# DevOps Deployment Guide

## React Application with Complete CI/CD Pipeline

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**Prepared By:** Surya Prakash C
**Classification:** Project Use

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## Executive Summary

This document provides comprehensive deployment procedures for a React-based web application utilizing modern DevOps practices. The solution implements automated CI/CD pipelines, containerized deployment, infrastructure as code, and comprehensive monitoring to ensure reliable, scalable, and maintainable application delivery.

### Key Technologies

- **Frontend Framework:** React with Nginx web server
- **Containerization:** Docker with multi-stage builds
- **CI/CD Platform:** Jenkins with automated pipeline orchestration
- **Infrastructure Management:** Terraform (Infrastructure as Code)
- **Cloud Platform:** Amazon Web Services (AWS)
- **Monitoring & Alerting:** AWS CloudWatch, SNS, Prometheus/Grafana
- **Container Registry:** Docker Hub with environment-specific repositories

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# Solution Architecture

## High-Level Architecture Overview

```
┌─────────────────┐    ┌─────────────────┐    ┌─────────────────┐
│   Developer     │    │    Jenkins      │    │     AWS Cloud   │
│   Workstation   │ ──▶│   CI/CD Server  │ ──▶│   EC2 Instances │
└─────────────────┘    └─────────────────┘    └─────────────────┘
        │                      │                      │
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        └──────────────────────▶┌─────────────────┐◀──────────────┘
                                │  Docker Hub     │
                                │  Container      │
                                │  Registry       │
                                └─────────────────┘
```

## Component Architecture

| Component | Purpose | Technology Stack |
|---|---|---|
| **Application Layer** | React frontend delivery | React, Nginx, Docker |
| **Build Pipeline** | Automated CI/CD | Jenkins, Docker, Shell Scripts |
| **Infrastructure** | Cloud resources management | Terraform, AWS EC2, VPC |
| **Monitoring** | System observability | CloudWatch, SNS, Prometheus |
| **Security** | Access control & compliance | AWS Security Groups, SSH Keys |

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# Prerequisites & System Requirements

## Required Software Components

| Software | Minimum Version | Purpose |
|---|---|---|
| AWS CLI | 2.0+ | Cloud infrastructure management |
| Terraform | 1.0+ | Infrastructure provisioning |
| Docker | 20.0+ | Container runtime |
| Node.js | 16.0+ | React application building |
| Git | 2.30+ | Source code management |

## Required Access Credentials

- [x] **AWS Account** with administrative privileges
- [x] **Docker Hub Account** with repository creation rights
- [x] **Git Repository** access with commit permissions
- [x] **Valid Email Address** for monitoring alerts

## Network & Security Requirements

- **Outbound Internet Access** for package downloads and container pulls
- **SSH Key Pair** for secure EC2 instance access
- **Static IP Address** for security group configuration
- **SSL Certificate** (recommended for production environments)

### Resource Requirements

| Environment | EC2 Instance Type | Storage | Network |
|---|---|---|---|
| Development | t2.micro | 20GB SSD | Standard networking |
| Production | t3.small+ | 50GB+ SSD | Enhanced networking |

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# Environment Configuration

## Step 1: AWS Environment Setup

### 1.1 Configure AWS CLI

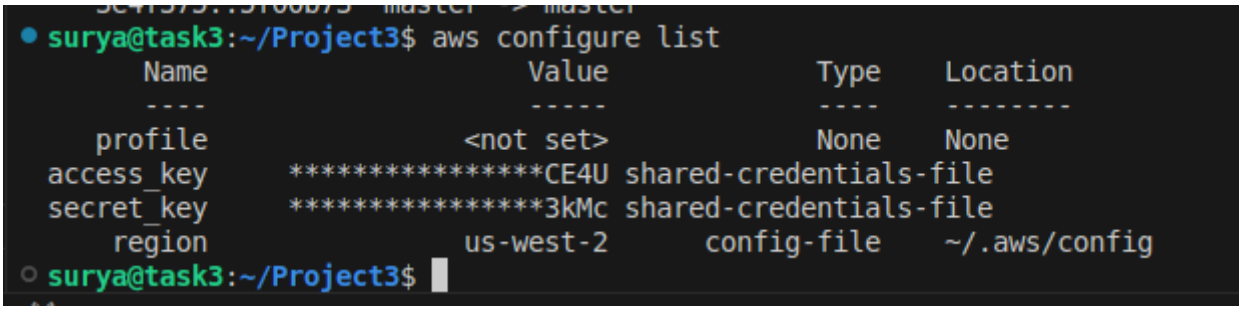
```
# Install and configure AWS CLI
aws configure
```

**Configuration Parameters:**

- Access Key ID: `[Your AWS Access Key]`
- Secret Access Key: `[Your AWS Secret Key]`
- Default Region: `us-west-2` (recommended)
- Output Format: `json`

### 1.2 Create EC2 Key Pair

```
# Generate SSH key pair for secure access
aws ec2 create-key-pair --key-name devops-key \
    --query 'KeyMaterial' --output text > ~/.ssh/devops-key.pem
chmod 400 ~/.ssh/devops-key.pem
```

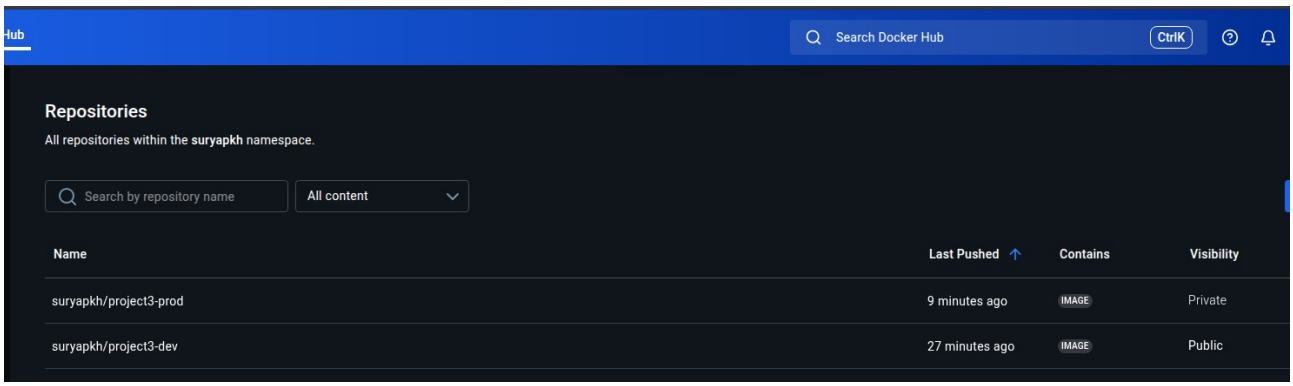



## Step 2: Container Registry Configuration

### 2.1 Docker Hub Repository Setup

Create the following repositories in Docker Hub:

| Repository Name | Environment | Access Level |
|---|---|---|
| `{username}/project3-dev` | Development | Private |
| `{username}/project3-prod` | Production | Private |




