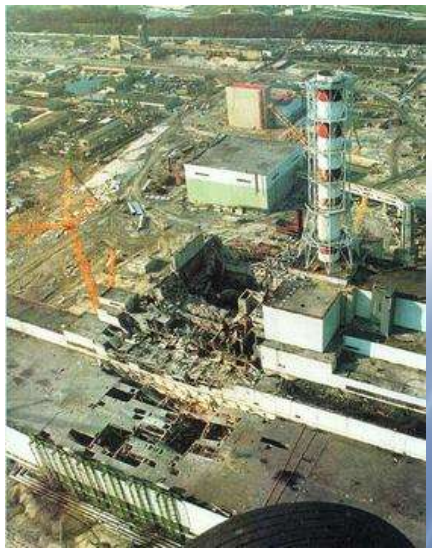
# Chernobyl: 30 years on

Lorraine Field

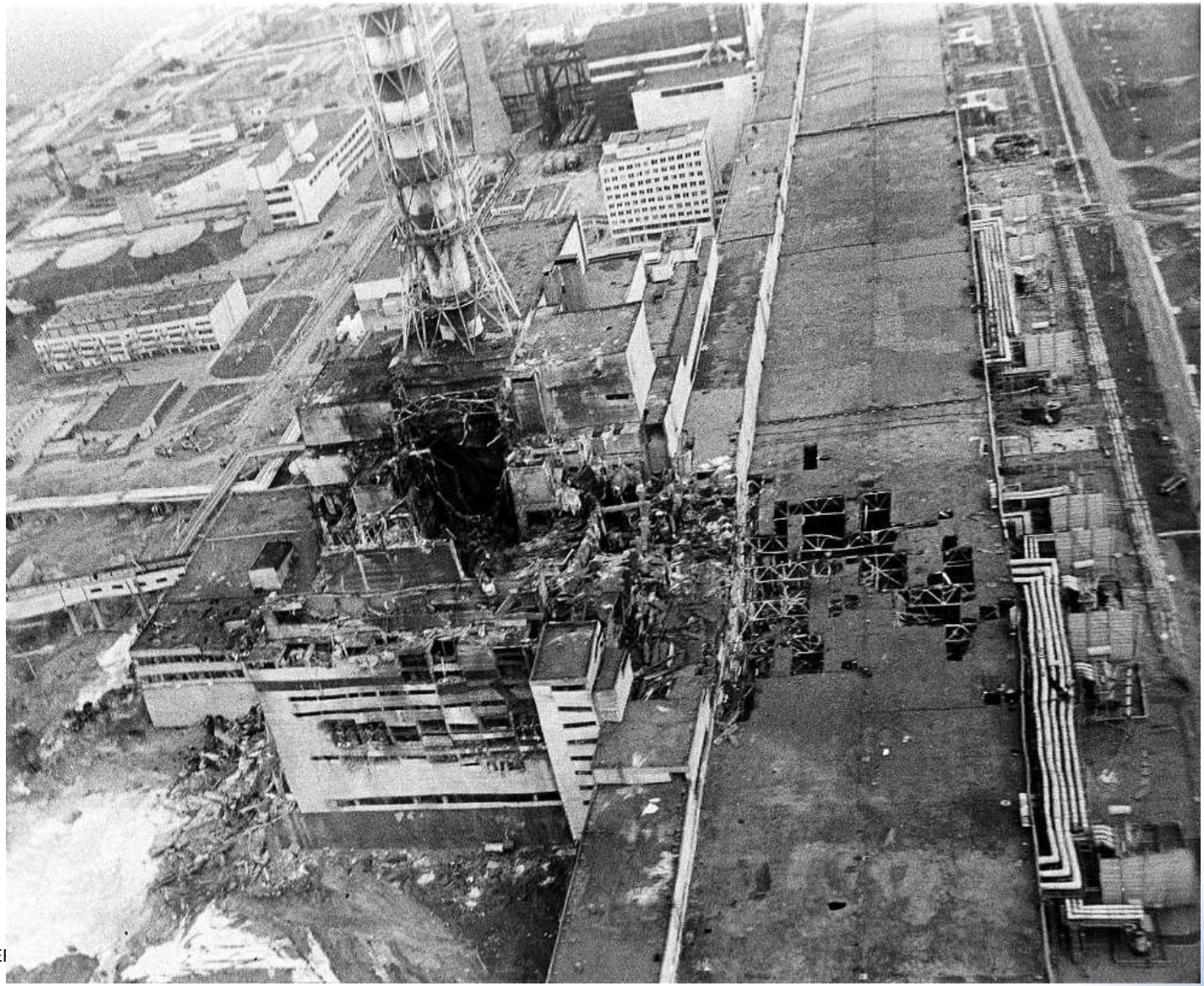
# 26th April 1986

- Explosions in reactor 4
- 400 times the amount of radioactive material released than in the Hiroshima bomb.
- First noticed in the west by Swedish nuclear power station workers
- This was the time of the cold war – the Soviet Union were reluctant to admit the scale of the accident
- Largest nuclear accident to date

Photographs taken by the Soviet Authorities in the immediate aftermath of Chernobyl Disaster. Downloaded from: https://en.wikipedia.org



