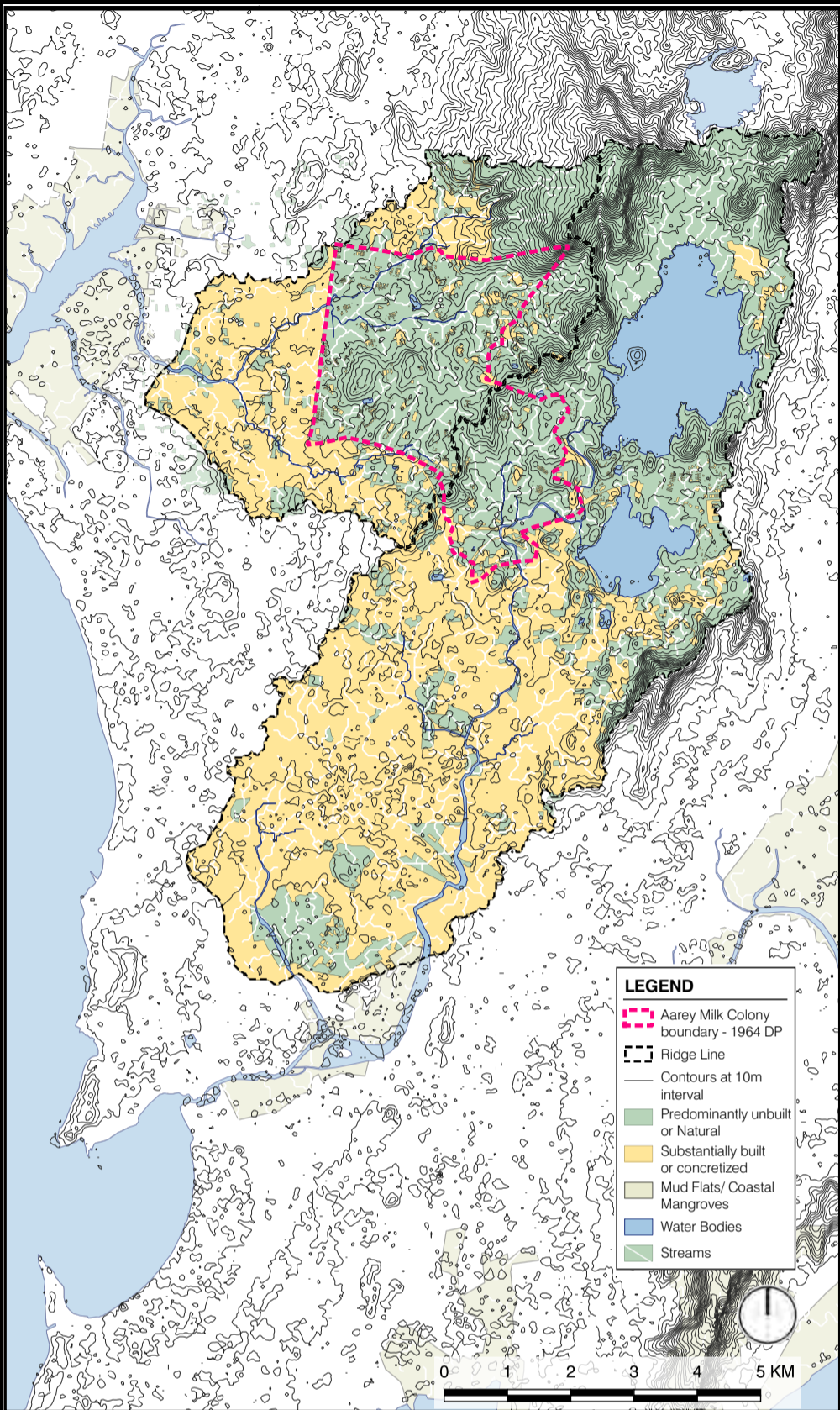
The land-cover map of 196 shows a substantial increase in the built up and concretised area in the catchment. Although a marginal increase in built up area in Aarey Colony is seen as a result of

its designation as a milk colony, it still retains its natural cover in comparison to remaining areas of the Catchments of the Mithi and Oshiwara rivers .

The land-cover map of 2004 shows that almost the entire catchments of the Mithi and Oshiwara rivers are built up or concretized except for a few areas including Aarey, the SGNP and surrounding hilly areas. In this map it is seen that despite high- intensity construction in surrounding areas, the SGNP is not affected due to its protected area status and Aarey remains largely under green cover due to its NDZ status that allowed only low-intensity uses.

The land-cover map of 2019 on the opposite page shows fragmentation of forest and natural vegetation cover in Aarey and surrounding areas

due to dereservation of and forest and NDZ areas and anthropogenic pressures.



Land Cover Map of Aarey and its Surroundings (2004): This map shows the broad land cover of 2004 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or natural areas, and yellow denotes substantially built or concretised areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line. Much of the area of the catchments outside the SGNP and Aarey are substantially built-up.

Land Cover Map of Aarey and its Surroundings (2018): This map shows the broad land cover of 2018 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or natural areas, and yellow denotes substantially built or developed areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line. Almost the entire area of the catchments outside the SGNP and Aarey are substantially built-up.

Note for above Maps (on pages 18,19):

Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.



5

Existing Landcover, Ecosystems, Wildlife and Habitats

A 2010 study titled the 'Biodiversity of Aarey Milk Colony and Film City'¹³ authored by Zeeshan Mirza and Rajesh Sanap identifies various habitats in the Aarey colony area including scrub forest, seasonal freshwater marshes, hillocks with various degrees of plant cover, rocky outcrops, grassland and scrub which sustain diverse forms of flora and fauna, and make the area significant for its biodiversity. A status report¹⁴ on the vegetation of Aarey prepared by St Xaviers College in 2019, observes that Aarey Colony is contiguous with Sanjay Gandhi National Park (SGNP) and has a floral and faunal composition which is similar to that of the National Park.

The report also classifies the forest vegetation in Aarey as mixed moist deciduous type which largely consists of "species which are recognized by botanists and foresters as being 'forest species' that are indigenous and have survived by self-propagation, apart from species planted

by the forest department, nature enthusiasts or indigenous and forest dependent communities for their sustenance. The report states that the presence of the forest tree species, lianas which do not occur outside forests, orchids and species of lichen which are an indicator of natural vegetation, the sightings of leopards in the area as well as the presence of spiders, scorpions and other invertebrates confirm the conclusion that Aarey Milk Colony is an extension of SGNP."

Another study titled "Wildlife, Biodiversity and landscape features of Aarey Milk Colony - A long-term Study (1986-2019)" * undertaken by Sprouts Environmental Trust pointed out that the "juxtaposition of densely forested habitats, natural and man-made grasslands, riverine vegetation, plantations, cattle sheds and small built up complexes, and its contiguity with the Sanjay Gandhi National Park (SGNP), provided AMC with unique and diverse ecosystems and

ecotones, unavailable even in the SGNP." The study identified 136 varieties of birds, 85+15 varieties of butterflies and moths, 13 varieties of amphibians, 47 varieties of reptiles, 90+20 varieties of Spiders and other Arachnids, 22+70 varieties of Ants and other Insects, 100 varieties of Bugs and Beetles, 40 varieties of Dragonflies and Damselflies, 19 varieties of Mammals. Aarey also "harbors several Scheduled (1, 2, 3 & 4) species, protected under the Wildlife(Protection) Act, 1972 and given special status (Vulnerable, Near Threatened & Endangered) and attention by the IUCN (2002)." These scientific findings, it noted,"makes Aarey Milk Colony, a site of very high biodiversity and critical from a conservation point of view. Any permanent and large-scale industrial, infrastructure or residential construction or establishment can permanently damage the biodiversity and cause local or global extinction of these range restricted and cryptic species. (Refer to Annex 2, Pg 54)



Chota Kashmir Picnic Spot

View of Aarey Milk Colony and its Surroundings showing forest cover and natural ecosystems

The image above is an aerial view of the Aarey colony, which shows natural ecosystems and habitats interspersed with settlement areas, pasturelands and cultivated areas. These include buildings related to the dairy, indigenous villages or adivasi-padas, informal settlements and newer constructions and apartment buildings seen towards the left of the image. New developments proposed in Aarey will impact these sensitive habitats and ecosystems.

13. Zeeshan Mirza and Rajesh Sanap, (2010). Biodiversity of Aarey Milk Colony & Film City, A Report Submitted to the Government of Maharashtra and the Forest Department of Maharashtra.

14. Shinde, Rajendra (2017). "Aarey Milk Colony, Mumbai as Forest Territory- A Status Report", XPIore - The Xavier's Research Journal, Vol 8, Issue 3 (Humanities & Social Sciences Edition),

* Anand Pendharkar et. al. "Wildlife, Biodiversity and landscape features of Aarey Milk Colony – A long-term Study (1986-2019)", Sprouts Environmental Trust, 2019.)

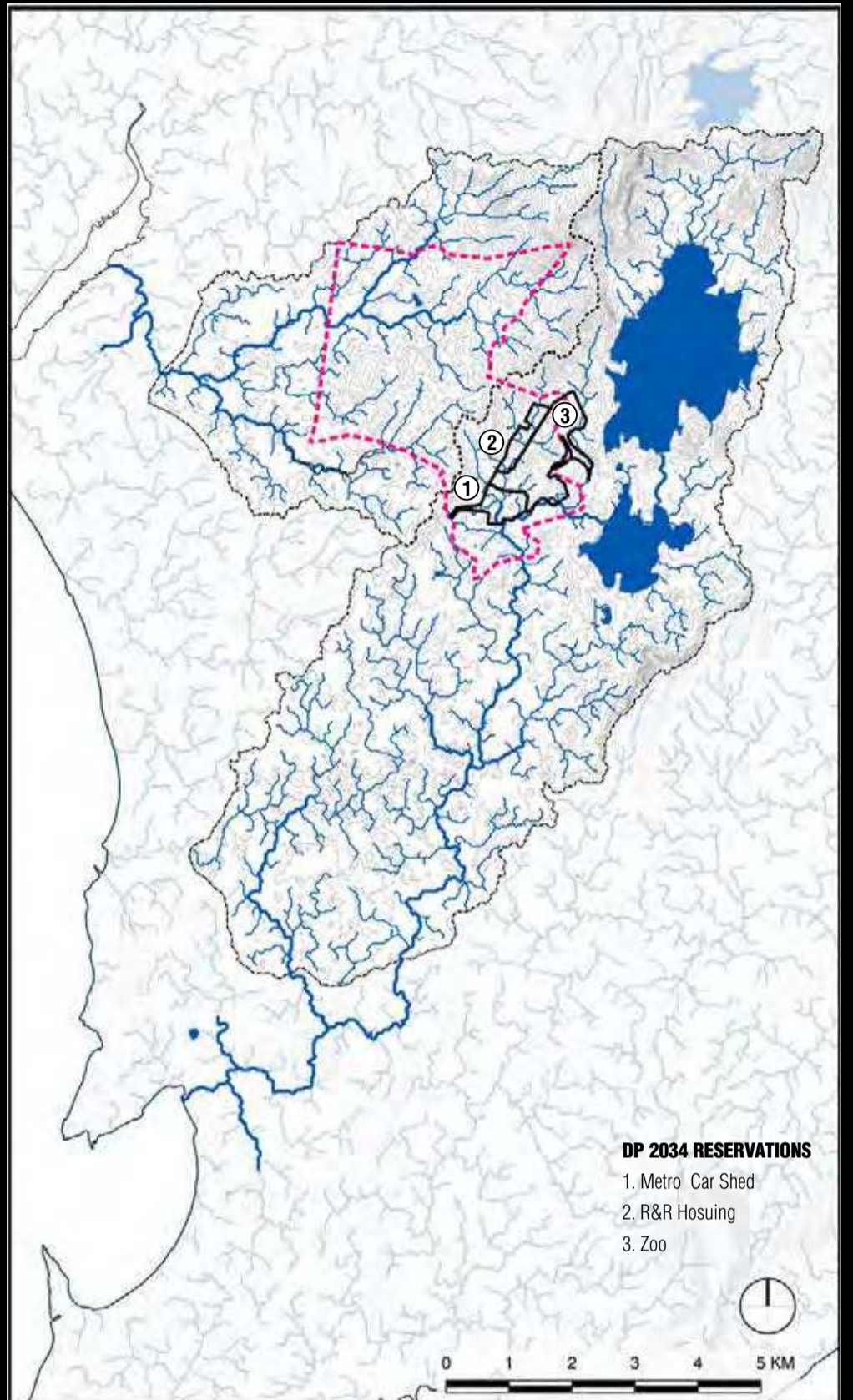
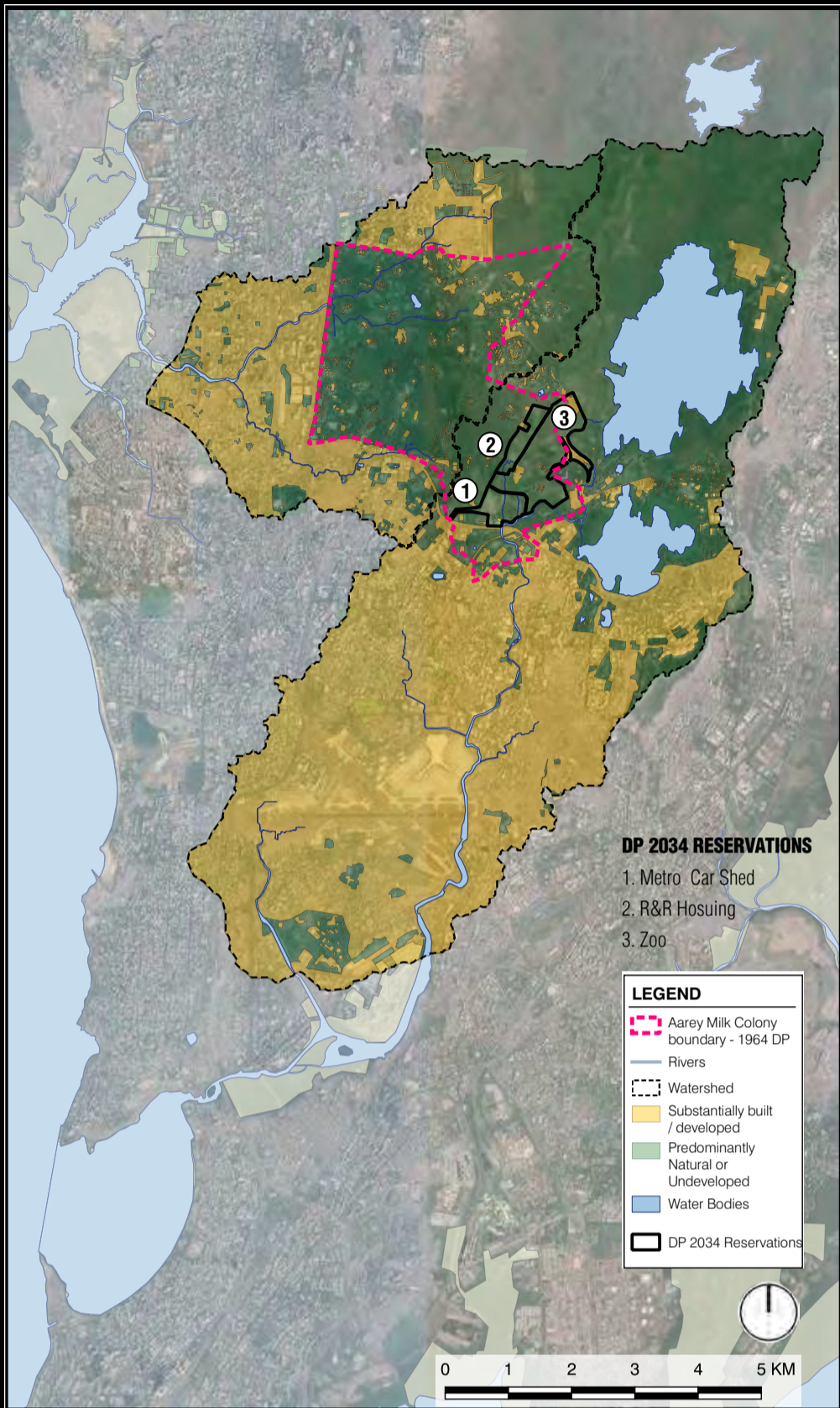


Hill Complex of SGNP





Densely forested hillocks and valley floors with natural and man-made grasslands.