## Step 3: Project Structure Validation

Ensure your project follows this standardized structure:

```
project-root/
├── application-files/
│   ├── .dockerignore
│   ├── Dockerfile
│   ├── nginx.conf
│   └── build/ (React build artifacts)
├── ci-cd/
│   ├── Jenkinsfile
│   ├── build.sh
│   └── deploy.sh
├── infrastructure/
│   └── terraform/
│       ├── main.tf
│       ├── variables.tf
│       ├── terraform.tfvars
│       └── user_data.sh
└── monitoring/
    ├── prometheus/
    │   ├── prometheus.yml
    │   └── alert_rules.yml
    └── docker-compose.monitoring.yml
```

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# Infrastructure Provisioning

## Step 1: Terraform Configuration

### 1.1 Environment Variables Configuration

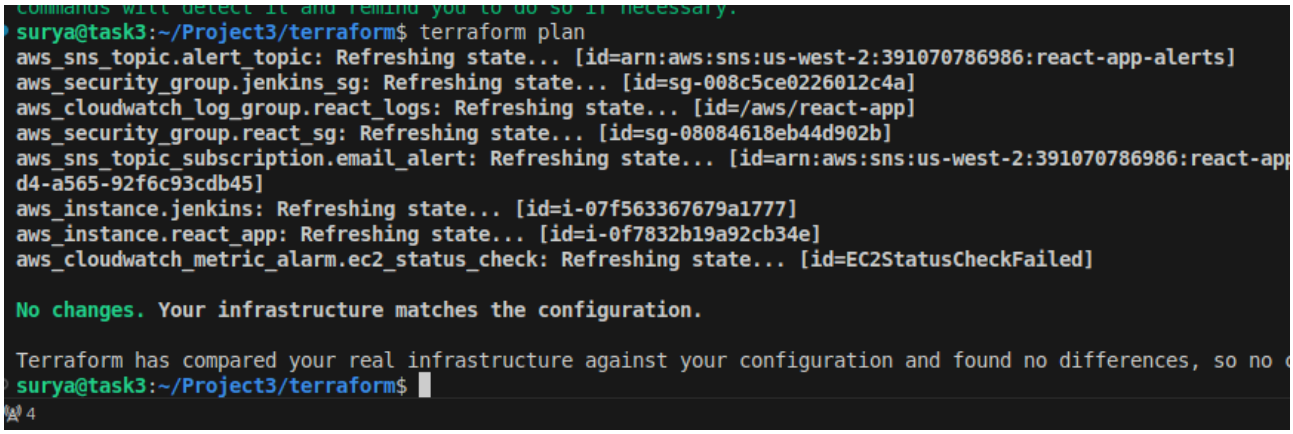
Edit `terraform/terraform.tfvars`:

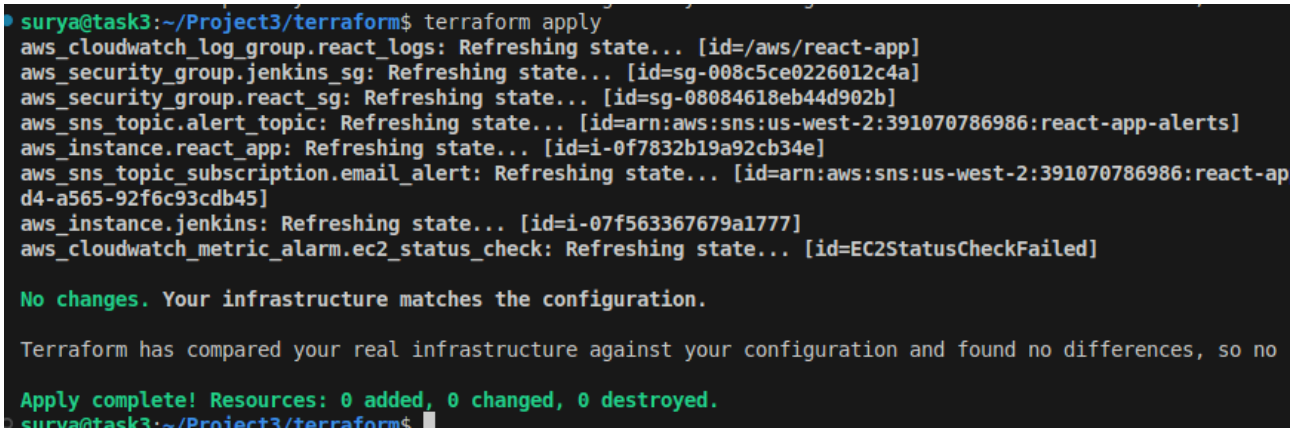
```
# Infrastructure Configuration
aws_region    = "us-west-2"
ami_id        = "ami-0a15226b1f7f23580"  # Ubuntu 20.04 LTS
instance_type = "t2.micro"               # Adjust for production
key_name      = "devops-key"

# Security Configuration
my_ip_cidr    = "YOUR.PUBLIC.IP/32"      # Replace with actual IP
alert_email   = "admin@yourcompany.com"   # Replace with actual email
```

### 1.2 Infrastructure Deployment

```
# Navigate to Terraform directory
```

```
cd terraform/

# Initialize Terraform workspace
terraform init

# Validate configuration
terraform validate

# Review deployment plan
terraform plan -out=deployment.tfplan

# Apply infrastructure changes
terraform apply deployment.tfplan
```




## Step 2: Infrastructure Verification

### 2.1 Validate Resource Creation

```
# Display created resources
terraform output

# Verify EC2 instances are running
aws ec2 describe-instances --filters "Name=tag:Name,Values=react-app-server"
```

### 2.2 Network Connectivity Test

```
# Test SSH connectivity
ssh -i ~/.ssh/devops-key.pem ubuntu@$(terraform output -raw react_app_public_ip)
```

```
surya@task3:~/Project3/terraform$ ssh -i /home/surya/Project3/devops-key.pem ubuntu@18.237.174.67

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

 System information as of Sun Sep 14 08:18:54 UTC 2025

  System load:  0.0               Processes:             102
  Usage of /:   47.5% of 7.57GB   Users logged in:       0
  Memory usage: 77%               IPv4 address for eth0: 172.31.38.23
  Swap usage:   0%

 * Ubuntu Pro delivers the most comprehensive open source security and
   compliance features.

   https://ubuntu.com/aws/pro

Expanded Security Maintenance for Infrastructure is not enabled.

0 updates can be applied immediately.

50 additional security updates can be applied with ESM Infra.
Learn more about enabling ESM Infra service for Ubuntu 20.04 at
https://ubuntu.com/20-04

New release '22.04.5 LTS' available.
Run 'do-release-upgrade' to upgrade to it.


Last login: Sun Sep 14 07:39:29 2025 from 34.56.11.242
ubuntu@ip-172-31-38-23:~$
```