# 26th April 1986

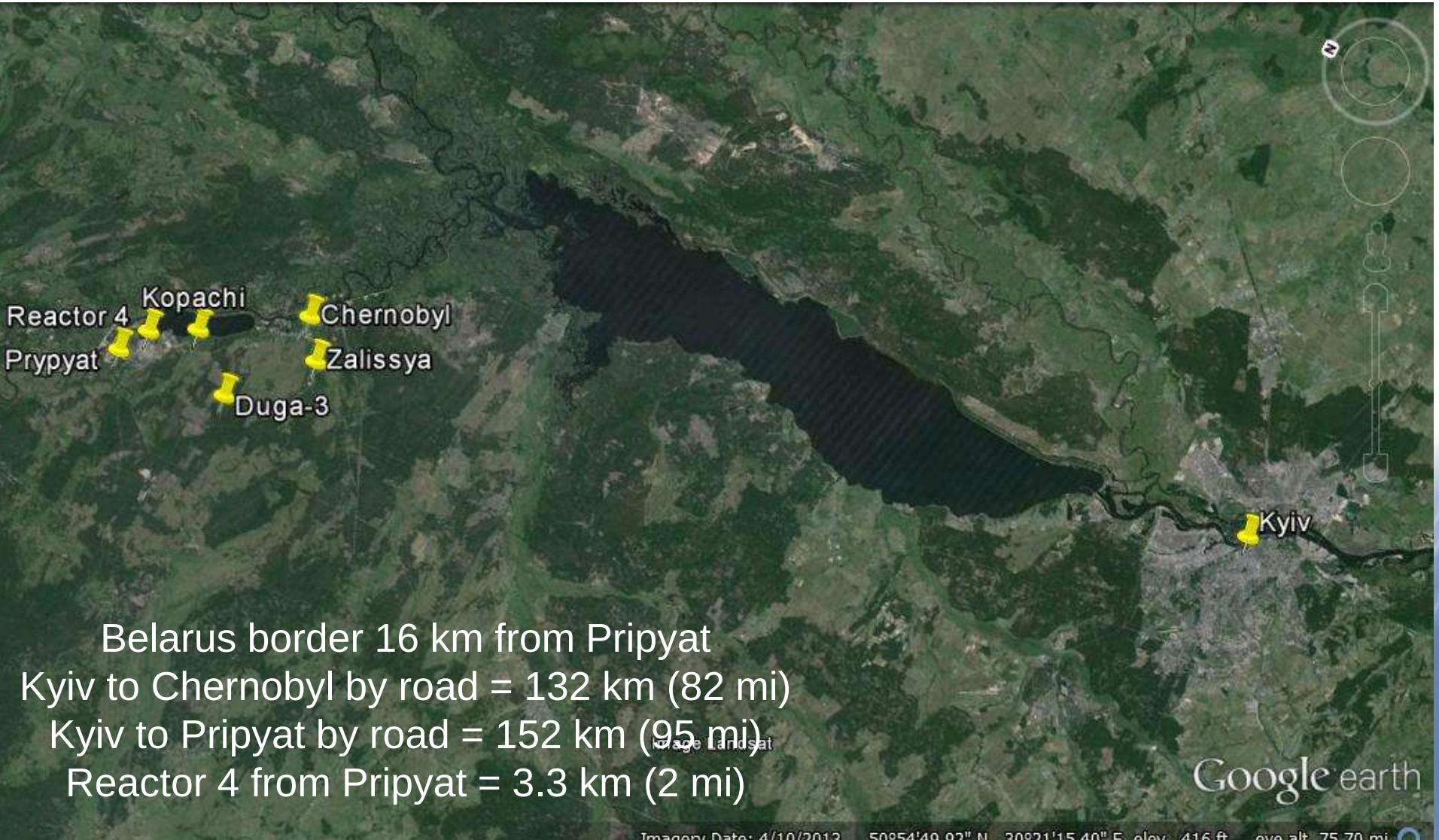


Photographs taken by the Soviet Authorities in the immediate aftermath of Chernobyl Disaster. Downloaded from: https://en.wikipedia.org

# Evacuation

- Delay by authorities of 36 hrs before 1st evacuations (27th May 1986). Evacuations cont. until 1995
- 47000 residents of Pripyat, an elite, purpose built city to house the workers of the Nuclear power plant were evacuated with 2 hrs notice
- Told to take official papers, and food for 3 days only
- Eventually 186 settlements within the ‘Zone of Alienation’ were permanently evacuated over the next few years (Polesie State Radioecological Reserve in Belarus is separate)
- Because of the ‘patchy’ nature of the contamination (due to changing winds), inevitably some people were evacuated from areas of lower contamination to areas of higher contamination outside the zone.