Broad Land Use / Land Cover Map in the Catchment with DP Reservations: This map shows the areas of natural vegetation (in green) in the catchment areas of Oshiwara and Mithi rivers (indicated in dotted black line). Aarey is indicated in pink dotted line (as per the 1964 Development Plan). The plots highlighted with heavy black outlines indicate the reservations for the Metro Car Shed, Zoo and Housing. The map shows the extent of natural cover that will be affected by the new reservations, in the areas where the streams that feed the Mithi river originate.

Watersheds with DP Reservations: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with a contour map of the study area at 10 meter intervals. The black dotted outlines indicate the catchments of the Oshiwara and Mithi rivers. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown indicating the natural drainage channels and stream networks that feed the two rivers. The plots with heavy black outlines indicate the reservations for the Metro Car Shed, Zoo and Housing. The map shows that the proposed new developments are located in the upper catchment area of the Mithi river.

6

Impacts of Landuse and Landcover Change

The map above to the left shows the catchment areas of the Mithi and Oshiwara rivers overlaid with a broad land-cover map (showing areas that are substantially built up or concretised and areas that are predominantly natural or unbuilt). It is also overlaid with new reservations proposed in this area in the DP 2034.

The map to the above right shows the proposed reservations on existing streams and natural drainage channels. From these maps it is evident that proposed development in the catchment areas will adversely affect the regions where the first order streams and tributaries that feed these rivers originate.

As the Pranab Sen Committee report explains:
"Relatively minor disturbances near the origin of a river may result in major changes of the geological and hydrological features of the surrounding areas. This would have major repercussions on the river itself. In addition, this may cause enhanced erosion rates in the mountains, fluctuations in the hydrologic regimes

*in downstream, silt accumulation rates, flooding water in the low lands and natural system of recharge, all of which can result in serious ecological damage in surrounding areas."*¹⁵

The map on the facing page (above) shows the streams and watersheds in Aarey Colony overlaid with the 2034 Development Plan that shows proposed land uses. The map on the facing page (below) shows the contours, streams and watersheds in Aarey overlaid on a broad land cover map with specific reservations (Metro Car Shed, Zoo and Rehabilitation and Resettlement housing) in the Mithi river catchment. The maps show that land use changes for the proposed Metro Car Shed along with the zoo and rehabilitation housing will involve a substantial area where construction and concretisation of land in the catchment area of the Mithi river will take place.

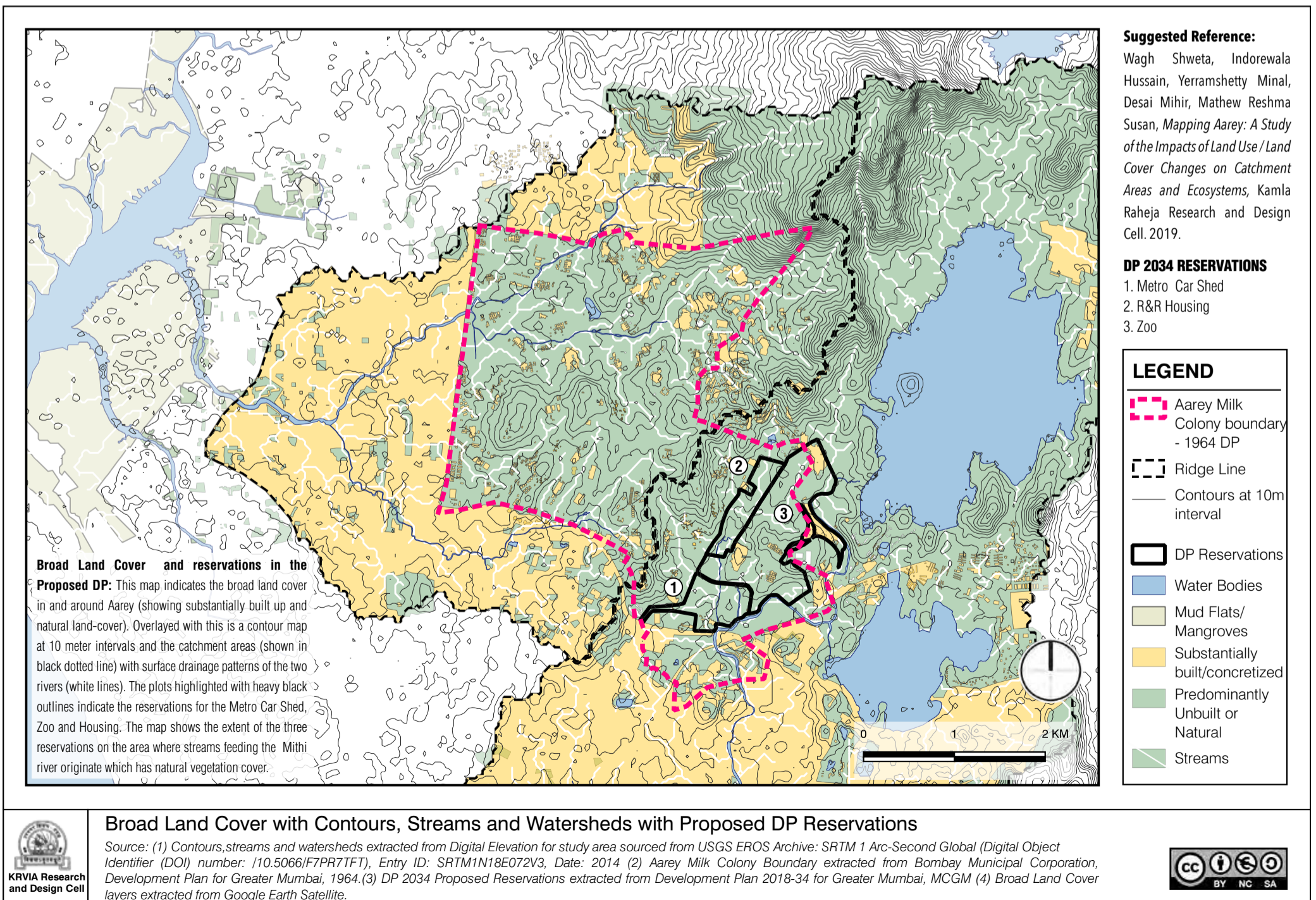
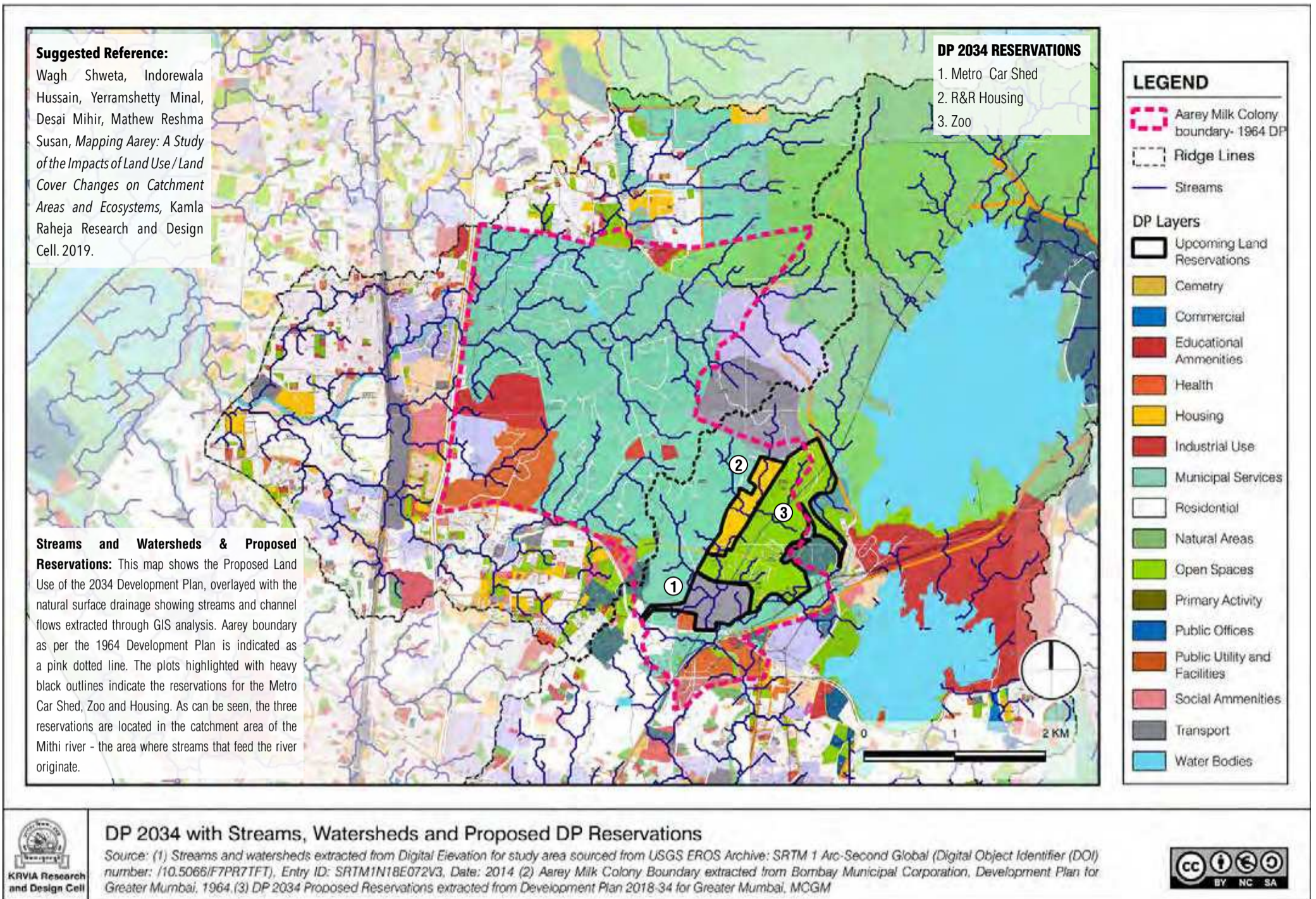
A study conducted by Dr Hrishikesh Samant and V. Subramanyan from the geology department at St Xaviers college pointed out the extent of drainage

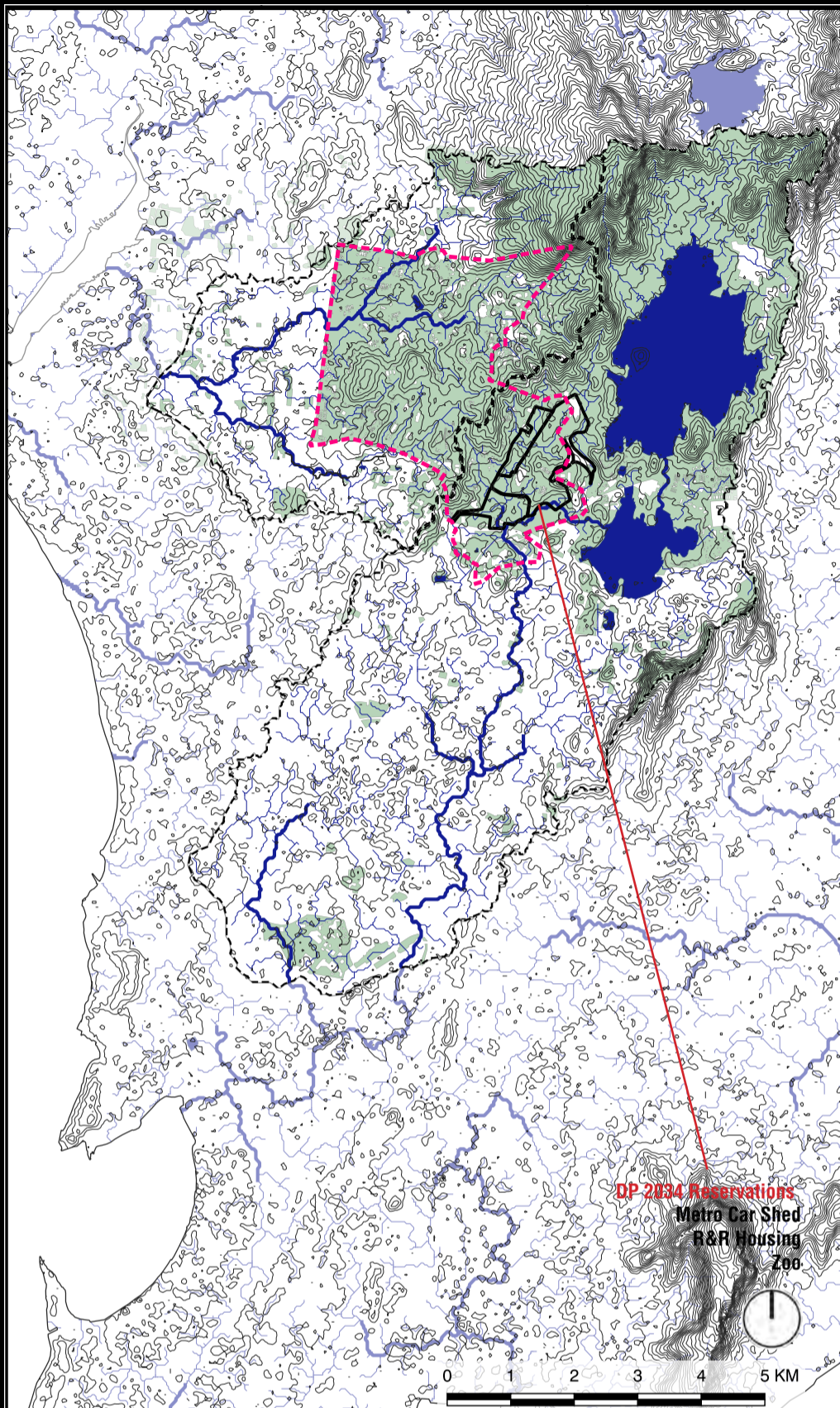
network disruption in Mumbai and Navi Mumbai. The study draws the link between anthropogenic activities that damage forest cover and drainage network of an area, with problems like monsoonal flooding.* Removal of soil from the upper reaches of the basin compounded by deforestation results in erosion and deepening of stream channels of first order streams, and the redeposition of silt in the lower reaches of the basin. This tends to reduce the water carrying capacity of the channel and increase the likelihood of flooding in adjoining densely populated and heavily built up areas.**

15. Pranab Sen, et. al, (2000). Report of The Committee on Identifying Parameters for Designating Ecologically Sensitive Areas in India, Ministry of Environments and Forests

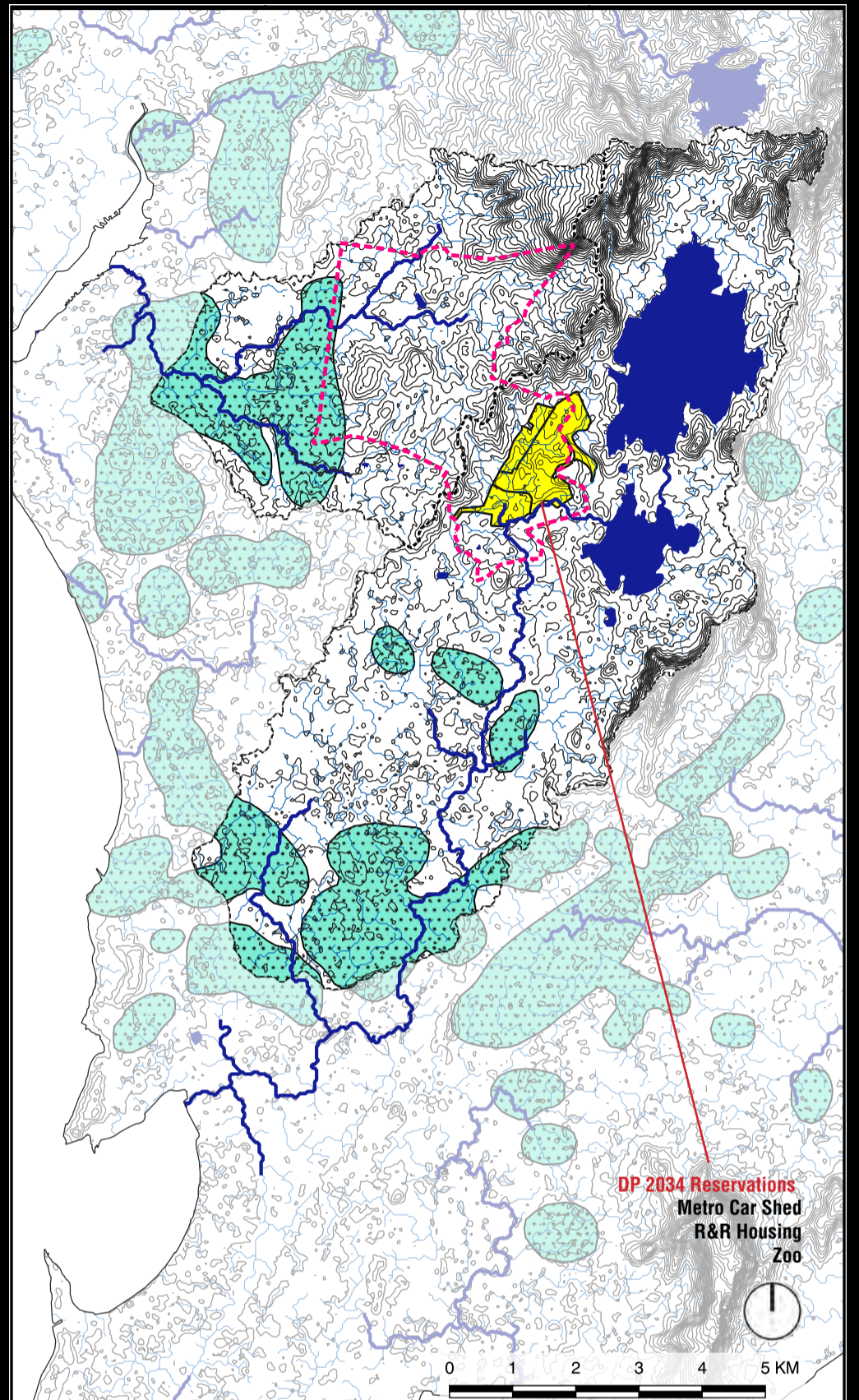
* Samant, Hrishikesh, and V Subramanyan. "Landuse/Land Cover Change in Mumbai-Navi Mumbai Cities and Its Effects on the Drainage Basins and Channels — A Study Using GIS." Journal of the Indian Society of Remote Sensing 26 (March 1, 1998): 1–6.