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# CI/CD Pipeline Implementation

## Step 1: Jenkins Server Configuration

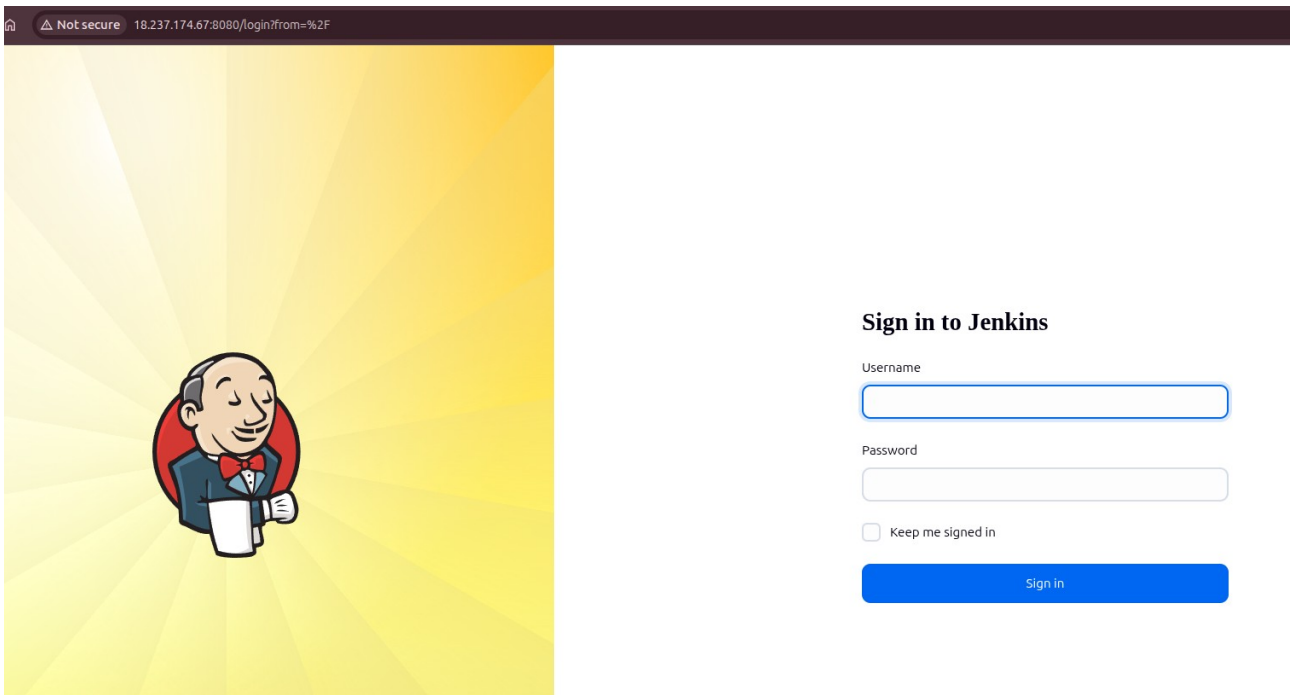
### 1.1 Jenkins Access and Initial Setup

```
# Retrieve Jenkins server IP
JENKINS_IP=$(terraform output -raw jenkins_public_ip)

# Access initial admin password
ssh -i ~/.ssh/devops-key.pem ubuntu@$JENKINS_IP \
    "sudo cat /var/lib/jenkins/secrets/initialAdminPassword"
```

### 1.2 Jenkins Web Interface Configuration

1. Navigate to `http://{JENKINS_IP}:8080`
2. Enter the initial admin password
3. Install suggested plugins
4. Create administrative user account
5. Configure Jenkins URL

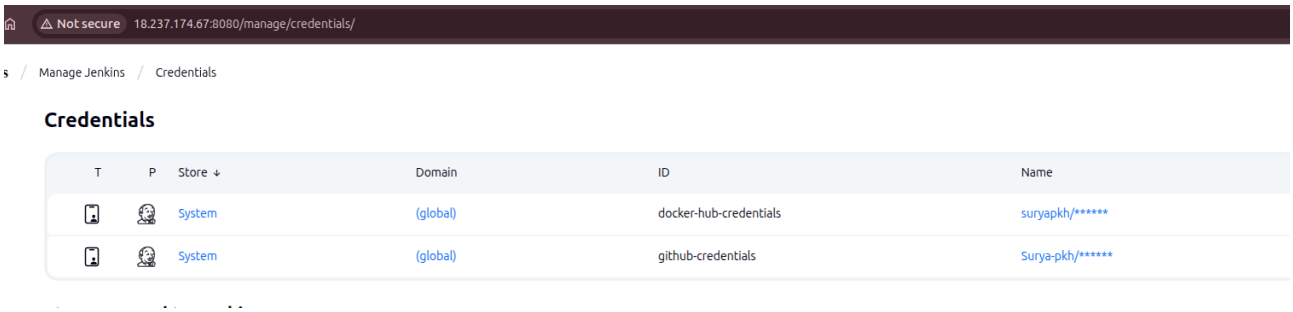



### 1.3 Credentials Management

Configure the following credentials in Jenkins:

| Credential Type | ID | Usage |
|---|---|---|
| Username/Password | `docker-hub-credentials` | Docker Hub authentication |