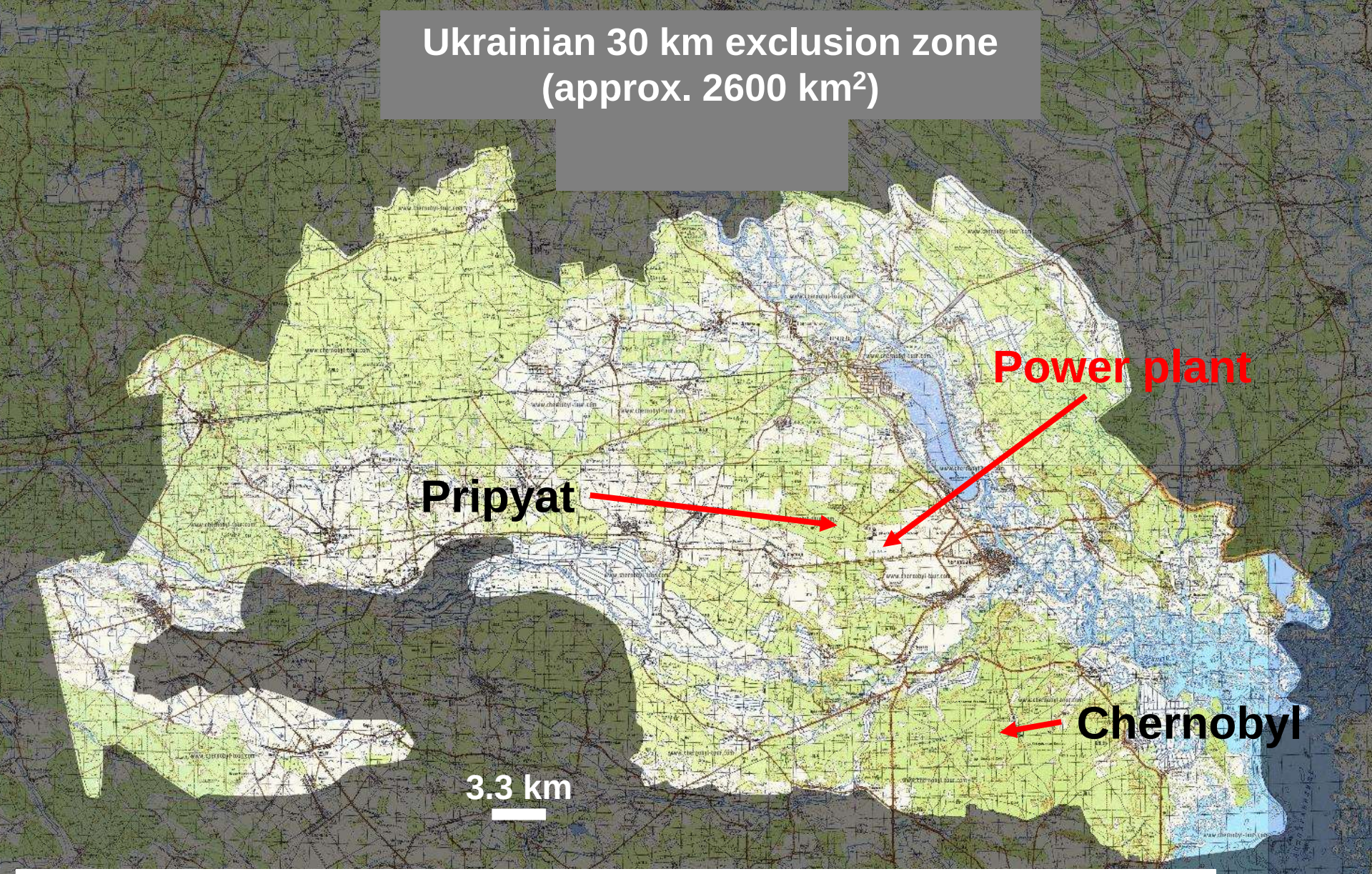
# Locations


Kopachi
Reactor 4
Chernobyl
Prypyat
Zalissya
Duga-3
Kyiv
Belarus border 16 km from Pripyat
Kyiv to Chernobyl by road = 132 km (82 mi)
Kyiv to Pripyat by road = 152 km (95 mi)
Reactor 4 from Pripyat = 3.3 km (2 mi)
Google earth

# Zone of alienation (exclusion zone)

**December 1989 Caesium 137 contamination**

# Ukrainian 30 km exclusion zone (approx. 2600 km²)




The borders were determined based on soil contents of Strontium 90, Caesium 137 and Plutonium, as well as the calculated dose rate (Sieverts): *Map from www.Chernobyl-tour.com*

# The zone

- Number of rules concerning the exclusion zone:
  - No tourists allowed within the zone (you enter as a ‘scientific observer’)
  - No-one under the age of 18
  - No alcohol, no drugs, no weapons
  - No eating or smoking in the open air
  - No removal of anything from the zone
  - No photographs of anything related to police or military (e.g. checkpoints), fences, barbed wire…
  - Curfew to be observed after 8pm
  - Must be accompanied by the ‘officer responsible for the envoy’ at all times