** ibid





Map showing Natural Vegetation in the Catchments overlaid with 2034 DP Reservations: This map shows the areas of natural vegetation (in green) in the catchment areas of Oshiwara and Mithi rivers (indicated in dotted black line). The thin black lines are contour intervals at 10 meters, and the thin blue lines indicate the surface drainage patterns of the two rivers. Aarey is indicated in pink dotted line (as per the 1964 Development Plan). The plots highlighted with heavy black outlines indicate the reservations for the Metro Car Shed, Zoo and Housing. The map shows the extent of natural cover that will be affected by the new reservations, in the areas where the streams that feed the Mithi river originate.



Map showing DP 2034 reservations in Catchment and Flood Prone areas: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with an elevation map of the study area with contours at 10 meter intervals. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown indicating the natural drainage basins and stream networks that feed the two rivers. The yellow highlighted area indicates reservations for the Metro Car Shed, Zoo and Housing. The green-blue areas show the flood prone areas of the two rivers. The land use changes in the upper catchment areas of the Mithi, that are comparatively steeper, are likely to exacerbate the flooding risks in the flood prone areas in the lower reaches of the basin

7

Flooding Risk due to Land Use Changes

The map to the left above shows the areas in the catchments covered with natural vegetation overlaid with streams and surface drainage networks in the catchment. This has been overlaid with the proposed DP 2034 reservations in the catchment: the Metro Car Shed, rehabilitation housing and the zoo. The map to the right above shows flooding areas from the Monograph on Flood Hazard prepared by the Envis Center on Human Settlements overlaid on the catchment areas of the Mithi and Oshiwara rivers showing surface drainage patterns.¹⁶

The photographs on the facing page taken at the Metro Car Shed area, show (1) the channelisation and diversion of the natural course of the Mithi with the construction of concrete embankments at the Metro Car Shed site and in urbanized areas further downstream;

(2) the destruction of vegetation, and changes to topographical conditions and modification of natural drainage channels at the Metro Car Shed site.

Typically in catchment areas in the region, on an average 30-35 percent of water percolates into the ground and contributes to subsurface flow. The remaining 65-70 percent of water is surface flow. The actual percentage of ground water percolation varies according to various factors. The slope of the terrain has direct control on surficial hydrological phenomena. Denudational landforms which have steeper slopes with exposed hard rock strata experience less infiltration or chance of recharge and more runoff, as compared with areas having steep slopes with forest cover. Here roots of trees penetrate the rock strata and increase the

percolative capacity of the ground. Ground water percolation is also higher in relatively less steep areas such as valley floors along streams where the velocity of water is comparatively lower. The area of Aarey which largely consists of densely forested hills interspersed with plains or valley floors, is therefore an area which has a higher capacity for ground water percolation.

The Madhav Chitale Committee report on Mumbai floods pointed out that "The soil type, the vegetative cover, topographical features of the land surface and the physical structure in the catchment play a key role in influencing the runoff process." Roads, pavements, buildings, parking lots, and other structures "increase impervious surfaces...arrest ground water infiltration, and take away the quantum of evapotranspiration from the grass cover and



1. Destruction of natural vegetation and streams, leveling of land at Metro Car Shed site // 03:28pm on 28th Sept 2019



2. Channelisation of the Mithi river in Aarey Milk Colony with concrete embankments // 04:53pm on 28th Sept 2019



3. Metro Shed Construction site and Channelisation of the Mithi river upstream of Bamandaya pada with concrete embankments // 04:10pm on 05th Sept 2019

the nature of construction activity that will be required for the Metro carshed is likely to significantly alter the natural drainage patterns in the catchment of the Mithi river.

16. Envis Center on Human Settlements, Monograph on Flood Hazard in Urban Area, School of Planning and Architecture, New Delhi (undated)

17. Madhav Chitale et. al., Fact Finding Committee on Mumbai Floods: Final Report Vol I, Government of Maharashtra, March 2006



4. Channelisation of the Mithi river near Bamandaya Pada with concrete embankments // 03:06pm on 28th Sept 2019



The Mithi river channelised and the natural course of water altered near the Metro Car Shed site

8

River or Drainage Channel?

The Expert Committee Report in Compliance to the Supreme Court in the case of MMRDA vs. Jalbiradari & Ors¹⁸ pointed out that of the four rivers that originate in Mumbai, the Mithi River is “the main, important and largest river with respect to catchment area.” The report observes that due to comparatively steeper areas in the upper stretches of the river, there is a sudden discharge of water in down-stream areas making it prone to floods. Therefore the construction of reinforced concrete retaining walls in Aarey that are constructed “without considering the riverine hydrology, environmental and flooding aspects” are completely unjustified, as they obstruct the river ecology and restrict the flow of water to and fro from the river. The report also points out that the land filling underway for the Metro yard has altered the natural course of the river, leading to an “acute 90 degree turn at the edge of the Metro yard,” and obstructed natural rainwater gradients and the passage of water from areas within Aarey from flowing into the Mithi river. It proposes that these natural channels be reopened or re-routed to ensure that surface water reaches the river

without any obstruction.

However it is important to note that, any kind of diversion, rerouting or channelisation will affect surface and subsurface hydrology of the river. Ground water percolation recharges underground aquifers and wells. The Pranab Sen report recommends the maintenance of “geo-hydrological features which channelise the rainfall to the underground sources.”

If the proposed projects in Aarey are developed, they will significantly alter the built up and concretised area, and result in 100 percent of water from the area being channelised into the Mithi river as surface flow including that which would have percolated into the ground. This will lead to a substantial increase in stream energy thus exacerbating the risk of flooding in the vicinity and downstream areas. “Since manmade changes are much faster than the capacity of drainage channels to modify over time, to accommodate the larger volume of water they now have to carry it results in channel overflow

and flooding in the vicinity of the drainage channels.”* Due to the nature of terrain in this region, rivers which originate in the hilly regions of the catchment flow over a very short distance before they reach low lying estuarine regions which are under tidal influence. This makes downstream areas vulnerable to flash floods.

Furthermore channelisation and concretisation will impact the ecology of streams and rivers by destroying the riparian zone-or habitats along natural streams as well as the hyporheic zone or the surface-subsurface hydrological exchange zone beneath and alongside the rivers or stream channels. This zone is significant as it recharges the stream during the dry season.

18. Supreme Court of India, (2018). Report of the Expert Committee Submitted in Compliance to Hon'ble Supreme Court of India, New Delhi, Orders, in the case of Mumbai Metropolitan Regional Development Authority vs. Jalbiradari & Ors, March.

* Samant, Hrishikesh, and V Subramanyan. “Landuse/Land Cover Change in Mumbai-Navi Mumbai Cities and Its Effects on the Drainage Basins and Channels — A Study Using GIS.” *Journal of the Indian Society of Remote Sensing* 26 (March 1, 1998): 1–6.



Concretised banks of Oshiwara River

9

Shrinking Aarey Colony: Proposed Land Uses Over the Decades

It is well-known that since the Aarey Milk Colony was established, substantial parcels of land were diverted "in an ad hoc manner over time for state and private infrastructure, slum rehabilitation and industries."¹⁹ The Earlier Development Plan 2034 Report, now known as the EDDP (after being scrapped by the Government and revised by the Municipal Corporation) pointed out that 133 hectares of Aarey land were given to Film City, 72.8 hectares were given to SRA projects, and 39.6 hectares were given to Force One, among others.²⁰ According to this plan, only 800 hectares of Aarey will remain undeveloped.²¹ The Revised Plan (or RDDP) dropped the proposal of Aarey being used as a 'new growth center' but proposed 113 hectares for a zoo and botanical garden. Meanwhile, documents of the Dairy Development Department admit that by 2014, only 857 out of 1,287 hectares remain for the Milk Colony, while 430 hectares have been allotted to 27 institutions for other uses.²² The maps on these two pages show the extent of Aarey Milk Colony as indicated in the three Development Plans of Mumbai: 1964 (sanctioned 1967), 1981 (sanctioned 1991) and 2016-34. GIS mapping suggests that the Proposed Land Use (PLU) of the 1964 DP reserved approximately 1,300 hectares of land for Aarey. In the 1981 DP, an area of approximately 990 hectares of Aarey was zoned as a No Development Zone (NDZ). In the 2016-2034 DP, approximately 175 hectares (113 for the zoo and garden, 34.4 for the Metro Car Shed and 28 for housing) have been excluded from the erstwhile NDZ areas, while the remaining 800 hectares have been zoned as a 'Green Zone' that allows the land to

Suggested Reference (for maps on page 31):
Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

be diverted for "other uses" approved by the Government of Maharashtra "with permission from the Ministry of Environment and Forest." This qualification (approval by the MoEFCC) is a tacit admission by the planning authority that Aarey is of great ecological significance. The maps on the facing page show the gradual shrinking of the original Aarey Colony area as sanctioned by the three Development Plans of Mumbai.

19. EDDP Report or Report on the Draft Development Plan 2034, Municipal Corporation of Greater Mumbai, 2015. p.281. (This report, along with the plan was subsequently scrapped, and a revised Development Plan was prepared and released in 2017).

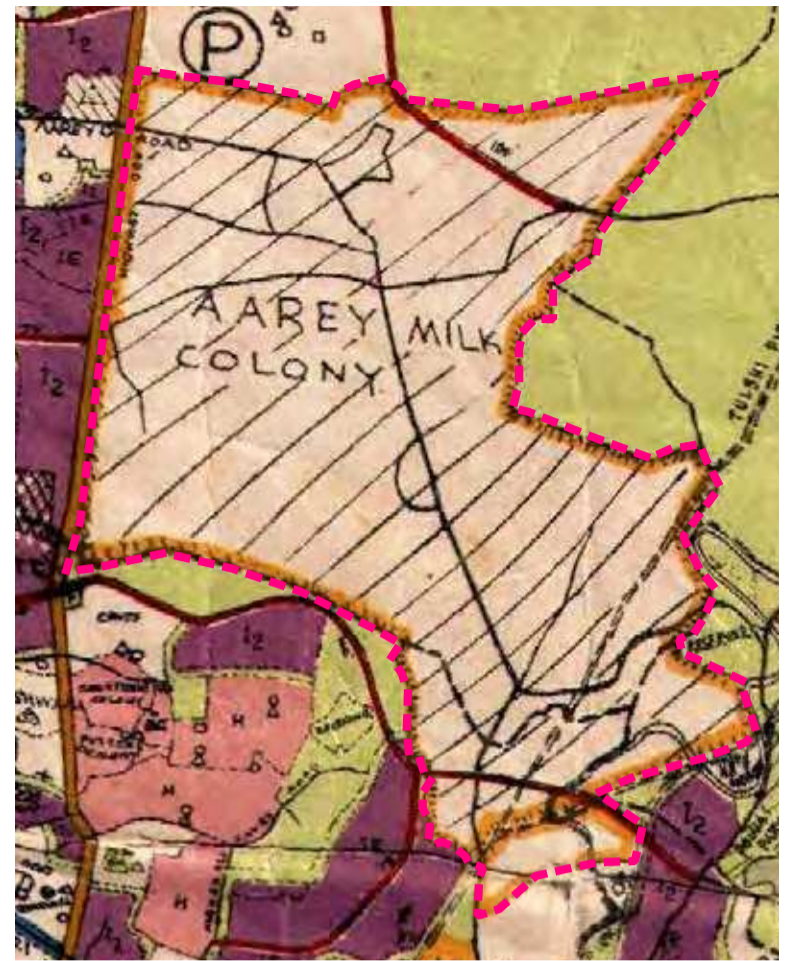
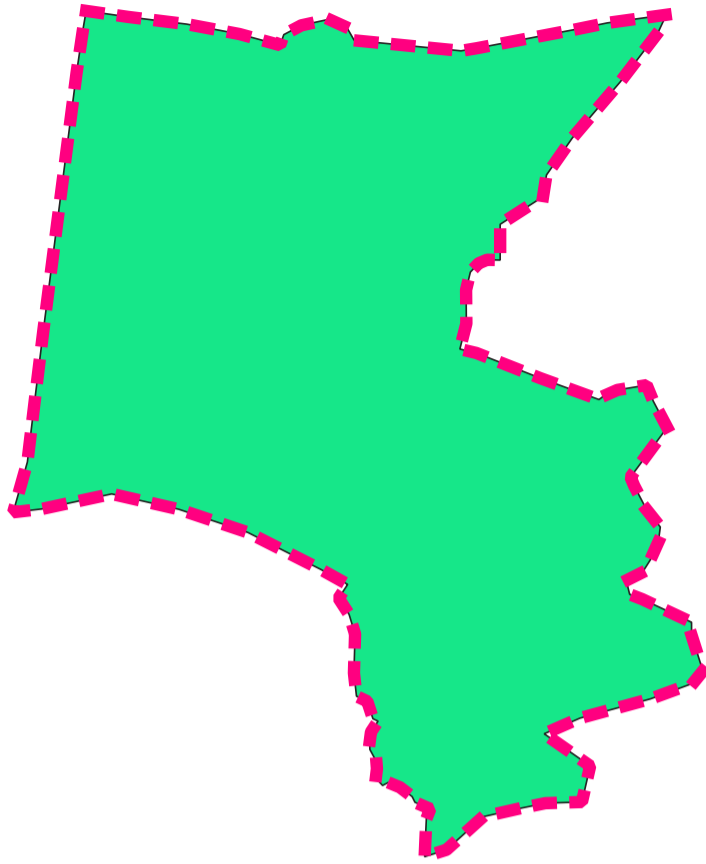
20. Ibid., p.281.