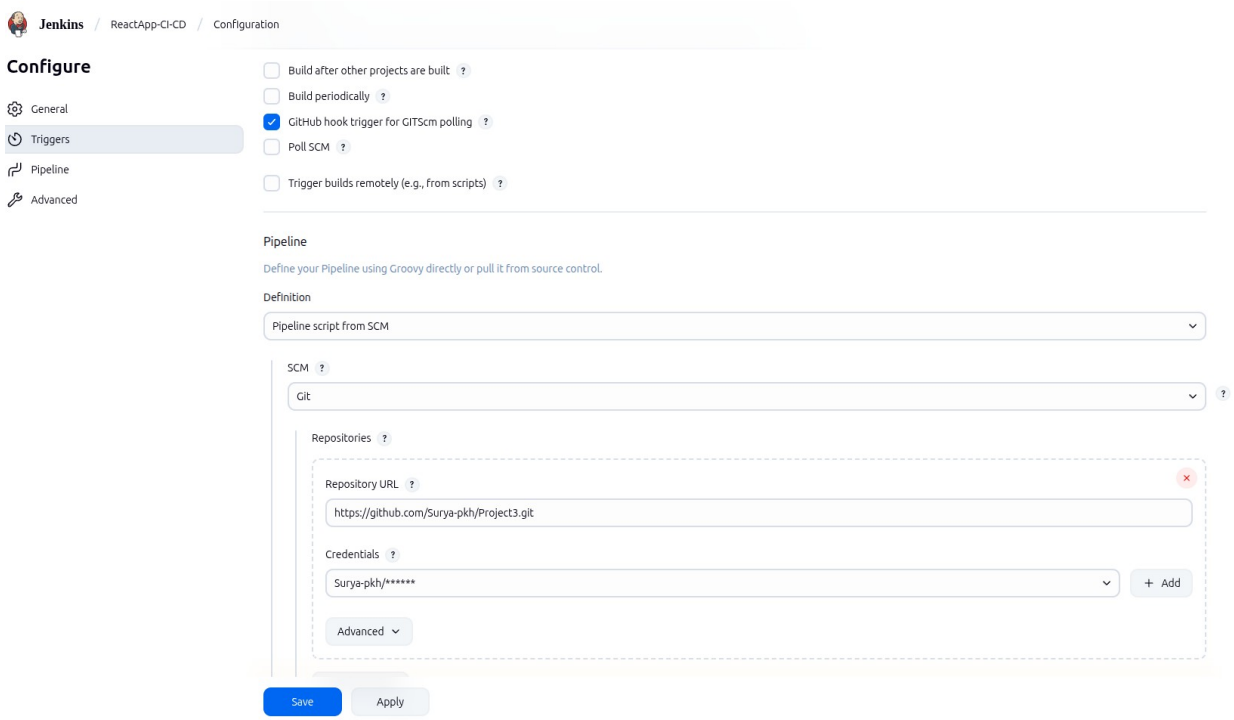
**Navigation:** Manage Jenkins → Manage Credentials → Global → Add Credentials

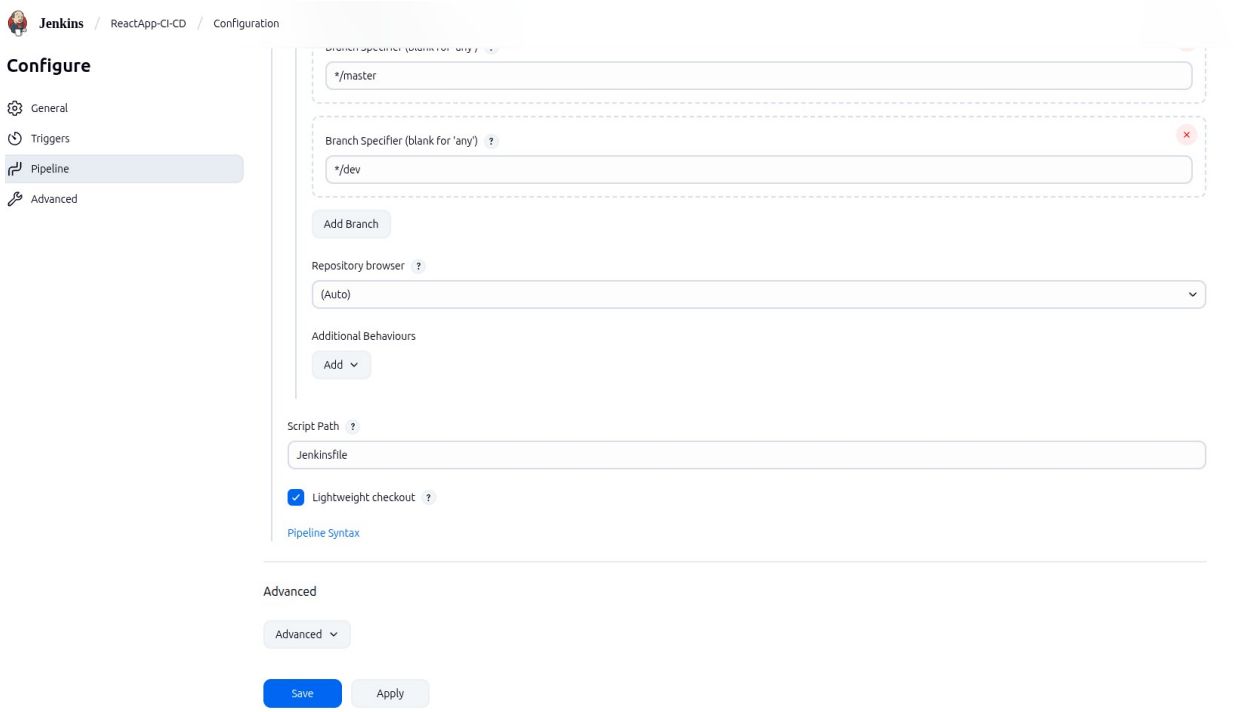



## Step 2: Pipeline Configuration

### 2.1 Create Jenkins Pipeline Job

1. New Item → Pipeline
2. Job Name: `React-App-CI-CD-Pipeline`
3. Pipeline Definition: Pipeline script from SCM
4. Repository Configuration: Your Git repository URL
5. Script Path: `Jenkinsfile`