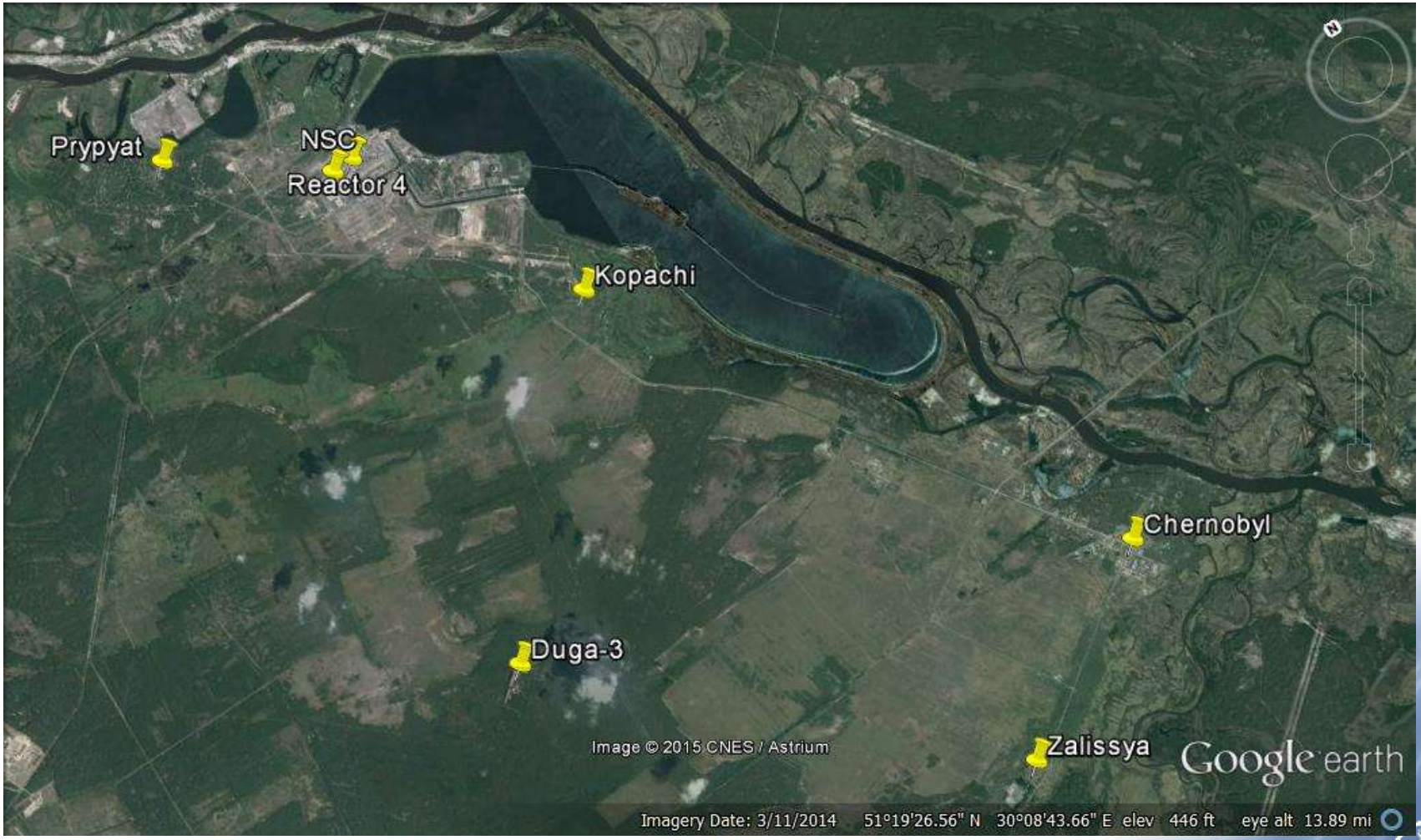
# The zone

*‘I, participant of the delegation coming to the exclusion zone on a study tour on Feb 21, 2015, agree that the State Department Administration of the exclusion zone shall not be liable for possible further deterioration of my health as a result of a visit to the exclusion zone’.*

# Checkpoints

- 3 checkpoints – 30 km entry point, 15 km and entry to Pripyat (5 km zone)
- Vehicle, goods and people / clothing must pass through radiation scanning 3 times on exit

# Key localities



# Inside the zone


Very few people. Currently about 3000 workers within the zone working shifts of 15 days on / 15 days off

General background radiation in Chernobyl town = 0.12 μSv/h

# Wildlife haven

# Wildlife haven





# Decontamination - bulldozed villages

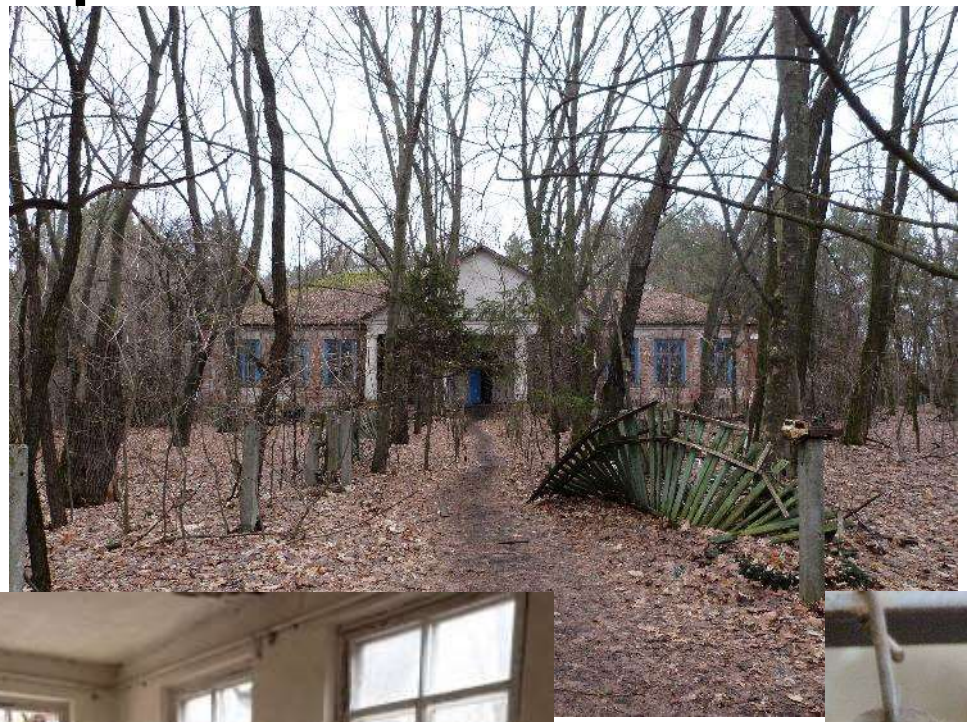
- Initial plan was to bulldoze and bury all wooden buildings
- Rock is sandstone and a major aquifer
- Ukraine demolished 3 villages which caused a significant rise in contamination in the Dnieper River which supplies water to Kyiv

  (Belarus continued to demolish villages until a few years ago)
- Kopache – all wooden buildings destroyed. 3 buildings remain: the kindergarten, the administration building and the collective farm. Brick built, these were washed down to de-contaminate.

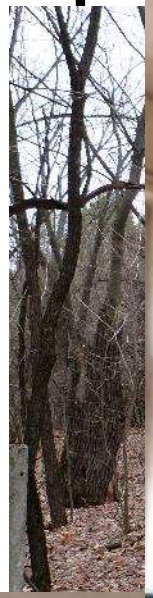
# Kopache

# Kopache

# Kopache



# Kopa



# Zalyssia

Non-bulldozed evacuated village

Pre 1986 pop. = 2849

Present pop. = 1

# Zalyssia

# Self-settlers (Samosely)

- ~1000 elderly people (over 40) illegally resettled into the Exclusion Zone (Ukraine and Belarus) – authorities turned a blind eye
- Around 100-200 still alive
- Incredibly strong sense of place – generations had lived in the same house
- No gas or electricity, water or pensions so completely self-sufficient
- Medical check-ups only set up in recent years

# Roseanna

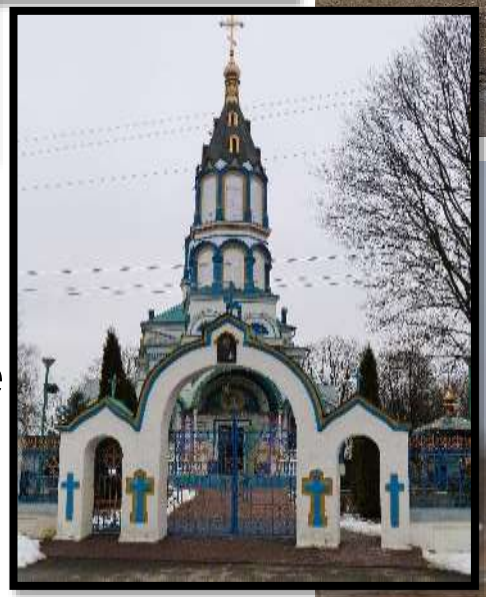
- 87 yrs old
- Evacuated for 5 months
- Only resident who returned
- Surrounded by >300 empty houses
- Has not left exclusion zone in 29 yrs
- Survives on contaminated well water and home grown veg
- Has not seen a child in 29 yrs