21. RDDP Report or Report on the Draft Development Plan 2034, Municipal Corporation of Greater Mumbai, 2016, p.12.

22. Performance budget of the Dairy Development Department 2013-14, Government of Maharashtra.

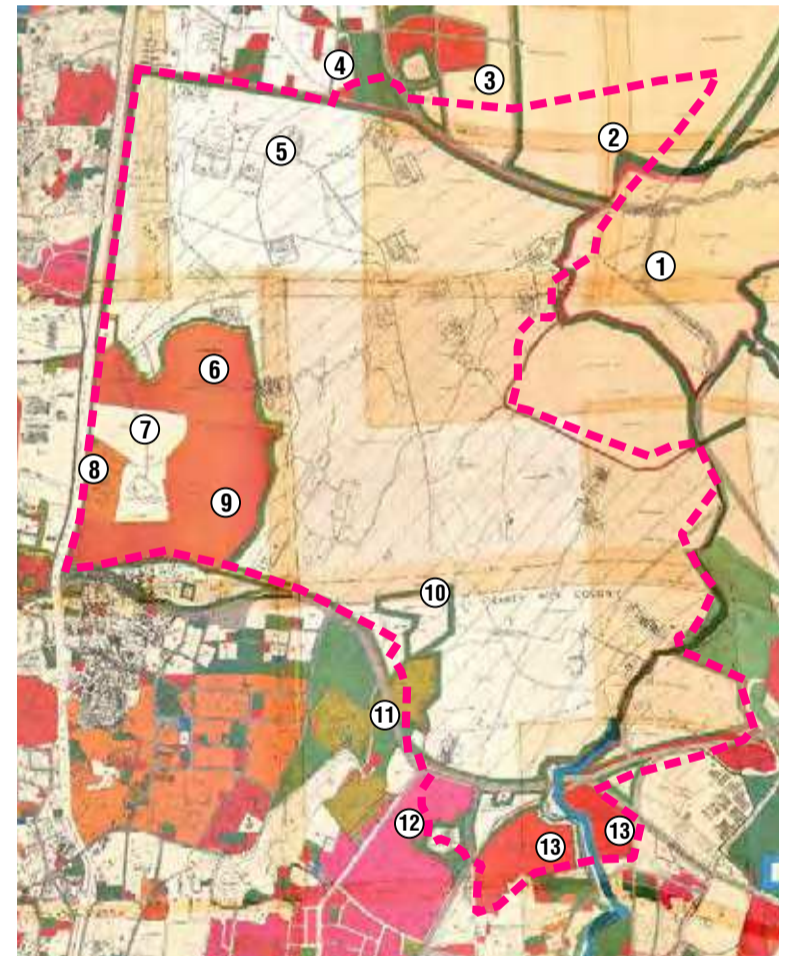
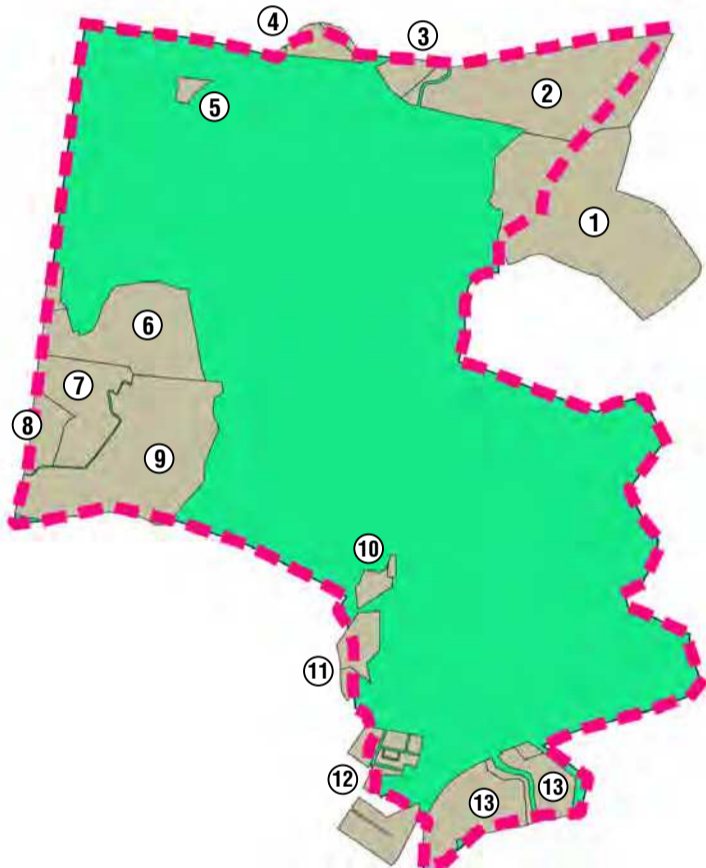
1964 DP

Aarey in the 1964 Development Plan: This figure shows the profile of the Aarey Milk Colony as indicated in the 1964 Development Plan of Bombay. Approximately 1,300 hectares was reserved for the Milk Colony.



1981 DP

Aarey in the 1981 Development Plan: This figure shows the profile of the Aarey Milk Colony as indicated in the 1981 Development Plan of Bombay. Approximately 990 hectares of the Milk Colony was reserved as a No Development Zone (NDZ) - shown here in green. The areas that were diverted for other uses are shown in grey.

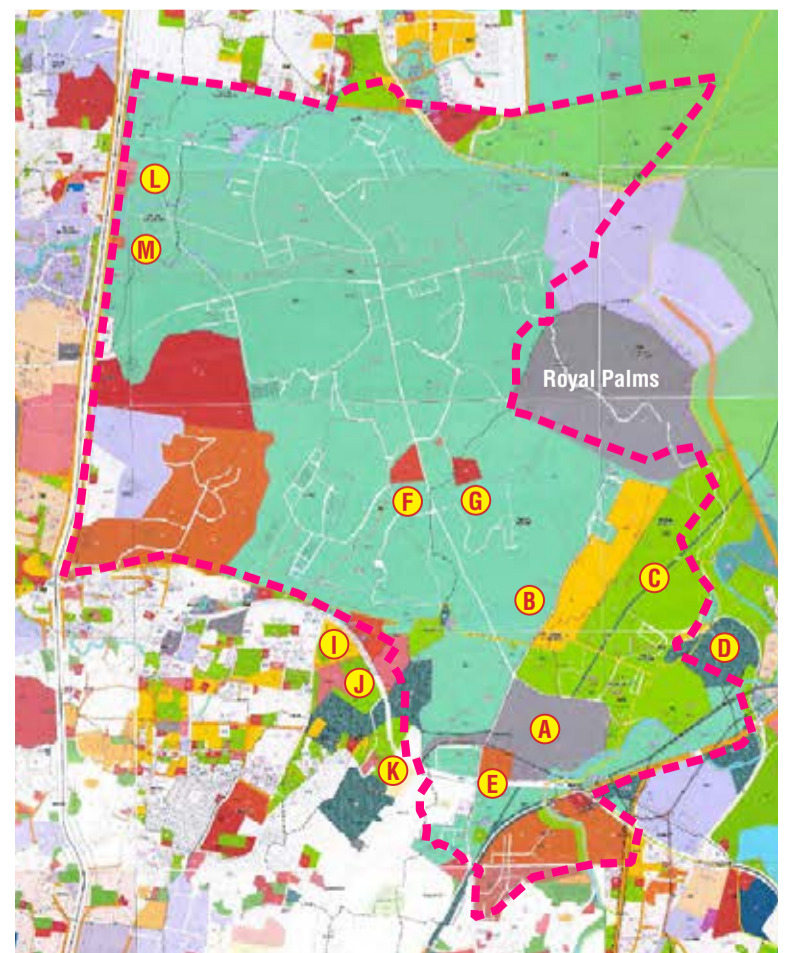
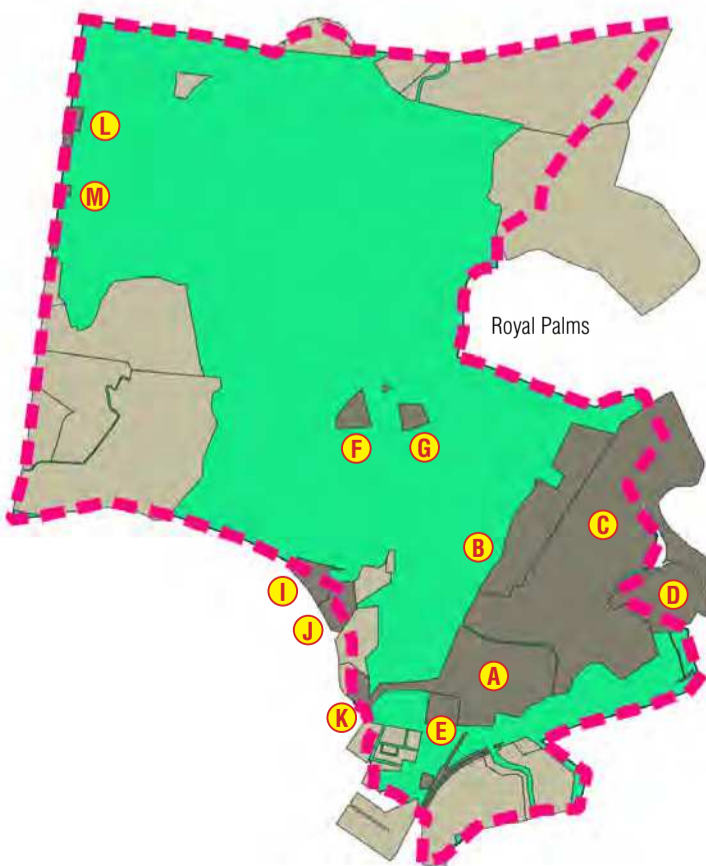


Labels:

- 1. Film City
- 2. Apportioned NDZ land for SGNP
- 3. Indira Gandhi Institute for Development Research
- 4. Recreational Ground
- 5. Maharashtra Agro Industry
- 6. Faculty of Veterinary Sciences
- 7. India Dairy Development Corporation & MAFCO
- 8. M.H.B. Transit Camp
- 9. SRP Site
- 10. Modern Bakery
- 11. Vyaravali Reservoir
- 12. SEEPZ
- 13. Police Armed HQ

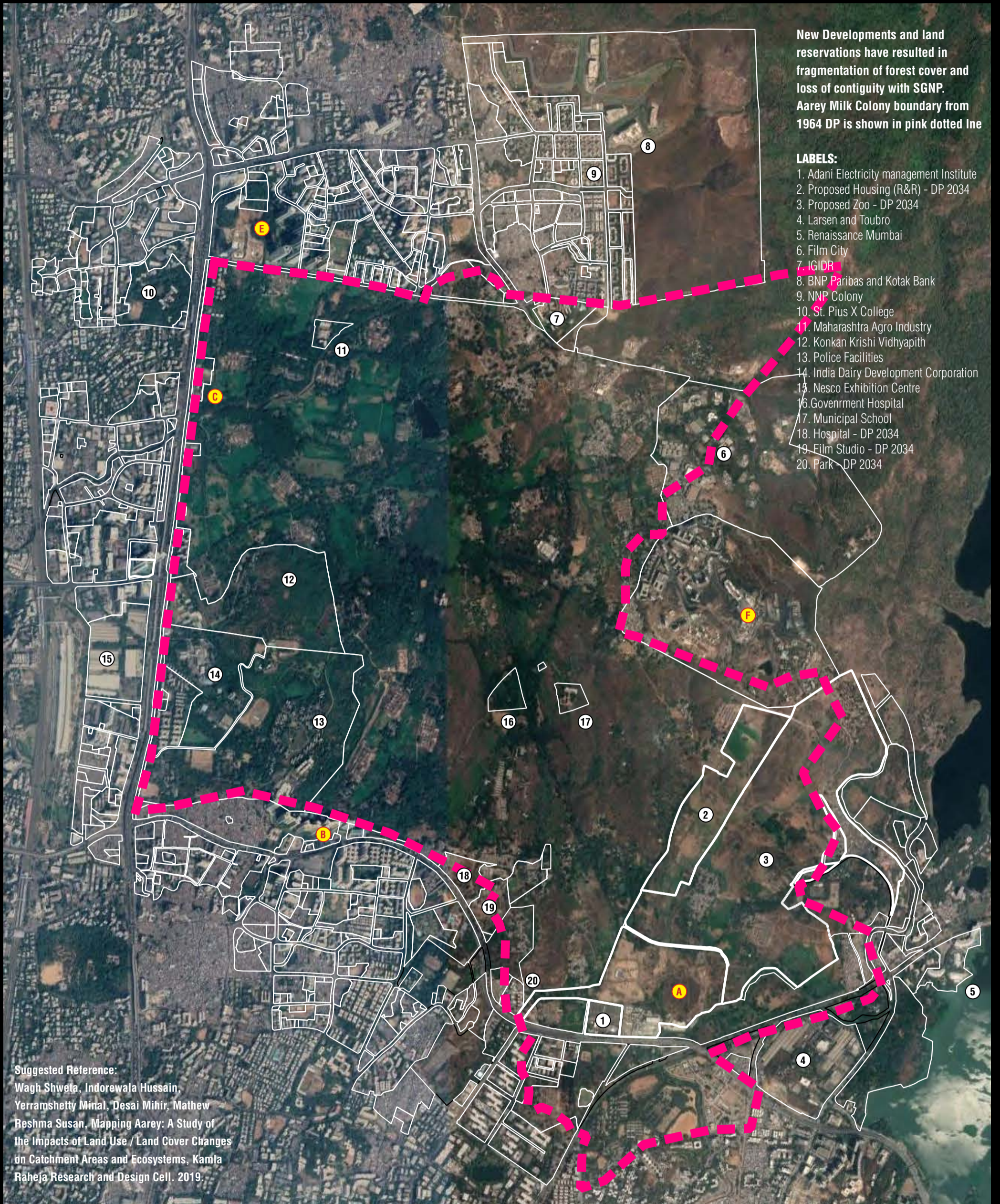
2034 DP

Aarey in the 2016 Development Plan: This figure shows the profile of the Aarey Milk Colony as indicated in the 2016 Development Plan of Mumbai. Approximately 800 hectares of the earlier NDZ land is demarcated as a 'Green Zone' - shown in green color. The areas that were diverted for other uses are shown in light grey, while the dark grey areas are lands that have been reserved for the Metro Car Shed, zoo and R&R housing. The C shaped area above these reservations is the Royal Palms residential development. With these new reservations, Aarey will be completely severed from the SGNP.



Labels:

- A. Metro Car Shed
- B. R&R Housing
- C. Zoo
- D. Reservoir
- E. Electrical Transmission and Distribution Facilities
- F. Government Hospital
- G. Municipal School
- I. Hospital
- J. Film/TV Studio
- K. Garden/Park
- L. Cemetery
- M. Fuel Station



The map above shows a Google satellite image of Aarey and adjacent areas overlaid with recent developments along the edges of Aarey colony which have expanded significantly over the past few decades.

As a result of new developments such as Royal Palms and the expansion of Film City into land which was earlier a part of SGNP, degradation of forest and

natural vegetation cover in these areas is observed. The edges of Aarey colony have slowly been eaten up by new commercial and luxury residential housing projects.

Aarey Colony which was designated as NDZ in the 1981 development plan, was a low development zone, with natural forest cover and vegetation. This area was contiguous with, and served as a buffer zone

for the protected forest area of the National Park. It is observed that new construction in the stretch between the SGNP and Aarey Colony has resulted in the fragmentation of the contiguous forest cover between SGNP and Aarey.

New developments proposed in the 2034 DP such as the Metro Car Shed and Metro Bhavan, the Rehabilitation and Resettlement housing the

proposed zoo will result in further fragmentation and loss of contiguity of forest and ecosystems. This will result in habitat loss and also affect the movement of wildlife. On Dec 2016 an area of 59.456 sq km around SGNP, that included Aarey Colony, was notified as Eco-Sensitive Zone to protect the area around SGNP from an ecological and environmental point of view. (Refer Annexure 1M)



A

Aarey Metro Shed and Metro Bhavan Site

Source: <https://mumbaimirror.indiatimes.com/mumbai/civic/metro-car-shed-at-aarey-setback-for-greens-as-ngt-disposes-of-case/articleshow/65894025.cms>



B

JVL R and Oberoi Splendor

Source: Satellite Image of Mumbai City, Google Earth, earth.google.com/web/



C

Cemeteries

Source: Satellite Image of Mumbai City, Google Earth, earth.google.com/web/



D

Doodh Sagar Co-op Housing

Source: Satellite Image of Mumbai City, Google Earth, earth.google.com/web/



F

Royal Palms

Source: Satellite Image of Mumbai City, Google Earth, earth.google.com/web/



E

Oberoi Business Center and Oberoi Exquisite Housing Complex

Source: Satellite Image of Mumbai City, Google Earth, earth.google.com/web/



E

Oberoi Woods, Oberoi Exquisite and Oberoi International School



Aarey Milk Colony



2004

Forests and Natural Ecosystems in SGNP are contiguous with those in Aarey Milk Colony

Google Earth Map overlaid with 1964 DP boundary (pink dotted) and 2034 DP Reservations

LABELS:

- 1. Metro Shed
- 2. Zoo
- 3. R&R Housing
- 4. Royal Palms
- 5. Film City

4 Royal Palms Golf Course

Vihar Lake

Powai Lake

Suggested Reference:
Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems, Kamla Raheja Research and Design Cell. 2019.