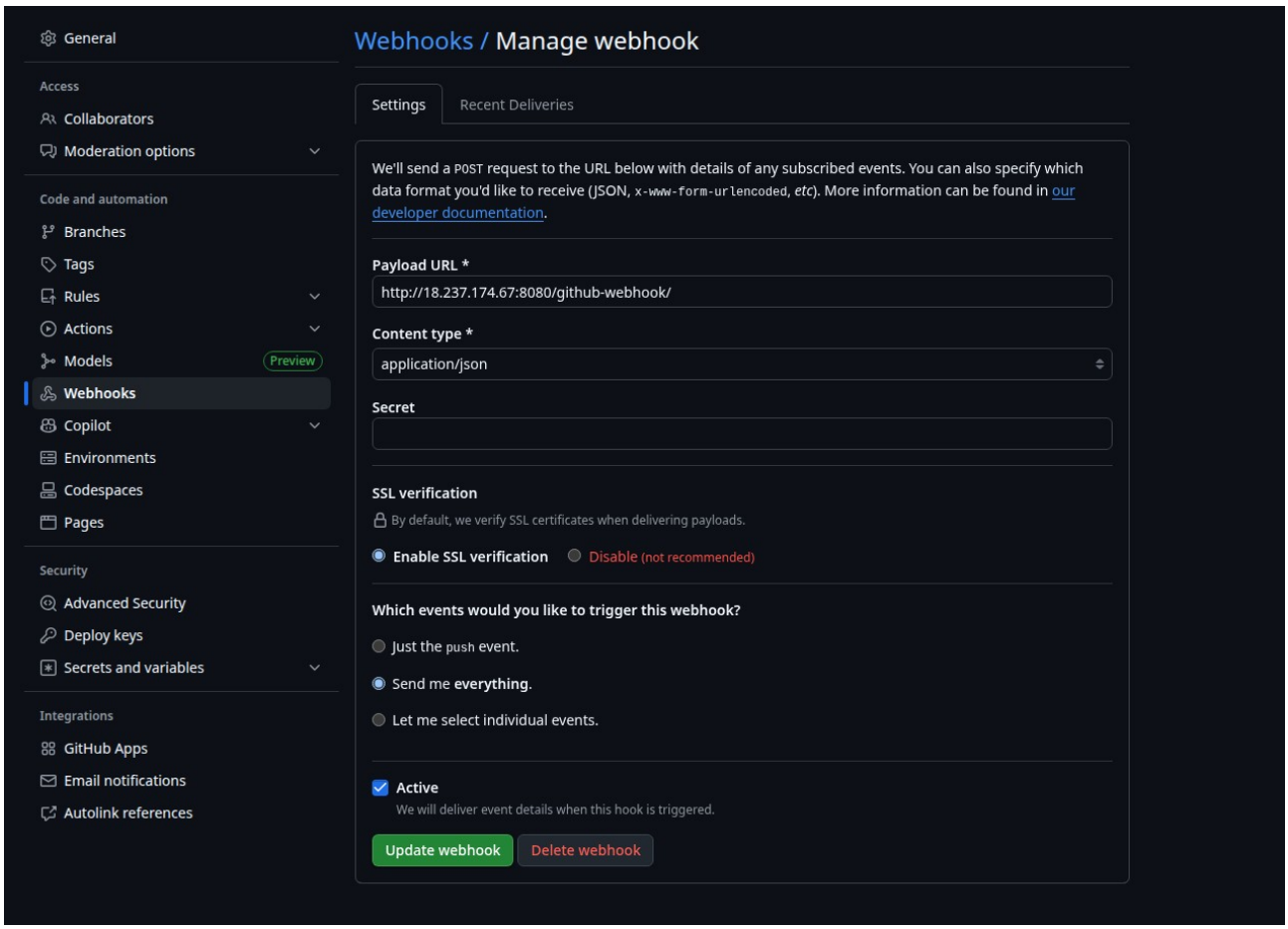



## 2.2 Webhook Configuration (Optional)

Configure Git webhook for automatic builds:

- Payload URL: `http://{JENKINS_IP}:8080/github-webhook/`
- Content Type: `application/json`
- Events: Push events




## Step 3: Manual Build and Deployment

### 3.1 Local Build Testing

```
# Make scripts executable
chmod +x build.sh deploy.sh

# Execute build process
./build.sh
```

### 3.2 Validate Container Registry

Verify images are successfully pushed to Docker Hub repositories:

- Development: `{username}/project3-dev:latest`
- Production: `{username}/project3-prod:latest`

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# Monitoring & Alerting Setup

## Step 1: AWS CloudWatch Configuration

### 1.1 Log Group Verification

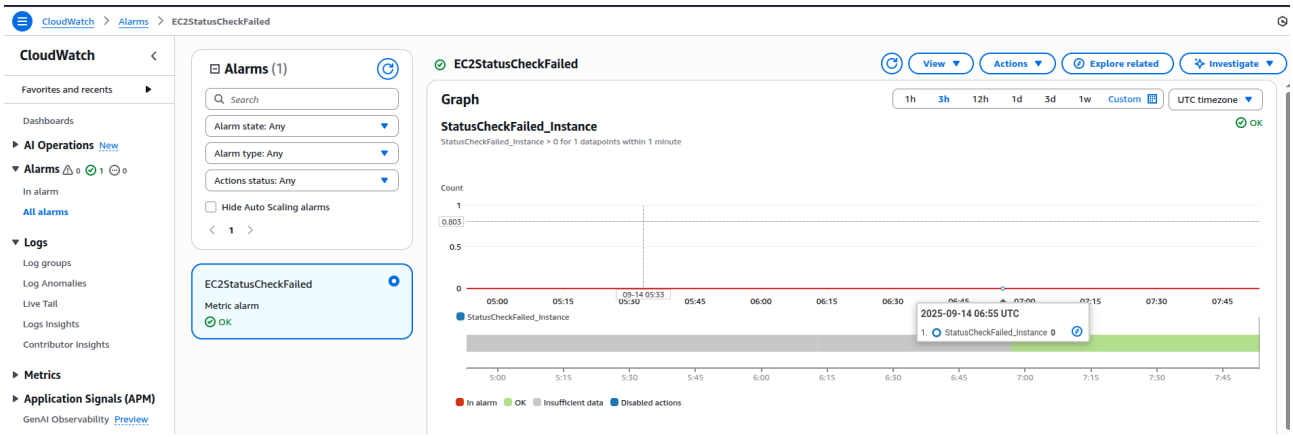
Navigate to AWS CloudWatch Console and verify:

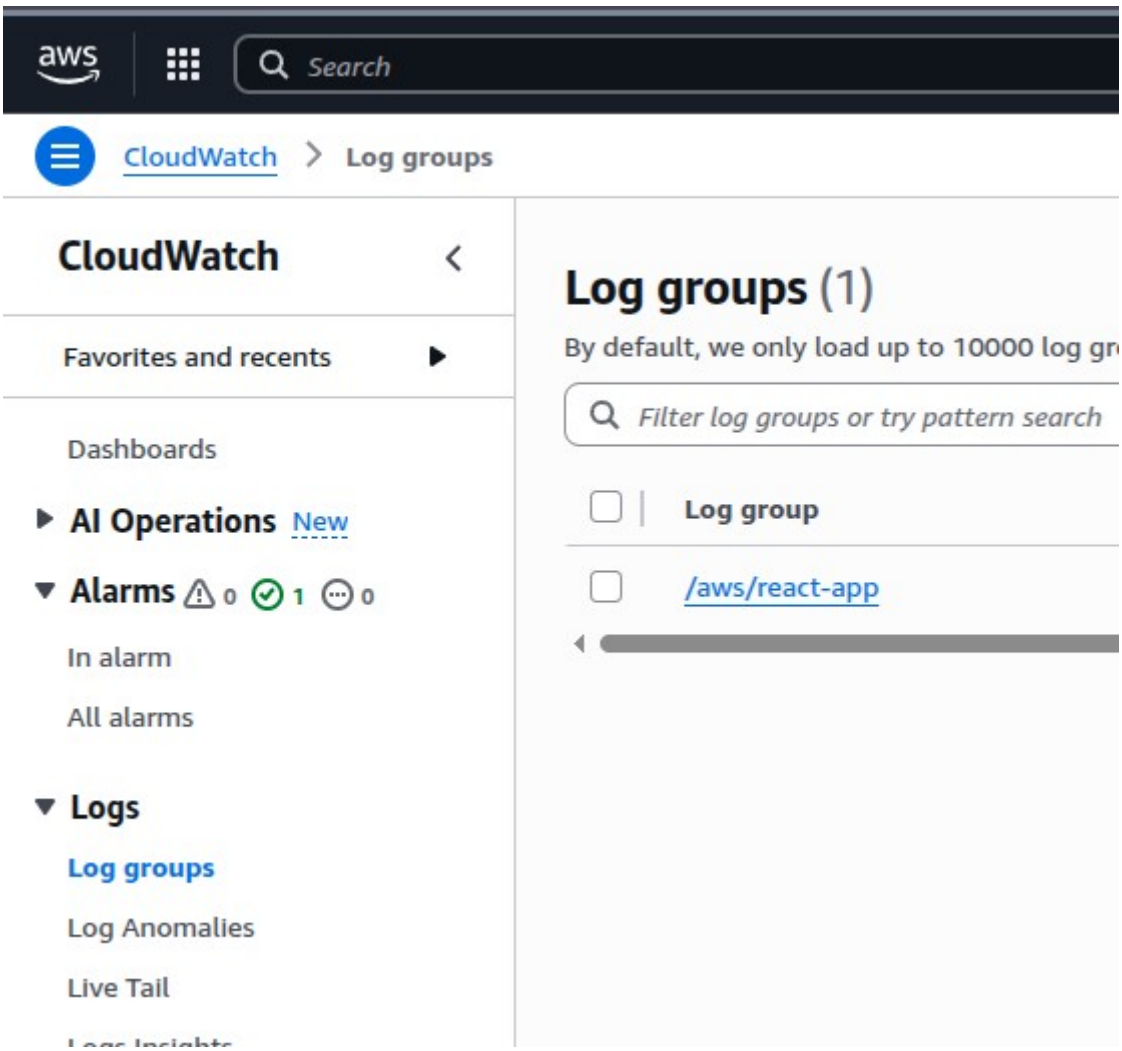
- Log Group: `/aws/react-app` exists
- Log streams are being populated
- Retention policy is set to 7 days

### 1.2 Metric Alarms Validation

Confirm the following alarms are active:

- EC2 Status Check Failed
- High CPU Utilization (if configured)
- High Memory Usage (if configured)






## Step 2: SNS Alert Configuration

### 2.1 Email Subscription Confirmation

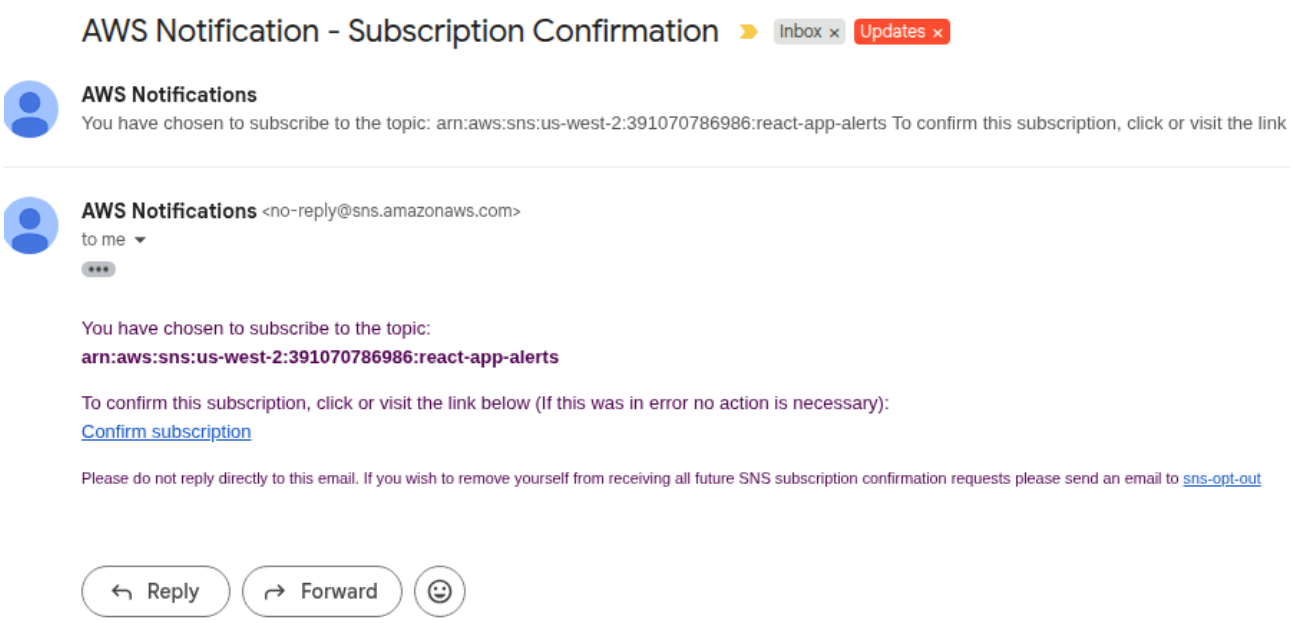
1. Check email for SNS subscription confirmation
2. Confirm subscription by clicking the provided link