# Roseanna

- Water has to be collected daily from the village well ~400 m from the house

# Chernobyl town

# Chernobyl town

Est c. 1100 A.D.
Pop. Pre 1986 = 14,000
Administrative centre for the exclusion zone

Lenin's statue still remains
…close to the only church in the zone

# Chernobyl

# Chernobyl


# Chernobyl

In the centre of the memorial garden are 4 post boxes, a slot for each of the evacuated villages.
Many of the evacuations occurred at a few hours notice, but were supposed to be temporary. Families, friends and neighbours were separated.
No records were kept of who was relocated where.
On the 25th anniversary of the disaster the post boxes were set up. These are opened on the anniversary each year with the aim of putting people back in touch.
For those who are computer literate a website has also now been set up with the same aim.

# Chernobyl museum

# Chernobyl

# Chernobyl


# Chernobyl Interform hotel – the yellow peril!

## RULES PREVENTION OF SAFETY

Radioactive contamination originates in a result of radioactive dust fallout. Contamination could be dangerous during several days or several months. Use shelter as irradiation protection – gas masks, respirators and dust masks as breath protection means/

If you received warning about radioactive contamination, go to the person in charge for the hotel, or your attendant in the Exclusion Zone/ To protect your skin use sports clothes, overalls and boots. Take wish you plastic cloak, jackets or raincoats.

Get from person in charge means of personal protection put on your personal protective gear, leave the premises and go to a safe place shown by the Director of the TOV «REKTAN» company or by the person in charge of civil defense matters (Anti-radiation Shelter – room # in administrative building in 1a B. Khmelnitskogo Str.)

Further follow recommendations from the civil defense headguarter.

**Manager of the hotel and**

**restaurant business** **Pashkevych SL**

# Duga-3 array (Soviet woodpecker)

- Top secret military early warning system
- 750 m long x 150 m high
- Consumed 30% of total output from V.I. Lenin Nuclear Power plant
- To be dismantled for scrap in 2015

# Duga-3 array (Soviet woodpecker)

# V.I. Lenin Nuclear Power plant

# V.I. Lenin Nuclear Power plant

- All 4 reactors were of Soviet RMBK-1000 design
- Reactor 1 operational in 1977, reactor 4 1983
- Several serious design flaws contributed to the disaster

- Following the disaster, reactors 1, 2 and 3 continued to operate. The last reactor (3) was shut down finally in 2000.
- Reactor 4 was encased in a rapidly constructed concrete sarcophagus estimated to last no more than 20 years…

# RMBK-1000 reactors

- RMBK – stands for ‘reactor, high-power, boiling, channel type’ in Russian
- The most fundamental design flaw is that there is no secure containment in the sense accepted in the West. The reactor core is located in a reinforced concrete lined cavity that acts as a radiation shield.
- Several major modifications to improve safety implemented following Chernobyl including *the prevention of the emergency safety system from being bypassed while the reactor is operating!*

- 11 RMBK reactors are still operating in Russia

# RMBK – 1000 reactors

| Location | Unit | First power | Status |
|---|---|---|---|
| **Russia** | | | |
| Kursk | 1 | 1976 | Operating until ~~2021~~ 2023 |
| | 2 | 1979 | Operating until 2024 |
| | 3 | 1984 | Operating until March ~~2014~~ 2029 |
| | 4 | 1986 | Operating until February ~~2016~~ 2030 |
| Leningrad | 1 | 1973 | Operating until 2019 |
| | 2 | 1975 | Operating until 2021 |
| | 3 | 1979 | Operating until June 2025 |
| | 4 | 1981 | Operating until August 2026 |
| Smolensk | 1 | 1983 | Operating until December ~~2013~~ 2028 |
| | 2 | 1985 | Operating until July ~~2015~~ 2030 |
| | 3 | 1990 | Operating until July ~~2023~~ 2034 |
| **Ukraine** | | | |
| Chernobyl | 1 | 1977 | Closed 1996 |
| | 2 | 1978 | Closed 1991 |
| | 3 | 1981 | Closed 2000 |
| | 4 | 1983 | Reactor destroyed April 1986 |
| | 5 | - | Construction cancelled |
| | 6 | - | Construction cancelled |