2019

Forests and Natural Ecosystems in SGNP are contiguous with those in Aarey Milk Colony

Google Earth Map overlaid with 1964 DP boundary (pink dotted) and 2034 DP Reservations

LABELS:

- 1. Metro Shed
- 2. Zoo
- 3. R&R Housing
- 4. Royal Palms
- 5. Film City

4 Area of Royal Palms that was originally opened up as a golf course was subsequently developed as a commercial housing

DP Proposals such as Metro Car Shed, R&R Housing and Zoo will result in loss of contiguity of ecosystems between Aarey and SGNP and will affect wildlife corridors

Vihar Lake

Powai Lake

Suggested Reference:
 Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems, Kamla Raheja Research and Design Cell. 2019.



10

Conclusion

This report provides a qualitative-spatial analysis to highlight the impacts of past and proposed land use and land cover changes in Aarey on its terrain, watersheds and ecosystems. Aarey is a landscape of numerous adivasi settlements, extensive forest cover and primary occupations. As a predominantly low-intensity development zone, it forms a much needed buffer area for the Sanjay Gandhi National Park. Due to its ecological character and location and on account of being a part of the city's ecologically vital hill complex, Aarey is an important catchment area and the streams and tributaries that feed two of the city's major rivers originate here. Any large project is likely to affect the hydrologic processes and drainage patterns in the upper catchments of these rivers, with serious repercussions both within Aarey and in downstream areas. The findings of this report highlight the following concerns:

(1) The original area of the Aarey Colony has been shrinking over the decades, through the diversion of land parcels for other uses. If we go by the latest Development Plan of Greater Mumbai, only 800 hectares of the approximately 1,300 hectares originally allocated as a 'Green Zone'; the Plan defines a Green Zone as a "large area predominantly with green cover" where construction of a zoo, resettlement housing and other "uses approved by GoM with permission from the Ministry of Environment and Forest" may be permitted.²³ This effectively leaves the door open for other unanticipated projects in the future, which will lead to the further shrinking of Aarey in an ad hoc and unplanned manner.

(2) Over the decades, Aarey has been gradually disconnected from the Sanjay Gandhi National Park by handing over land on its eastern edge for various private projects such as Film City and

Royal Palms. The area where the Metro Car Shed, zoo and rehabilitation housing is planned is the last remaining connection with the National Park, and if these projects are constructed, Aarey will lose its contiguity with the National Park. These changes will result in the fragmentation of forest cover and irreversibly affect movement of wildlife between the National Park and Aarey. It will also increase the likelihood of Aarey being completely taken over for high-intensity land uses in the future, and eventually, the disappearance of this ecological landscape altogether. It is therefore critical that a cumulative impact assessment is undertaken in order to assess possible impacts of these proposed developments.

(3) The location and extent of these newly proposed projects on the catchment of Mithi river that will result in disruption of hydrological processes and existing drainage patterns in these areas. These disruptions are likely to lead to



displacement of adivasi communities and loss of traditional livelihoods and cultural rights of the community; a reduction of the scarce permeable forest cover in the suburbs; and a destruction of ecosystems and wildlife habitats and its rich biodiversity. In other words, opening up large land parcels in Aarey will lead to significant socio-ecological impacts, since the Aarey landscape provides vital ecosystem services to the city.

(4) The consequences of the newly proposed projects on the catchment areas of Mithi, an area where the streams that feed the river originate, is likely to exacerbate the risk of urban floods in downstream areas during and after construction of these projects.

(5) The development intensity around Aarey Colony is quite high, and Aarey as a low development zone with extensive forest cover and open areas feeds the Mithi and Oshiwara rivers as well as provides a sizable permeable

area for rainwater infiltration and groundwater recharge. Opening up Aarey to similar built up intensity will not only exacerbate stormwater runoff and flood risk, but will affect the subsurface water resources of the area.

(6) Aarey has over the decades acted as a buffer area for the Sanjay Gandhi National Park. The new projects in Aarey and its disconnection from the SGNP will not only imperil Aarey itself, but eventually risk exposing the heart of the city's river systems and its National Park to real estate speculation. Aarey was included in the 2016 ESZ notification that is meant to protect the area around the SGNP from an ecological point of view. While this notification prohibits "commercial or industrial related development activities," it permits infrastructure works such as Mumbai Metro, "residential needs of local residents" and "eco-tourism facilities." These categories are ambiguous, as there is a

significant difference between existing villages and informal settlements versus large scale rehabilitation and resettlement projects that are being planned there, in terms of their ecological impacts. Similarly, the eco-tourism category allows many activities that may have local and downstream impacts, and may end up displacing communities and livelihoods. Similarly, as past experience has shown, infrastructure works and tourism projects subsequently allow many ancillary activities that are not anticipated earlier. In other words, many of these regulations provide a false sense of environmental security, but little actual protection. Therefore activities ought to be regulated through a meticulous ecological planning process that specify suitability and intensity of development based on the nature of their impacts.

In light of these concerns, any diversion of land

in Aarey and in the catchment areas of the city's major rivers need to be avoided, impacts very carefully assessed, and if any projects are taken up, these must be only for uses that cause little or no disturbance to the forest cover, natural drainage, wildlife habitats, wildlife movement, settlements of adivasi communities and their livelihoods.

11

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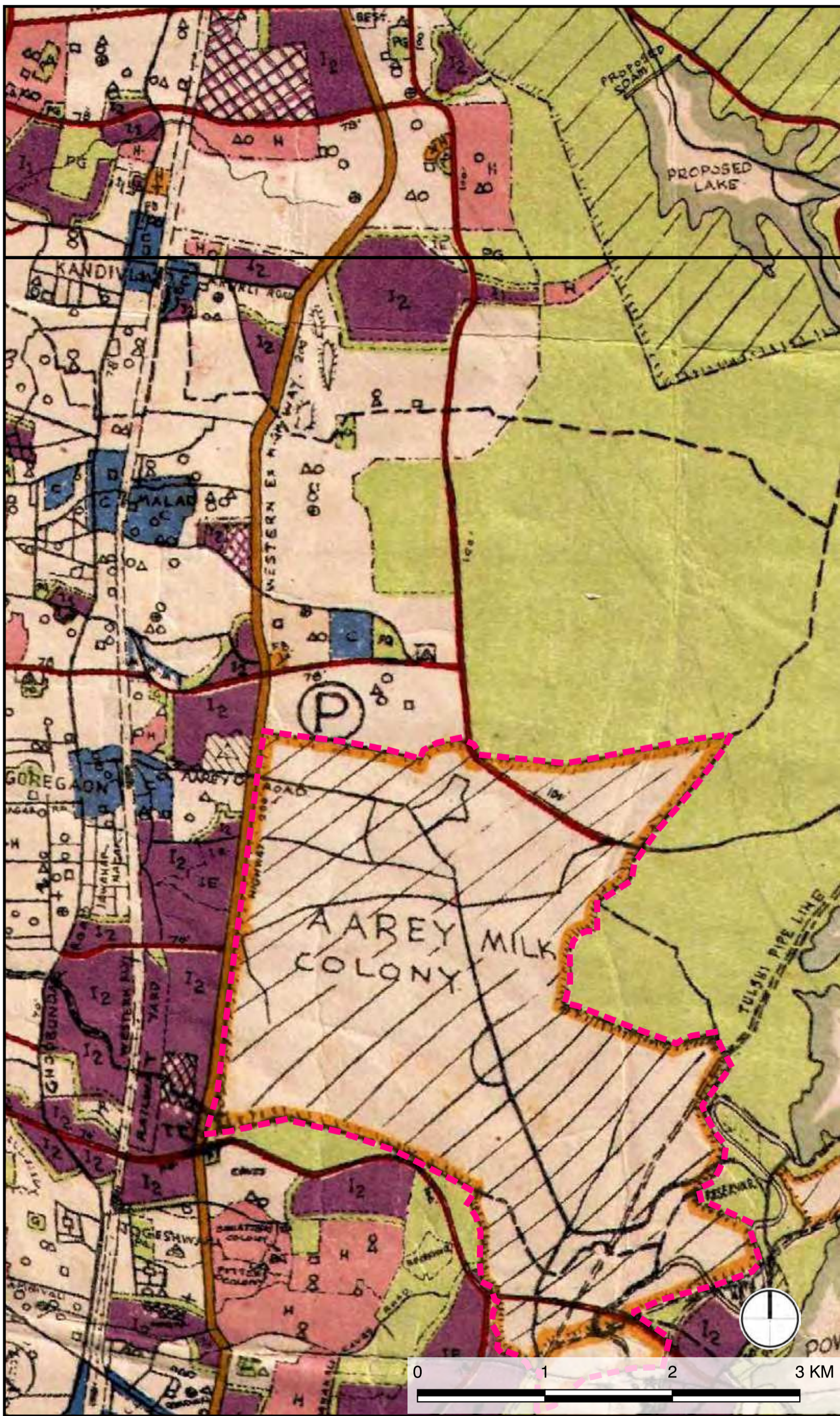
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1

Annexure Maps

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Eco-Sensitive Zone (ESZ) around SGNP

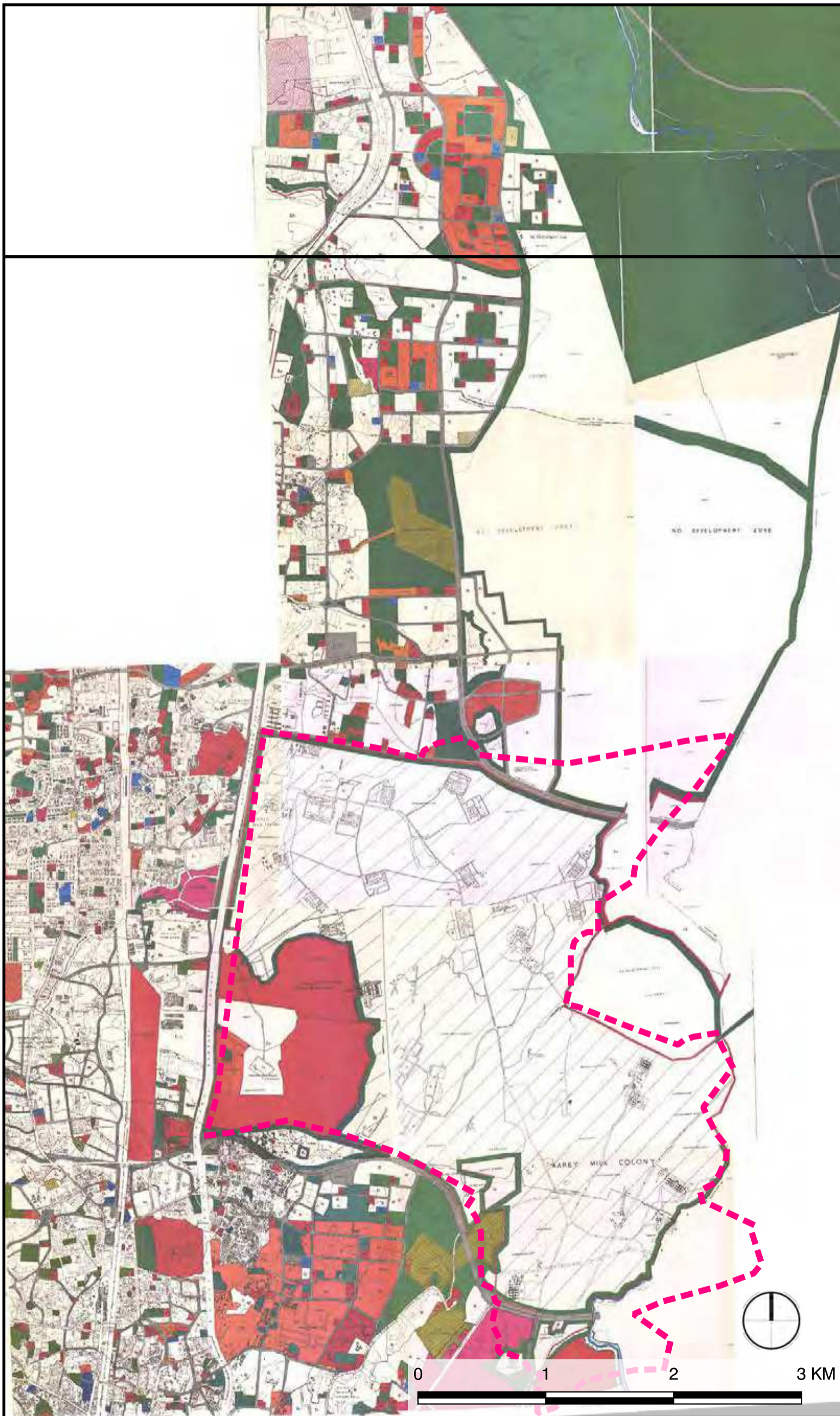


NOTE: This figure shows the profile of the Aarey Milk Colony as indicated in the 1964 Development Plan of Bombay. Approximately 1,300 hectares was reserved for the Milk Colony.

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LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Proposed Main Roads
- Commercial Zones
- Godowns
- Hospitals
- Housing Reservations (major)
- Industrial Zones
- Open Spaces



NOTE: This map of the 1981 Development Plan's Proposed Land Use (PLU) is overlaid with the boundary of Aarey extracted from the 1964 Plan (in pink dotted line). Notice the reservations in the south-west corner for the veterinary hospital and transit housing. Also notice the plots for Film City and an excluded part that would become Royal Palms golf course in the 1990s.

Suggested Reference:

Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND



- Aarey Milk Colony boundary - 1964 DP
- Commercial Ammenities
- Industrial
- No Development Zone
- Open Spaces
- Proposed Residential
- Public Institutions
- Residential



NOTE: This map indicates the study area (white box) on a satellite image of Mumbai. The boundary of Aarey Colony (as per the 1964 Development Plan) is shown as a dotted pink outline. The map shows the contiguity of Aarey with the Sanjay Gandhi National Park and proximity to the Powai and Vihar lakes.

Suggested Reference:
 Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

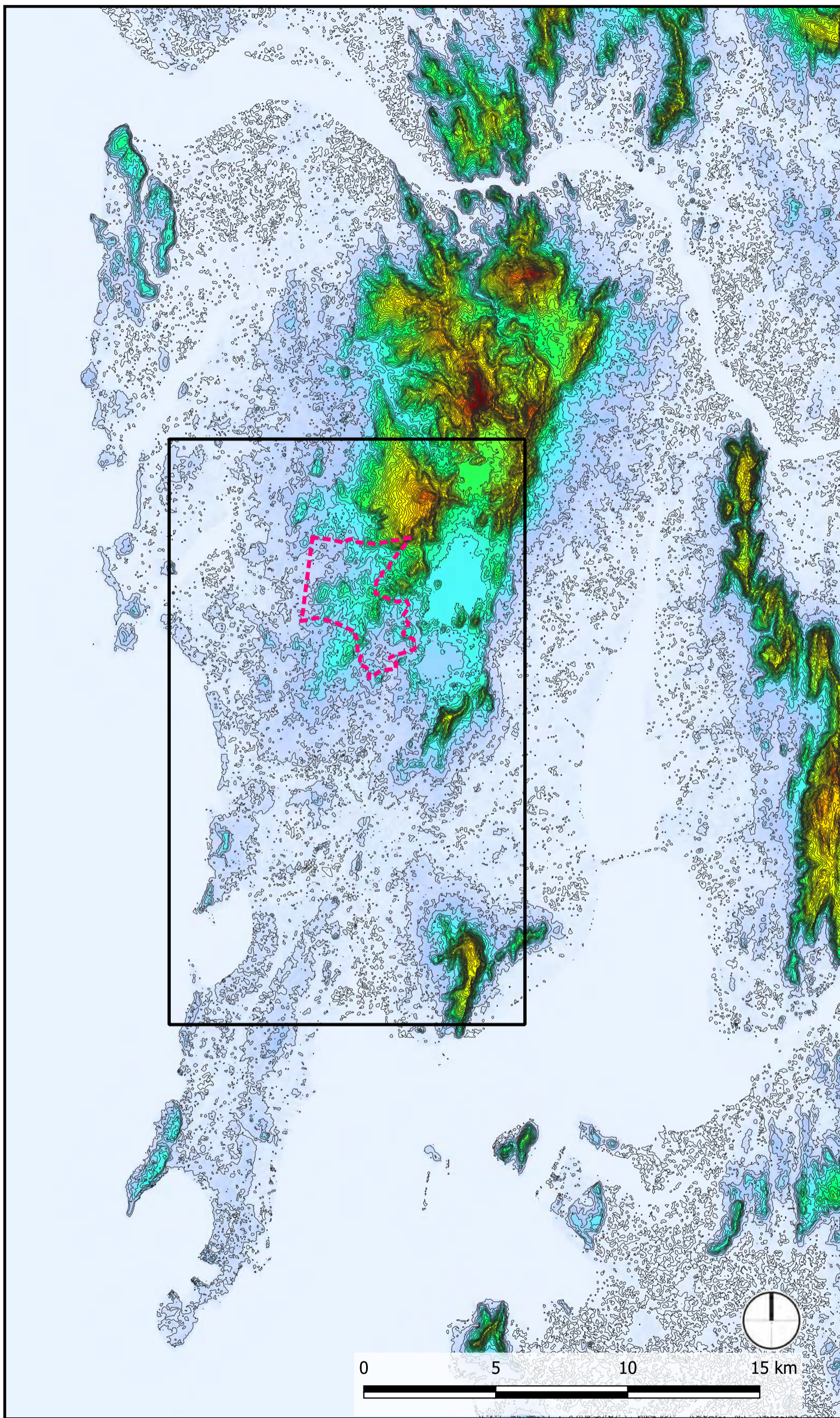
-  Aarey Milk Colony boundary - 1964 DP
-  Study Area



Location of Aarey Milk Colony

Source: (1) Satellite Image of Mumbai City, Google Earth, earth.google.com/web/ (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.
