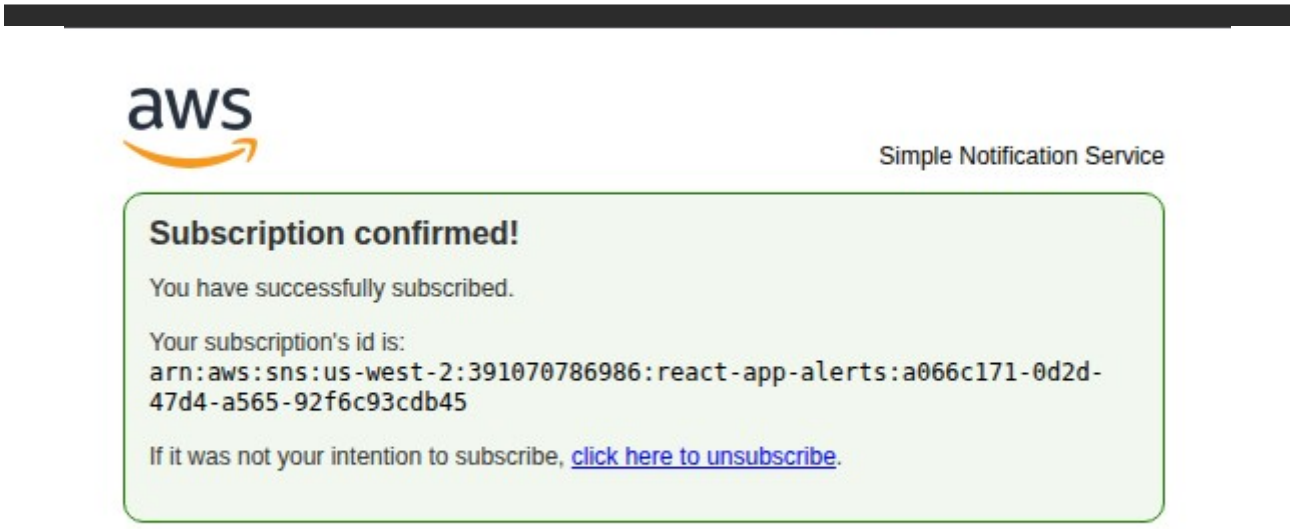
3. Verify subscription status in AWS SNS Console

### 2.2 Alert Testing

```
# Test alert system by simulating instance failure
aws ec2 stop-instances --instance-ids $(terraform output -raw
react_app_instance_id)

# Monitor for alert email delivery
# Restart instance after testing
aws ec2 start-instances --instance-ids $(terraform output -raw
react_app_instance_id)
```



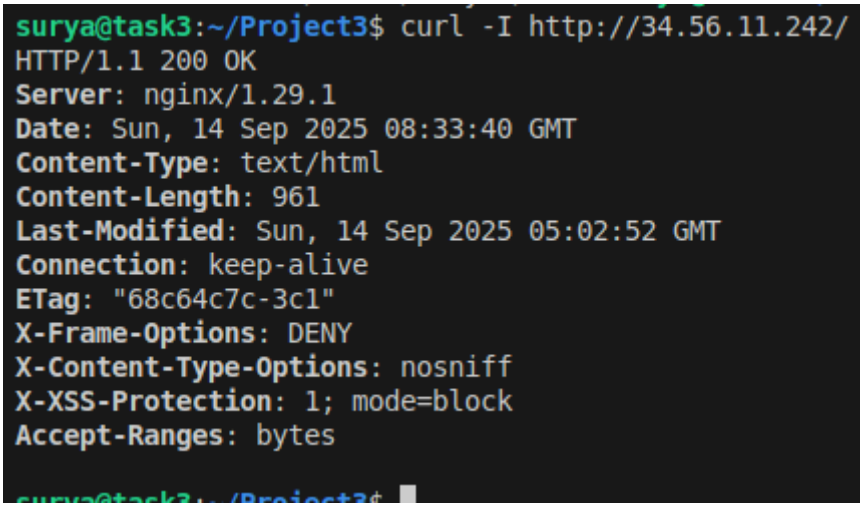
# Deployment Validation

## Step 1: Application Accessibility Testing

### 1.1 HTTP Response Validation

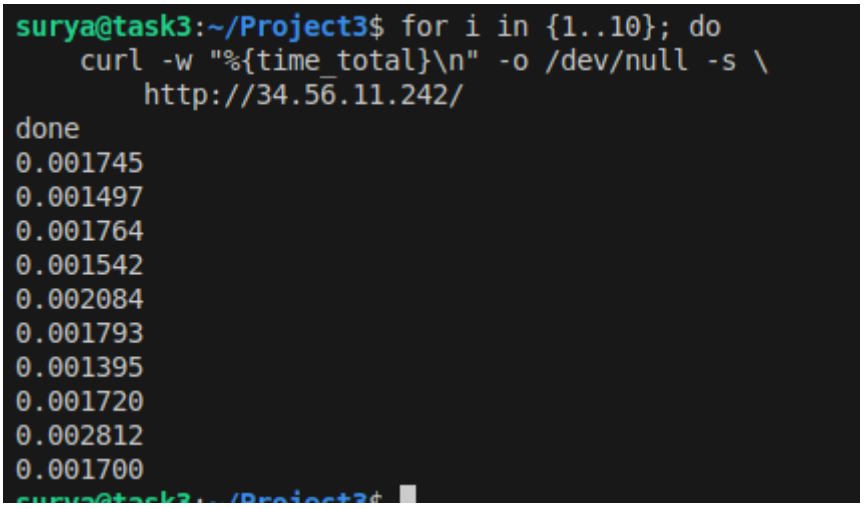
```
# Test application endpoint
curl -I http://$(terraform output -raw react_app_public_ip)

# Expected Response: HTTP/1.1 200 OK
```




### 1.2 Load Testing (Basic)

```
# Simple load test
for i in {1..10}; do
    curl -w "%{time_total}\n" -o /dev/null -s \
        http://$(terraform output -raw react_app_public_ip)
done
```