Taken from the World Nuclear Association website 02/04/16

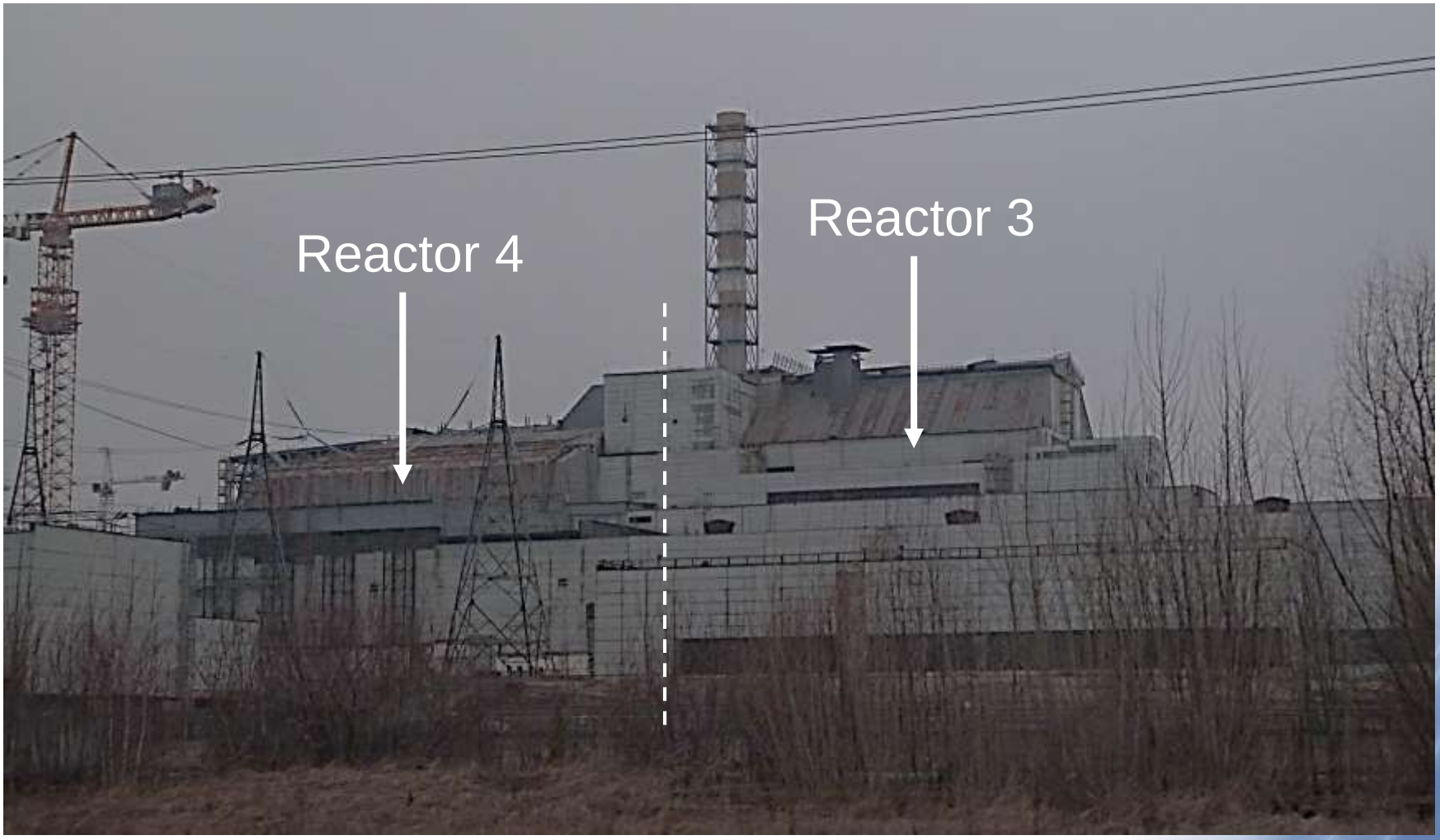
# Reactor 4



Background radiation = 2.77 µSv/h
Shielding from monument reduces dose to 0.83 µSv/h

# Reactor 4

# Reactor 4



# The NSC

- Estimated cost €2.15 bn
- (Dec 2014 EBRD pledged a further €350 m towards the €615 m shortfall)
- Completion estimated Nov 2017
- Weight 30,000 tonnes
- 300 m from sarcophagus
- 110 m tall, 257 m wide
- Predicted lifespan 100 yrs
- Should withstand -43 to +45 $^{o}$C, mag 6 earthquakes and cat 3 tornadoes

# Reactors 5 and 6

- Building work on reactors 5 and 6 was stopped, although had continued all through the 26th April.
- 5 was due to come on-line in Nov 1986, 6 not until 1994