NOTE: This map shows the elevation of land in Greater Mumbai (higher elevations are in warmer colors and low lying areas in cooler colors). The study area is highlighted as the black box. The boundary of Aarey (as per the 1964 Development Plan) is shown as the dotted pink outline. The map shows the hill complex at the center of Salsette, that slopes downward on all sides towards the Arabian sea in the west, the Ulhas estuary in the north, the Thane creek in the east and the Mahim bay in the south.

Suggested Reference:

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LEGEND

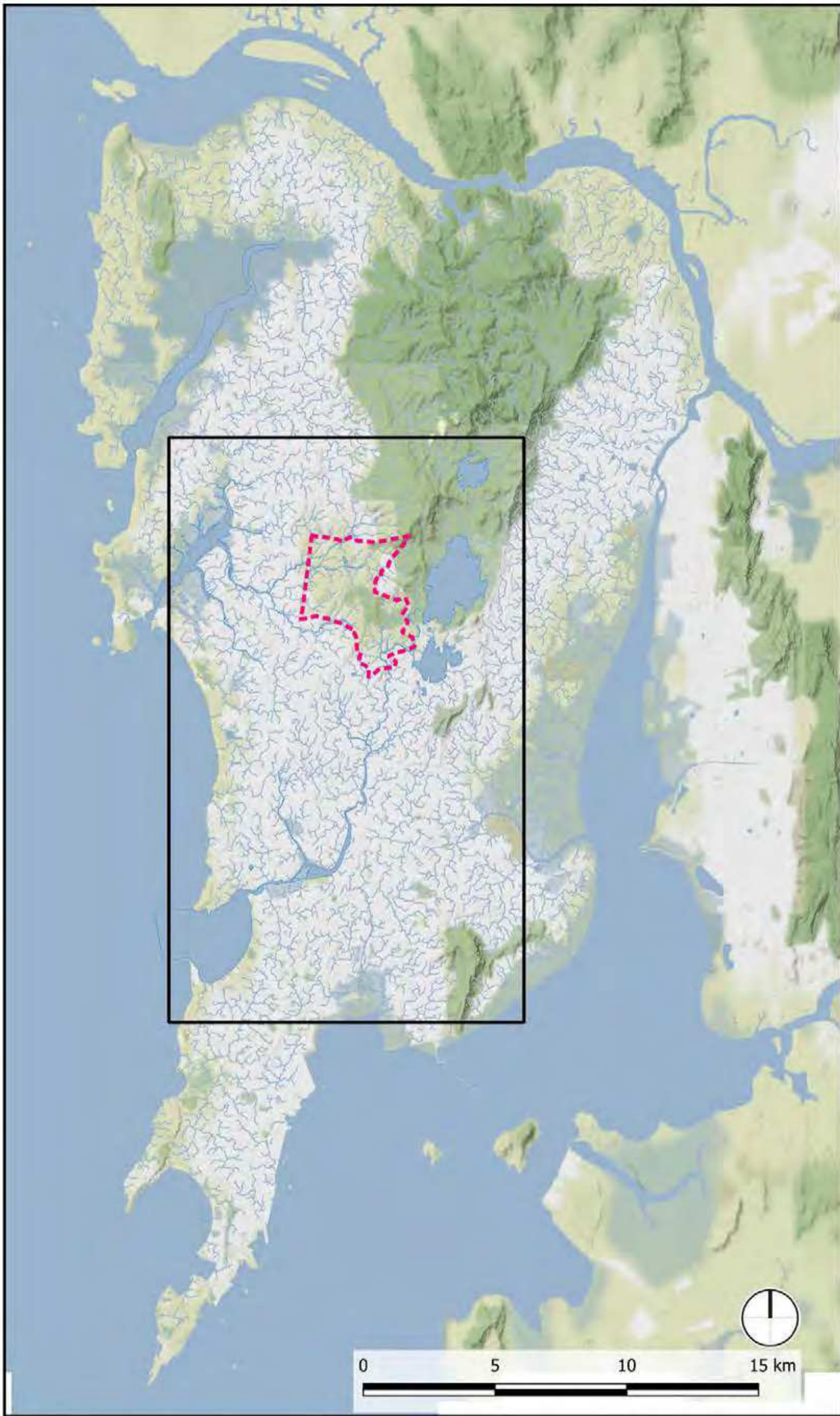
-  Aarey Milk Colony boundary - 1964 DP
-  Study Area
-  Contours at 10m interval
- Clipped DEM for Mumbai**
-  0m
-  0 - 25m
-  26 - 50m
-  51 - 100m
-  101 - 150m
-  151 - 200m
-  201 - 250m
-  251 - 300m
-  301 - 350m
-  350 - 400m
-  401 - 450m
-  451 - 500m



Elevation Map of Mumbai

Source: (1) Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: / 10.5066/1F7PR7TFT), Entry ID: SRTM1N18E072V3, Date: 2014. (see legend on opp. page) (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.





NOTE: This map shows the terrain of Greater Mumbai and the surface drainage (streams and rivers) of the rain-fed rivers that originate from the hill complex in and around the Sanjay Gandhi National Park. The black box indicates the study area, and the pink dotted line indicates the outline of Aarey (as per the 1964 Development Plan). Stream lines indicated in white have been vectorised from Land Survey Maps.

Suggested Reference:

Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

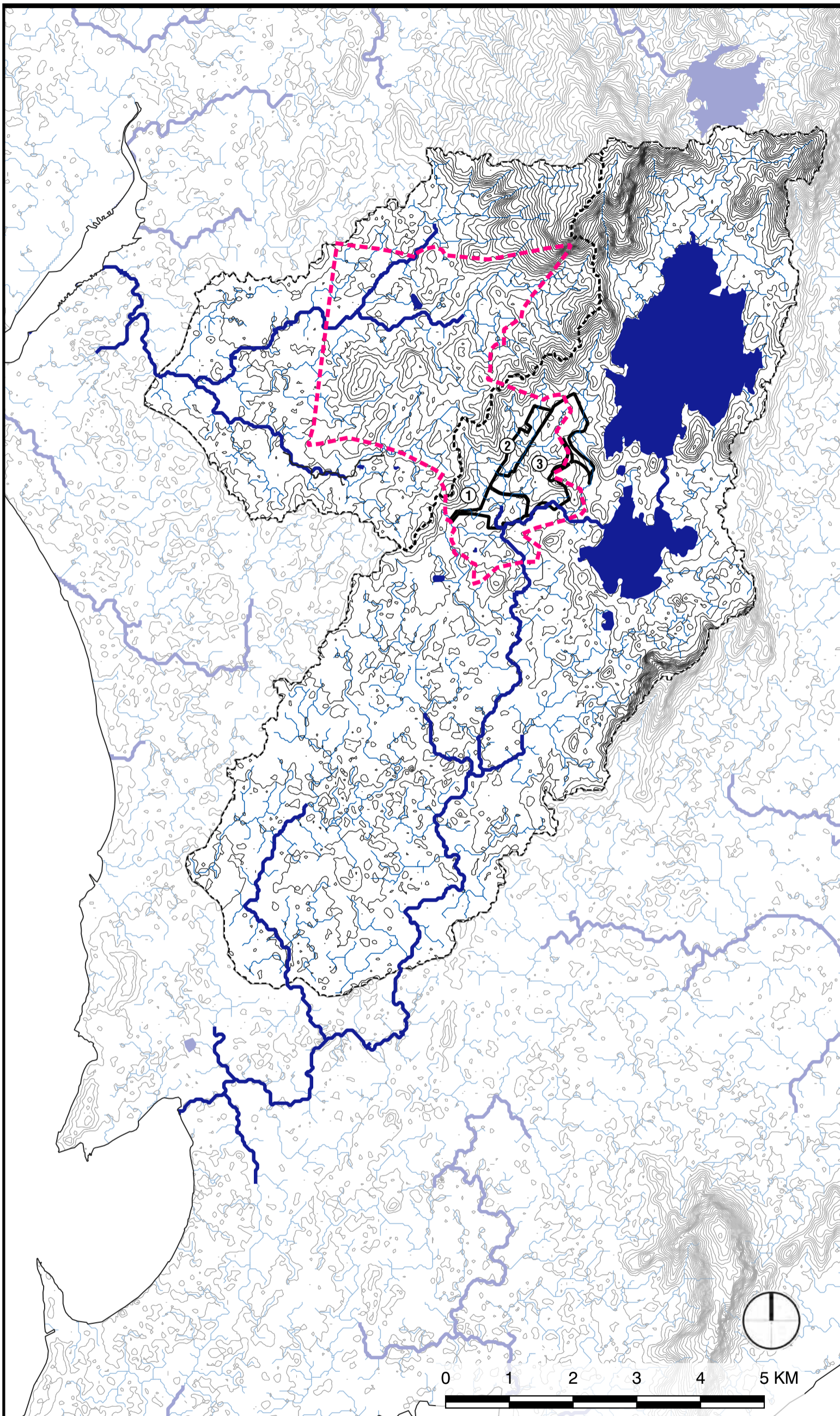
LEGEND	
	Aarey Milk Colony boundary - 1964 DP
	Ridge Lines
	water bodies
	Contours at 10m intervals
	Streams



Terrain and Surface Drainage of Mumbai

Source: (1) Terrain Background sourced from Map files by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.(2)Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.





NOTE: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with a contour map of the study area at 10 meter intervals. The black dotted outlines indicate the catchments of the Oshiwara and Mithi rivers. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown indicating the natural drainage channels and stream networks that feed the two rivers. The plots with heavy black outlines indicate the reservations for the Metro Car Shed, Zoo and Housing. The map shows that the proposed new developments are located in the upper catchment area of the Mithi river. Stream lines indicated in white have been vectorised from Land Survey Maps.

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LABELS:

1. Metro Car Shed
2. R&R Housing
3. Zoo

LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Ridge Lines
- Lakes
- Major streams
- Minor streams
- Contours at 10m intervals
- DP Reservations

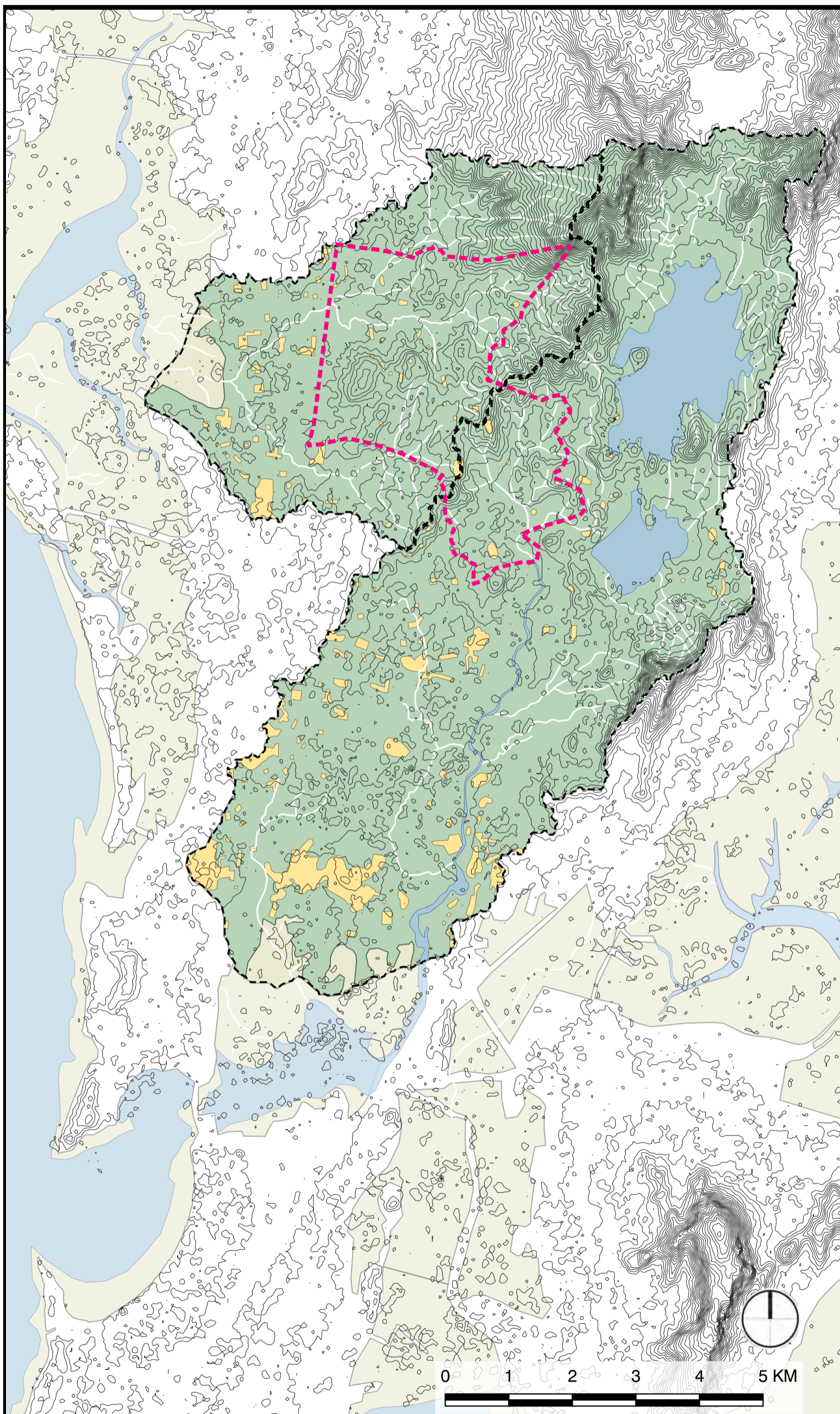


KRVIA Research and Design Cell

Watersheds with DP Reservations

Source: (1) Contours, streams and catchments extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/1F7PR7FT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.(3) DP 2034 Reservations extracted from Development Plan 2018-34 for Greater Mumbai, MCGM.













NOTE: This map shows the broad land cover of 1926 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or undeveloped areas, and yellow denotes substantially built or developed areas. Aarey Milk Colony did not exist in 1926 - the pink outline of Aarey extracted from the 1964 Development Plan is shown here for orientation only.