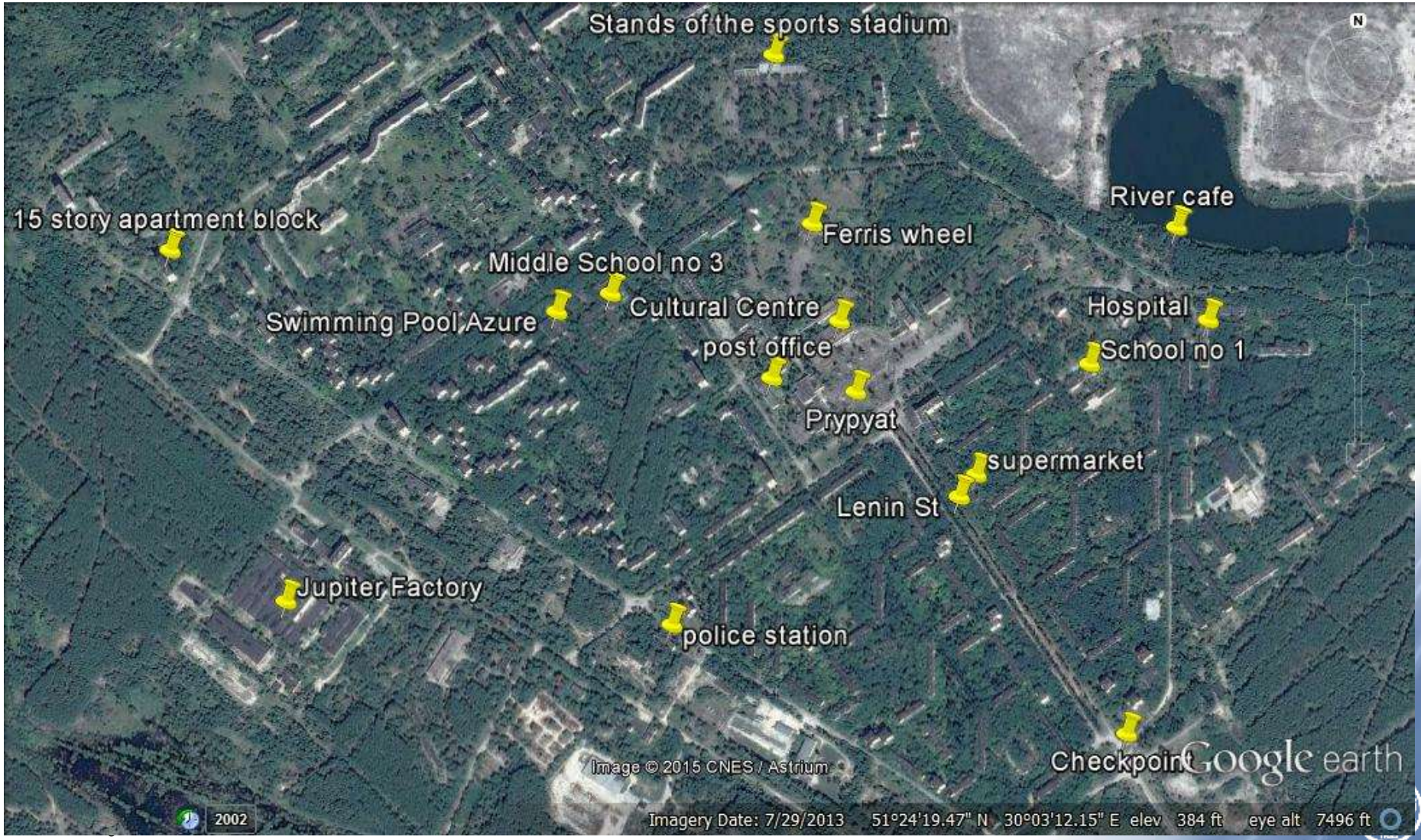
# Reactors 5 and 6

- Cooling ponds insufficient so reactors 5 & 6 were to have cooling towers
- Ground not decontaminated background = 3.55 µSv/h


# Pripyat


- <3 km from the reactor – purpose build, model Soviet town to serve the power plant
- 47,000 residents at the time of the explosion (average age 26)
- Order for evacuation not given for 36 hrs – residents simply told there was a fire at the reactor and that everything was under control.
- No instructions given to stay indoors nor keep windows closed. Weather was warm, so children carried on playing outdoors…
- 2 hrs notice given of evacuation. Told to assemble in front of each of the 26 accommodation blocks.
- Fleets of buses turned up and distributed the ‘nuclear refugees’ across the Ukraine. Families, friends and neighbours were split up…

# Pripyat


Stands of the sports stadium
15 story apartment block
Ferris wheel
River cafe
Middle School no 3
Swimming Pool Azure
Cultural Centre
Hospital
post office
School no 1
Prypyat
supermarket
Lenin St
Jupiter Factory
police station
Checkpoint
Image © 2015 CNES / Astrium
Google earth
2002
Imagery Date: 7/29/2013 51°24'19.47" N 30°03'12.15" E elev 384 ft eye alt 7496 ft

# Main street – Lenin Ave

# Main street – Lenin Ave

# The post office

# Colour

# The Cinema

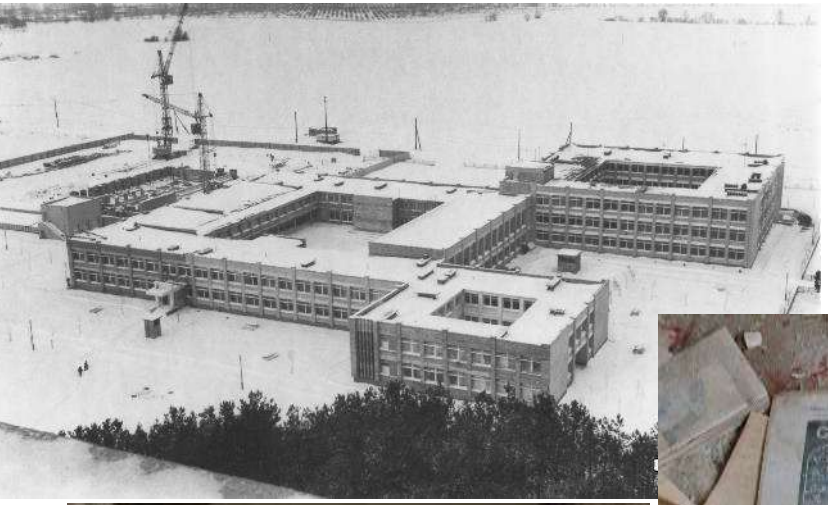

# The sports stadium

Football pitch

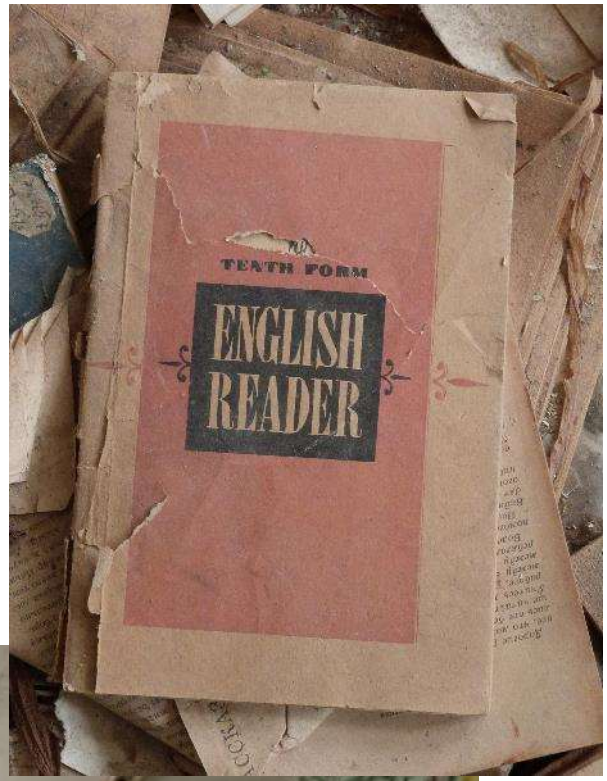
Running track

# The amusement park


# Middle school no 3




# Middle school no 3


# Hospital no 6


# Hospital - radiation


Highest radiation in Pripyat – Discarded fireman's clothing in the hospital -still radioactive 1.198 mSv/h (background in Chernobyl is 0.00012 mSv/h)