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

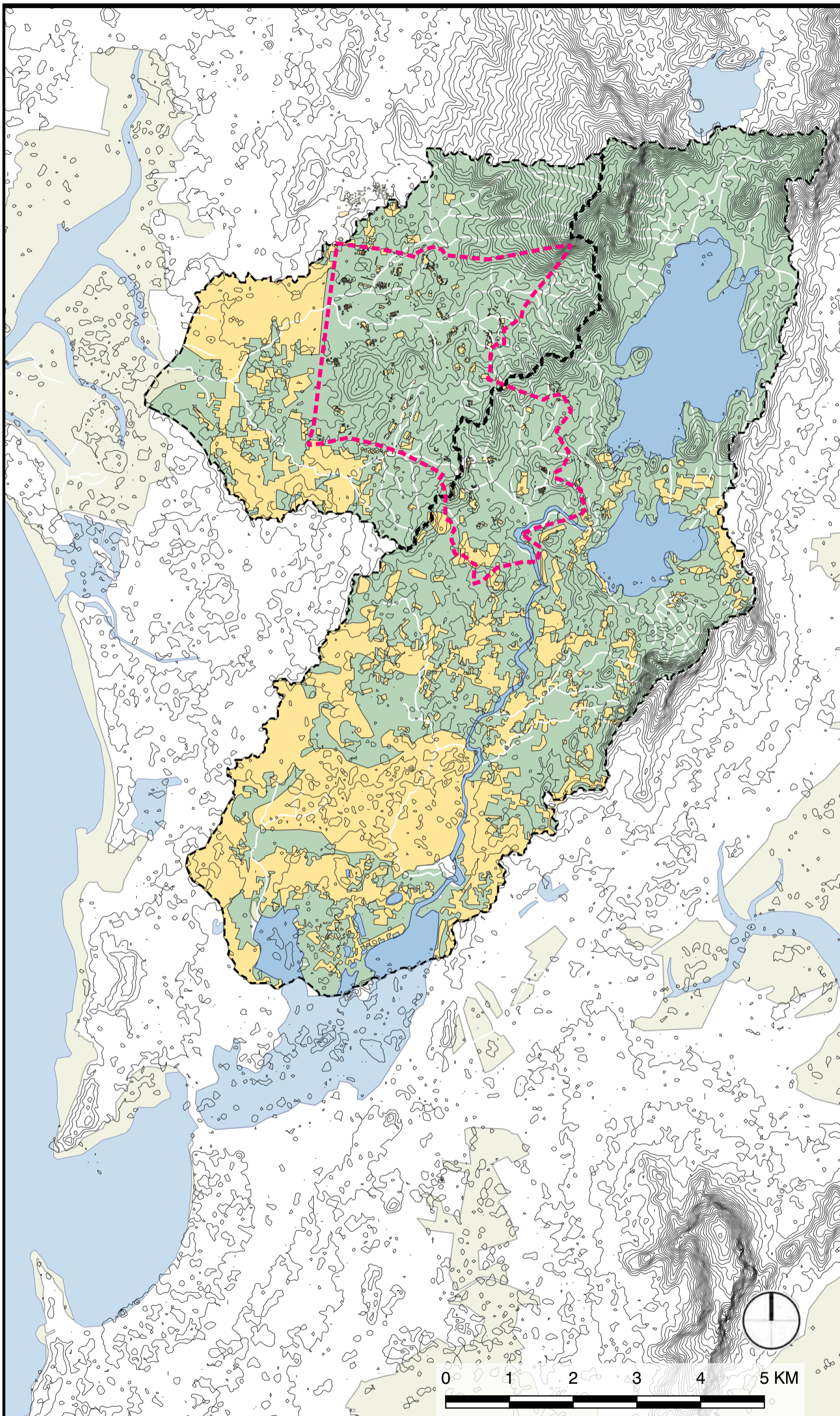
Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

-  Aarey Milk Colony boundary - 1964 DP
-  Ridge Line
-  Contours at 10m interval
-  Predominantly unbuilt or Natural
-  Substantially built or concretized
-  Mud Flats/ Coastal Mangroves
-  Water Bodies
-  Streams

Broad Land Cover 1926

Source: (1) Streams extracted from Lieutenant Col. C.P Gunter, Survey of India, Revised Second Survey of India, South Salsette, 1926. (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) Land Cover layers extracted from Lieutenant Col. C.P Gunter, Survey of India, Revised Second Survey of India, South Salsette, 1926.











NOTE: This map shows the broad land cover of 1966 within the two catchments of the Mithi and Oshiwara rivers, overlaid with contours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or undeveloped areas, and yellow denotes substantially built or developed areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line.

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

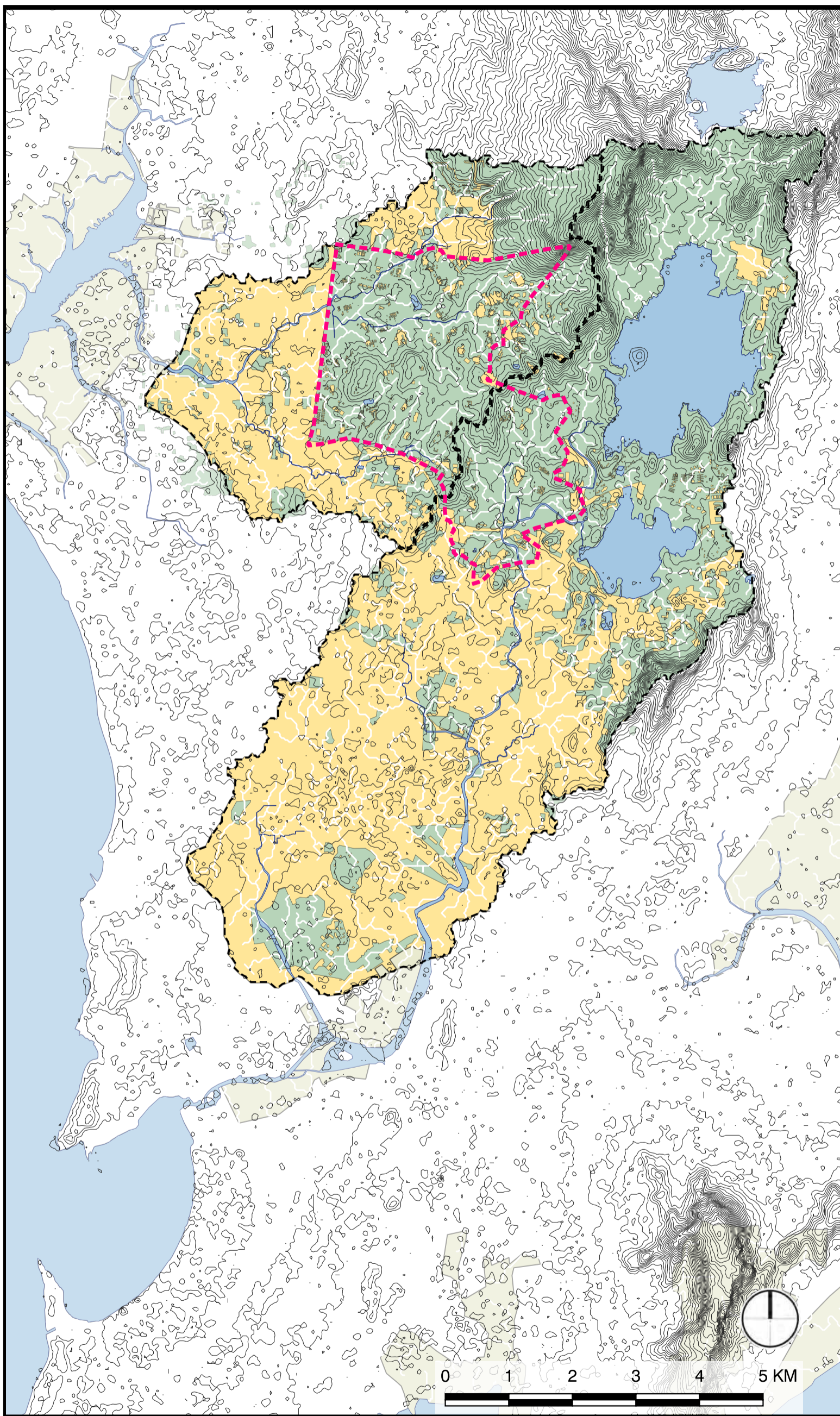
Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

-  Aarey Milk Colony boundary - 1964 DP
-  Ridge Line
-  Contours at 10m interval
-  Predominantly unbuilt or Natural
-  Substantially built or concretized
-  Mud Flats/ Coastal Mangroves
-  Water Bodies
-  Streams

Broad Land Cover 1966

Source: (1) Streams extracted from Survey of India, South Salsette, 1947-66. (DOI) number: /10.5066/F7PR7TFT, Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) Land Cover layers extracted from Survey of India, South Salsette, 1947-66.











NOTE: This map shows the broad land cover of 2004 within the two catchments of the Mithi and Oshiwara rivers, overlaid with countours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or undeveloped areas, and yellow denotes substantially built or developed areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line. Much of the area of the catchments outside the SGNP and Aarey are substantially built-up. Stream lines indicated in white have been generated using QGIS.

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

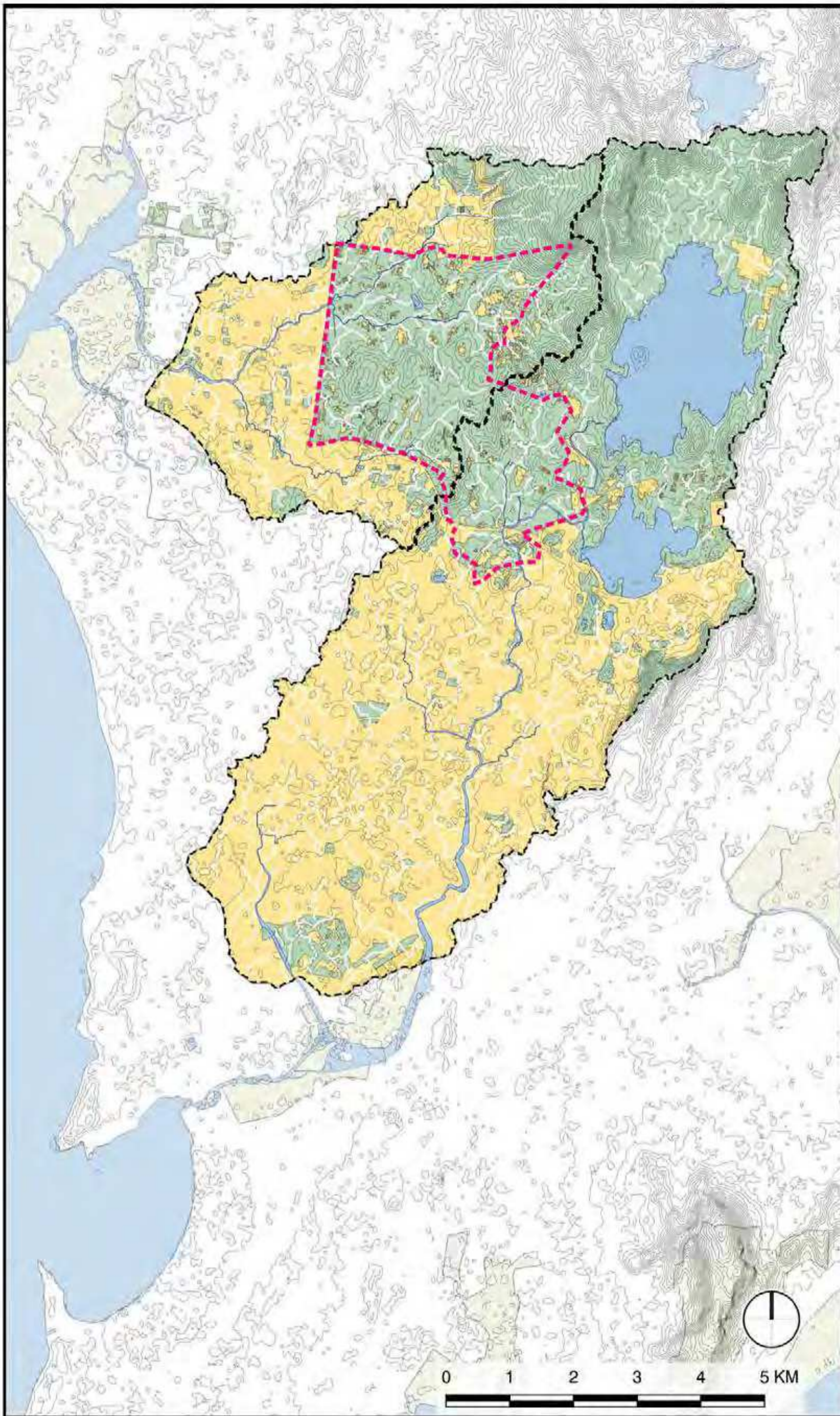
Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

-  Aarey Milk Colony boundary - 1964 DP
-  Ridge Line
-  Contours at 10m interval
-  Predominantly unbuilt or Natural
-  Substantially built or concretized
-  Mud Flats/ Coastal Mangroves
-  Water Bodies
-  Streams

Broad Land Cover 2004

Source: (1) Streams extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/1F7PR7FT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) Land Cover layers extracted from 2004 Satellite Image of Mumbai City, Google Earth, earth.google.com/web/.





NOTE: This map shows the broad land cover of 2018 within the two catchments of the Mithi and Oshiwara rivers, overlaid with countours at 10 meter intervals and the stream networks (white lines). The green color denotes the predominantly unbuilt or undeveloped areas, and yellow denotes substantially built or developed areas. Aarey Milk Colony as it was designated in the 1964 Development Plan is shown in pink dotted line. Almost the entire area of the catchments outside the SNGP and Aarey are substantially built-up. Stream lines indicated in white have been generated using QGIS.

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

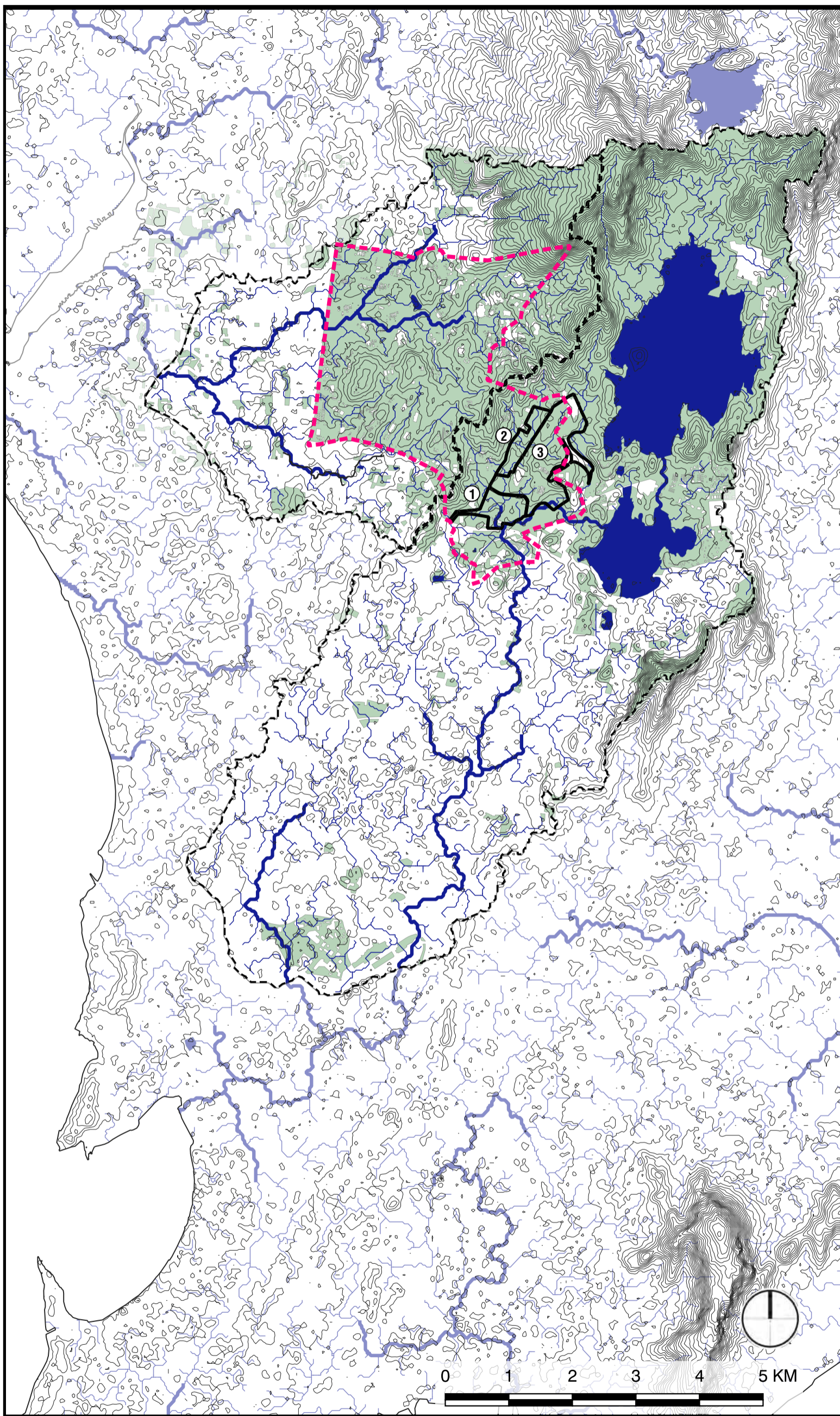
-  Aarey Milk Colony boundary - 1964 DP
-  Ridge Line
-  Predominantly unbuilt or Natural
-  Substantially built or concretized
-  Mud Flats/ Coastal Mangroves
-  Water Bodies
-  Streams
-  DP Reservations



Broad Land Cover 2018

Source: (1) Streams extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/F7PR7TFT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) Land Cover layers extracted from 2018 Satellite Image of Mumbai City, Google Earth, earth.google.com/web/.





NOTE: This map shows the areas of natural vegetation (in green) in the catchment areas of Oshiwara and Mithi rivers (indicated in dotted black line). The thin black lines are contour intervals at 10 meters, and the thin blue lines indicate the surface drainage patterns of the two rivers. Aarey is indicated in pink dotted line (as per the 1964 Development Plan). The plots highlighted with heavy black outlines indicate the reservations for the Metro Car Shed, Zoo and Housing. The map shows the extent of natural cover that will be affected by the new reservations, in the areas where the streams that feed the Mithi river originate.

- LABELS:**
1. Metro Car Shed
 2. R&R Housing
 3. Zoo

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

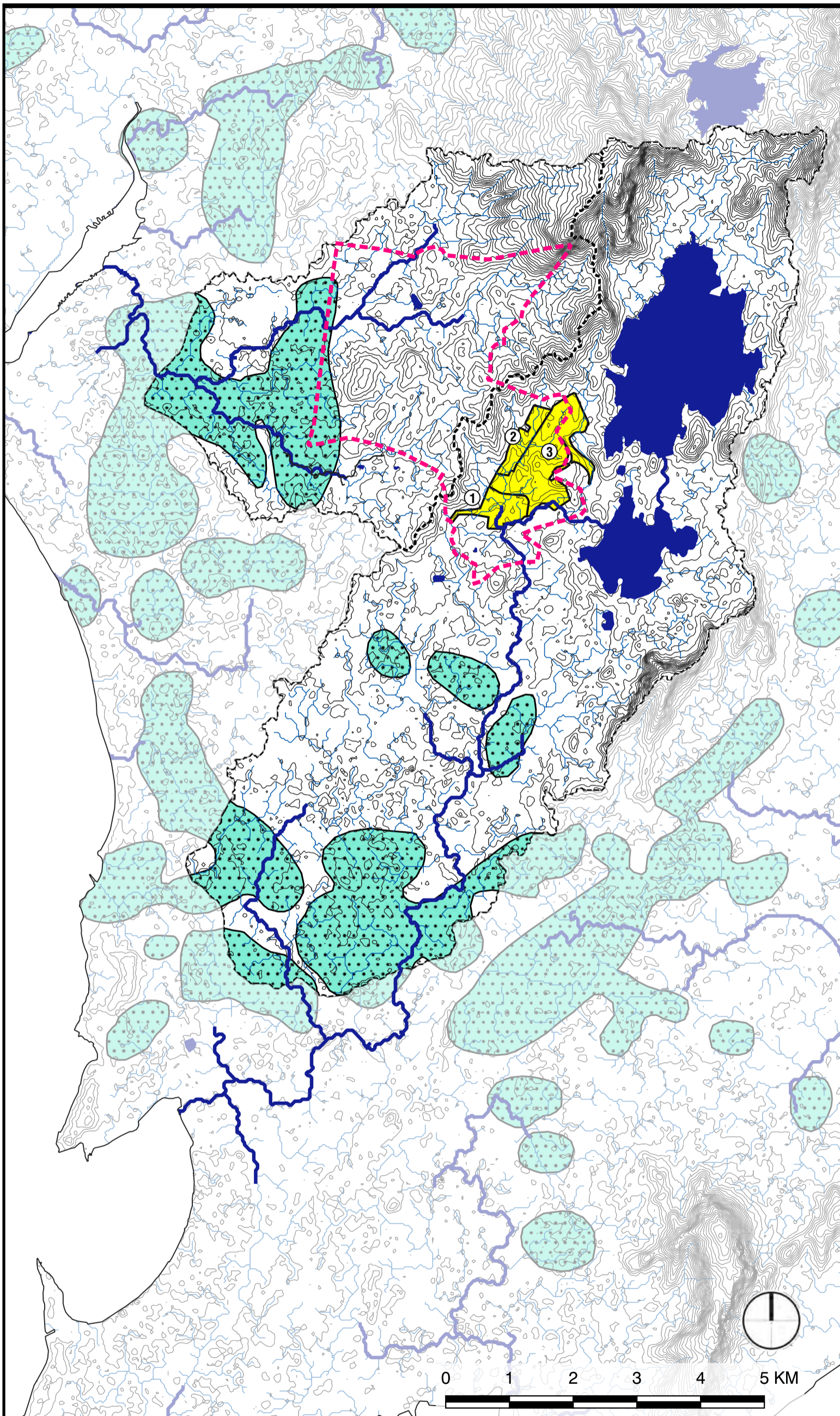
Suggested Reference:
 Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Ridge Lines
- Lakes
- Predominantly Unbuilt/ Natural
- Major Streams
- Minor Streams
- Contours at 10m interval
- DP Proposed Reservations

Vegetation in Oshiwara and Mithi River Catchments

Source: (1) Contours, streams and catchments extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/F7PP7TFT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) DP 2034 Proposed Reservations extracted from Development Plan 2018-34 for Greater Mumbai, MCGM (4) Broad Land Cover layers extracted from Google Earth Satellite overlaid with DP 2034.



NOTE: This map shows the boundary of Aarey (in pink dotted outline, as per the 1964 Development Plan) overlaid with contours at 10 meter intervals. The catchment areas and natural drainage basins of the Mithi and Oshiwara rivers (generated through GIS analysis) have been shown indicating the natural drainage basins and stream networks that feed the two rivers. The yellow highlighted area indicates reservations for the Metro Car Shed, Zoo and Housing. The green-blue areas show the flood prone areas of the two rivers. Land use changes in the upper catchment areas of the Mithi, that are comparatively steeper, are likely to exacerbate the flooding risks in the floodplains and downstream flood prone areas. Concretization will increase percentage of surface runoff and increase in streams energy and possibility of flash floods.

LABELS:

- 1. Metro Car Shed
- 2. R&R Housing
- 3. Zoo

NOTE: Catchments define the extent of land that drains storm-water and runoff into a body of water and generally do not include areas under tidal influence. Since drainage patterns and extent of tidal influence are considerably altered in reclaimed areas of the river, areas up to present reclamation have been included within the catchment boundary for the purpose of this study.

Suggested Reference:

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LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Ridge Lines
- Lakes
- Flooding Areas
- Major streams
- Minor streams
- Contours at 10m intervals
- DP Proposed Reservations

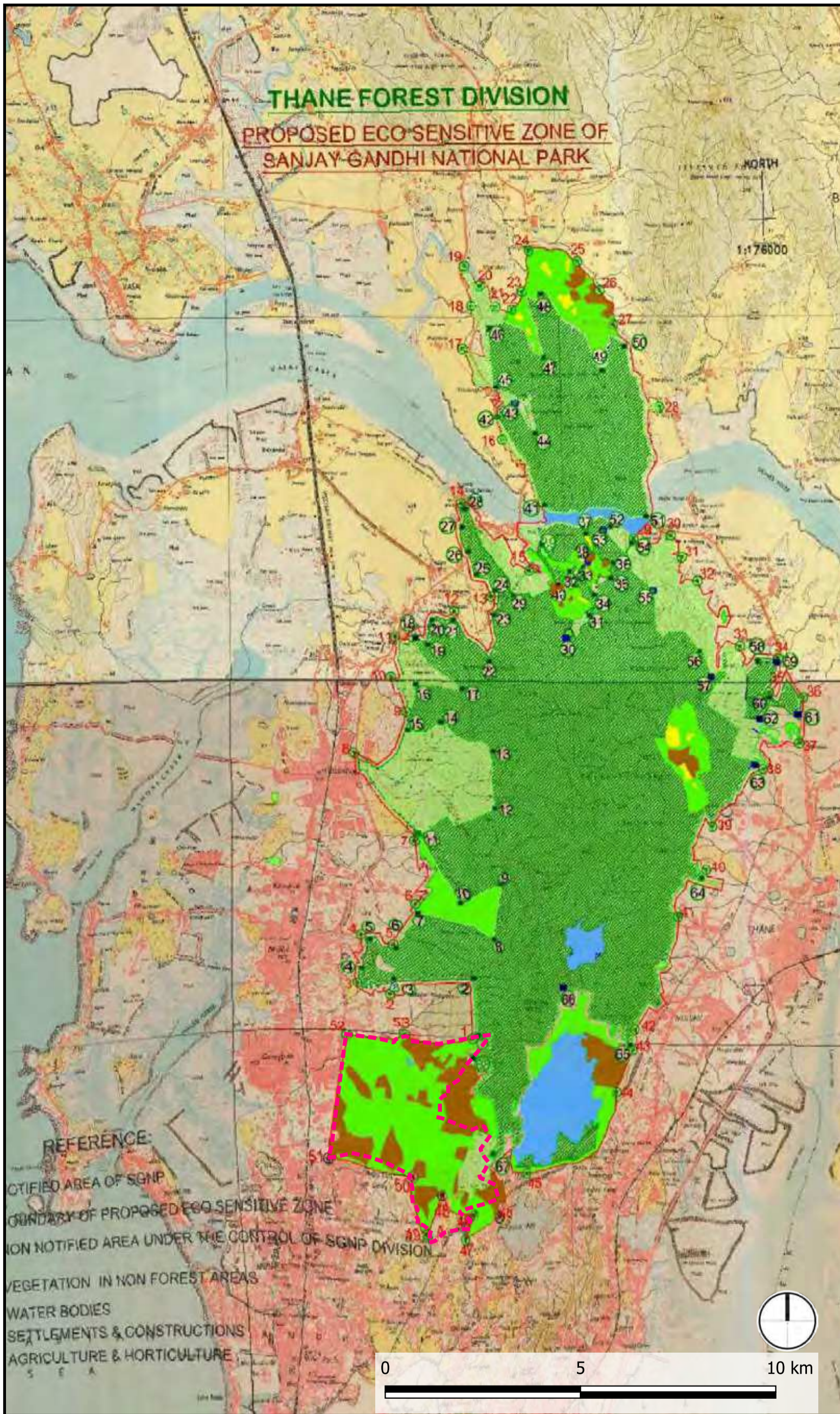


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Flood Prone Areas in Catchments

Source: (1) Contours, streams and catchments extracted from Digital Elevation for study area sourced from USGS EROS Archive: SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/1F7PR7FT), Entry ID: SRTM1N18E072V3, Date: 2014 (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964. (3) DP 2034 Reservations extracted from Development Plan 2018-34 for Greater Mumbai, MCGM. (4) Flooding Areas extracted from Monograph on Flood Hazard by ENVIS Centre on Human Settlements, SPA-New Delhi.





NOTE: This map shows the proposed boundary of the Eco-Sensitive Zone around Sanjay Gandhi National Park which was notified on 5th December 2016. The Eco-Sensitive Area is spread over an area of 59.456 sq km to an extent of 100 meters to four kilometers from the boundary of Sanjay Gandhi National Park. It includes 1114.7 HA of Area of Aarey Dairy Division and areas handed by Aarey Dairy Division to other State Departments. The Notification states that it is necessary to conserve and protect the area around Sanjay Gandhi National Park as Eco-Sensitive Zone from Ecological and Environmental point of view.

Suggested Reference:
 Wagh Shweta, Indorewala Hussain, Yerramshetty Minal, Desai Mihir, Mathew Reshma Susan, *Mapping Aarey: A Study of the Impacts of Land Use / Land Cover Changes on Catchment Areas and Ecosystems*, Kamla Raheja Research and Design Cell. 2019.

LEGEND

- Aarey Milk Colony boundary - 1964 DP
- Notified Area of SGNP
- Vegetation in non forested areas
- Settlements and Construction
- Non-notified area under control of SGNP Division
- Boundary of Eco Sensitive Zone

Boundary of Aarey overlaid with the Boundary of the notified Eco-Sensitive Zone (ESZ) around SGNP

Source: (1)The Gazette of India, Notification by the Ministry of Environment, Forest and Climate Change, 5th December 2016, declaring Eco-Sensitive Zone around Sanjay Gandhi National Park. (2) Aarey Milk Colony Boundary extracted from Bombay Municipal Corporation, Development Plan for Greater Mumbai, 1964.

2

Biodiversity of Aarey Milk Colony

1. Butterflies and Moths



2. Avifauna (Birds)



4. Bugs and Beetles



5. Ants



7. Odonates

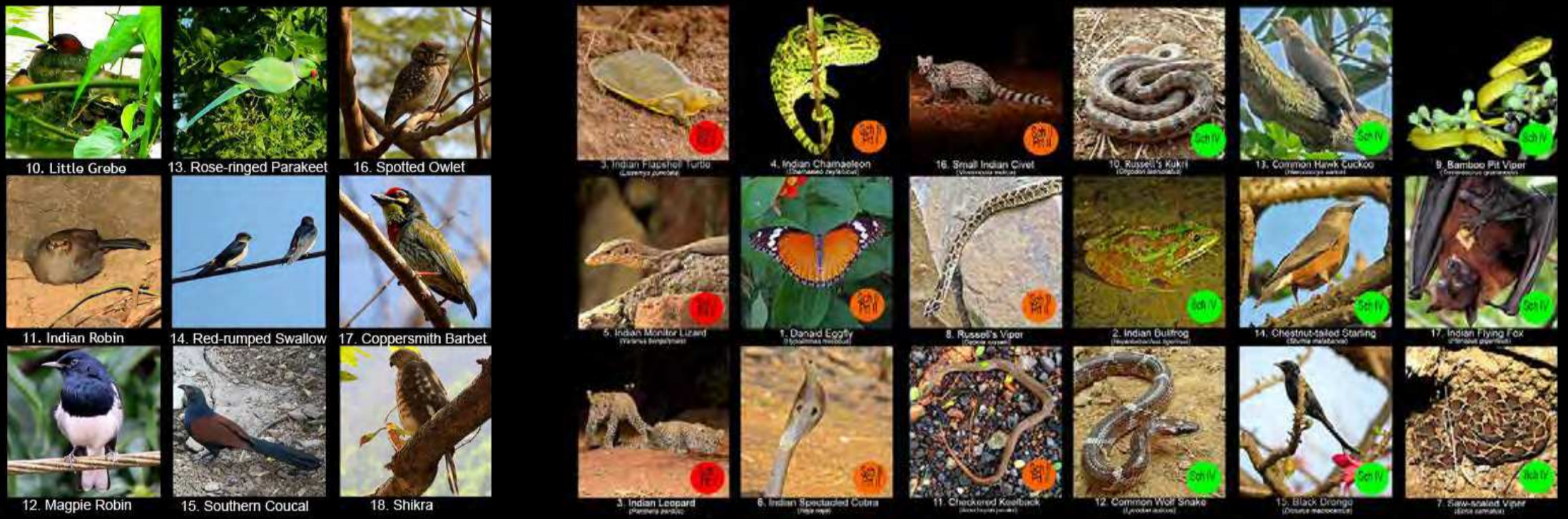


8. Amphibians and Reptiles



Photo plates prepared by SPROUTS Environmental Trust.

3. Scheduled Species



6. Mosses, Ferns, Fungi and Lichens



9. Arachnids





Stream that Feeds the Mithi River as it flows through Catchment Areas in Aarey Having Natural Vegetation.



Concretised Banks of the Channelised portion of the Mithi River in the Area Near the Metro Car Shed.

Aarey is a hilly landscape of extensive forest cover, natural ecosystems, numerous adivasi settlements, and primary occupations. Since it was established as a government Milk Colony in the late 1940s, it has been a predominantly low-intensity development zone, forming a much needed buffer area to the Sanjay Gandhi National Park (SGNP). Aarey is a part of Mumbai's ecologically vital hill complex along with the National Park, where streams and tributaries that feed two of four major rivers of the city originate: Oshiwara and Mithi. This report provides a qualitative-spatial analysis to highlight the impacts of past and proposed land use / land cover changes in Aarey on its river catchments and ecosystems.