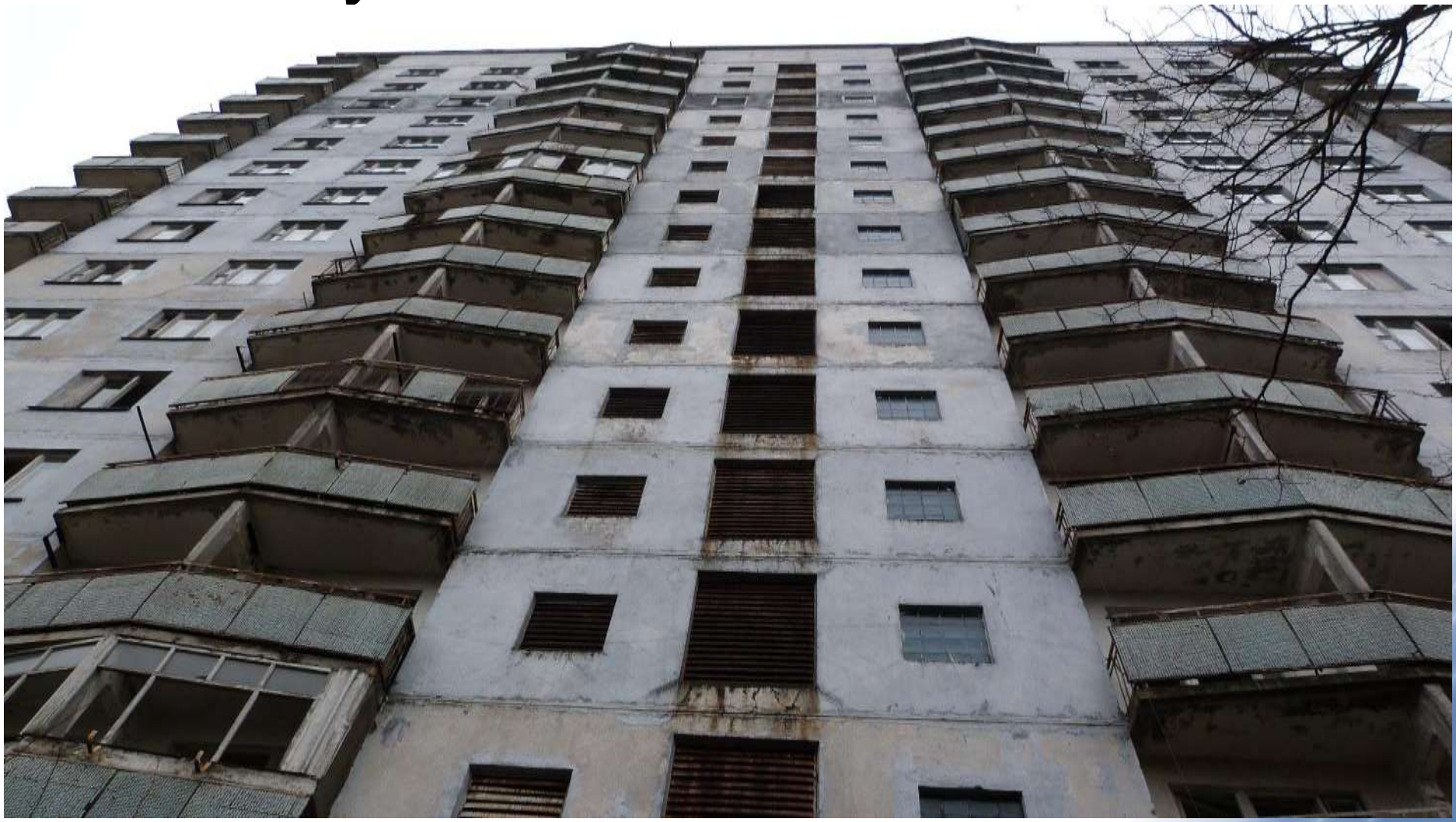
# The future – school no 1

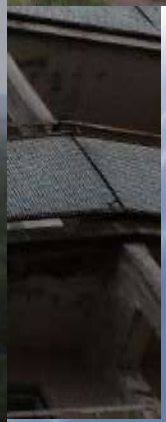
Collapsed 2013

# The future

# The future

# Finally…






Received dose for 48 hrs in the zone = 0.007 mSv

Calculated out for a worker on 15/15 shifts (assuming no other radiation e.g. medical), annual dose <1 mSv

**Comparison of doses from sources of exposure – from Public Health England**

| Source of exposure | Dose |
|---|---|
| Dental x-ray | 0.005 mSv |
| 100g of Brazil nuts | 0.01 mSv |
| Chest x-ray | 0.014 mSv |
| Transatlantic flight | 0.08 mSv |
| Nuclear power station worker average annual occupational exposure (2010) | 0.18 mSv |
| UK annual average radon dose | 1.3 mSv |
| CT scan of the head | 1.4 mSv |
| UK average annual radiation dose | 2.7 mSv |
| USA average annual radiation dose | 6.2 mSv |
| CT scan of the chest | 6.6 mSv |
| Average annual radon dose to people in Cornwall | 7.8 mSv |
| CT scan of the whole spine | 10 mSv |
| Annual exposure limit for nuclear industry employees | 20 mSv |
| Level at which changes in blood cells can be readily observed | 100 mSv |
| Acute radiation effects including nausea and a reduction in white blood cell count | 1000 mSv |
| Dose of radiation which would kill about half of those receiving it in a month | 5000 mSv |

# If you want to know more….

- Selected bibliography
  - Medvedev, Z (1986) The Legacy of Chernobyl, WW Norton & Co
  - Alexievich, S (1997) Voices from Chernobyl: The oral history of a nuclear disaster, Picador.
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- Websites
  - http://world-nuclear.org/ Informative website of the World Nuclear Association
  - https://www.gov.uk/government/publications/ionising-radiation-dose-comparisons/ionising-radiation-dose-comparisons Public Health England radiation doses
  - http://www.chernobyl-tour.com/english/ Ukranian travel company I used

# Any questions?