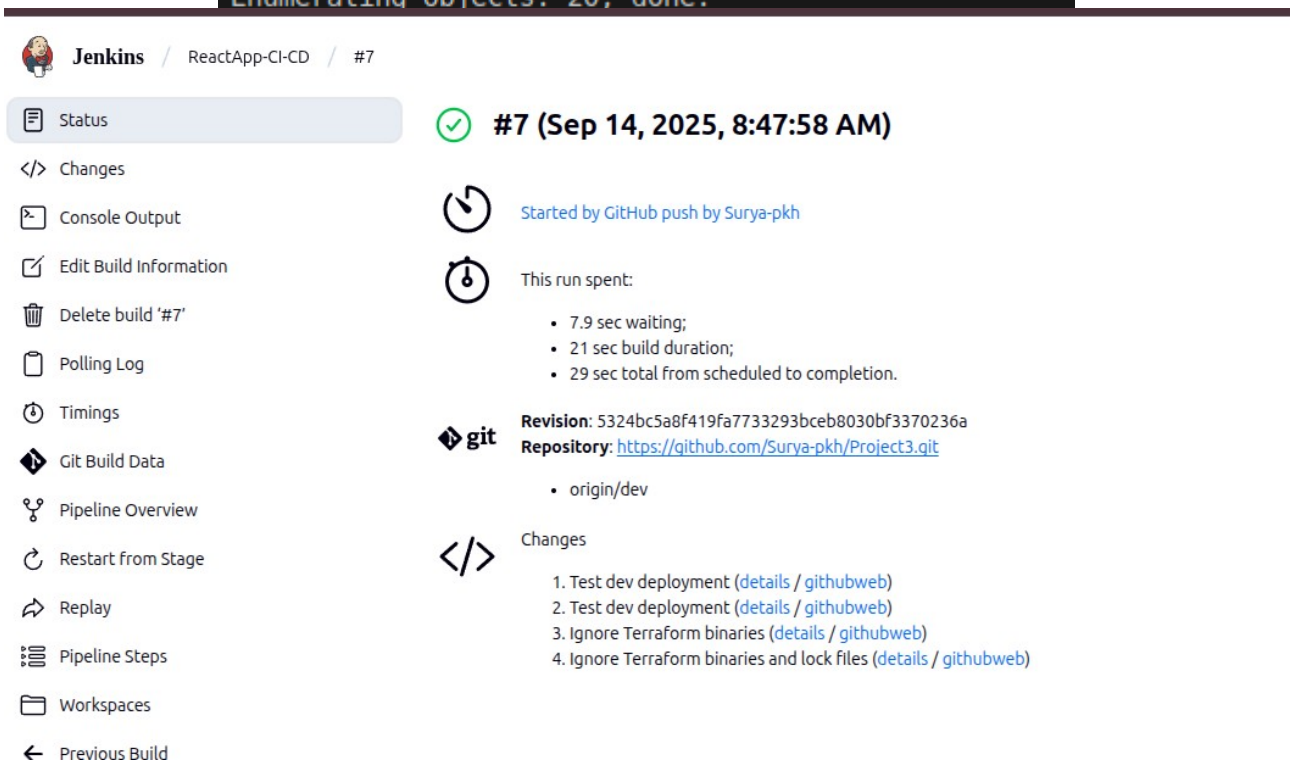



## Step 2: CI/CD Pipeline Validation

### 2.1 Development Branch Testing

```
# Test development pipeline
git checkout dev
echo "// Test change" >> Readme.md
git add . && git commit -m "Test dev deployment"
git push origin dev
```

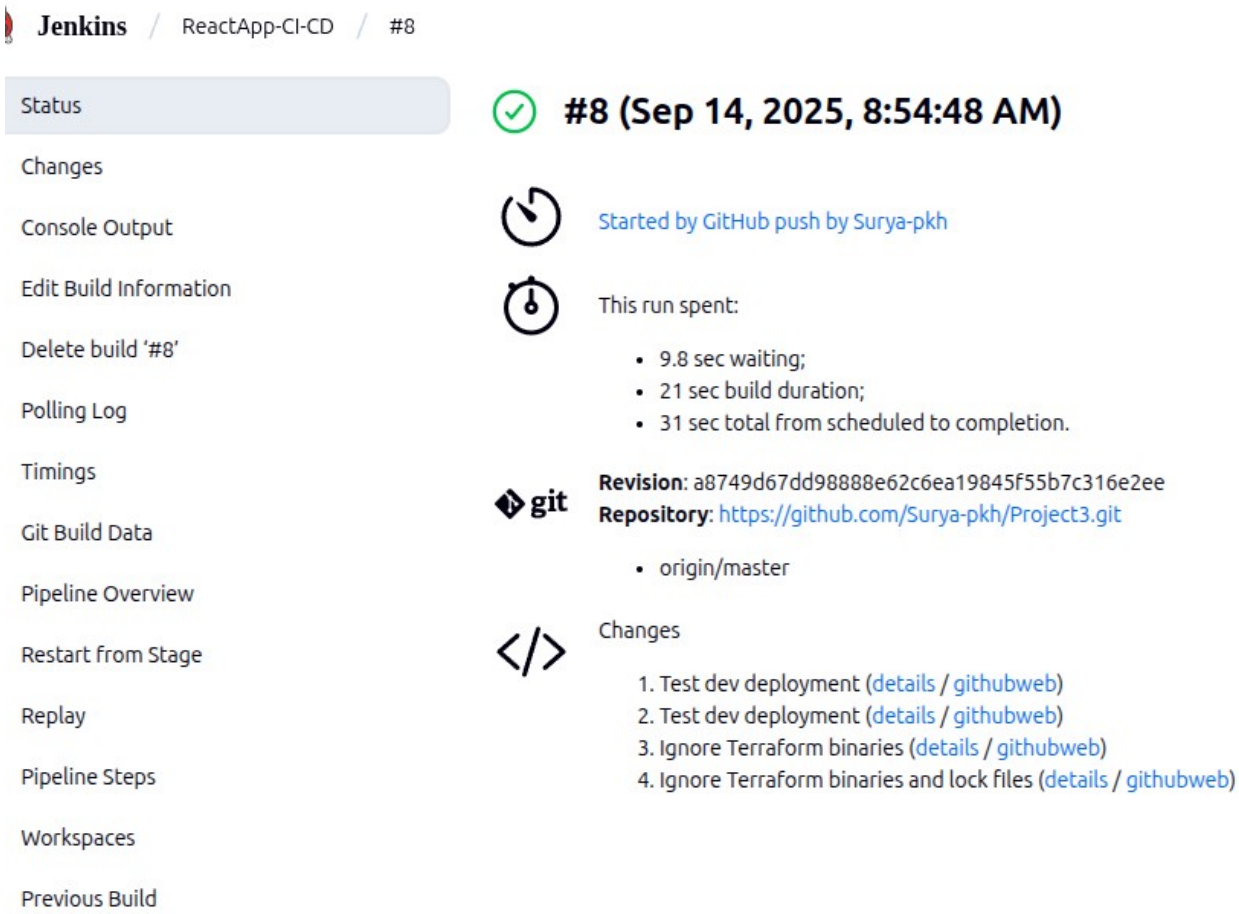
```
surya@task3:~/Project3$ git push origin dev
Enumerating objects: 20, done.
```




## 2.2 Production Branch Testing

```
# Test production pipeline
git checkout main
git merge dev
git push origin main
```

```
surya@task3:~/Project3$ git commit -m "Merge dev into master"
[master a8749d6] Merge dev into master
surya@task3:~/Project3$ git push origin master
Enumerating objects: 4, done.
Counting objects: 100% (4/4), done.
Delta compression using up to 2 threads
Compressing objects: 100% (2/2), done.
Writing objects: 100% (2/2), 352 bytes | 352.00 KiB/s, done.
Total 2 (delta 1), reused 0 (delta 0), pack-reused 0
remote: Resolving deltas: 100% (1/1), completed with 1 local obje
To https://github.com/Surya-pkh/Project3.git
   281dd6e..a8749d6  master -> master
surya@task3:~/Project3$
```



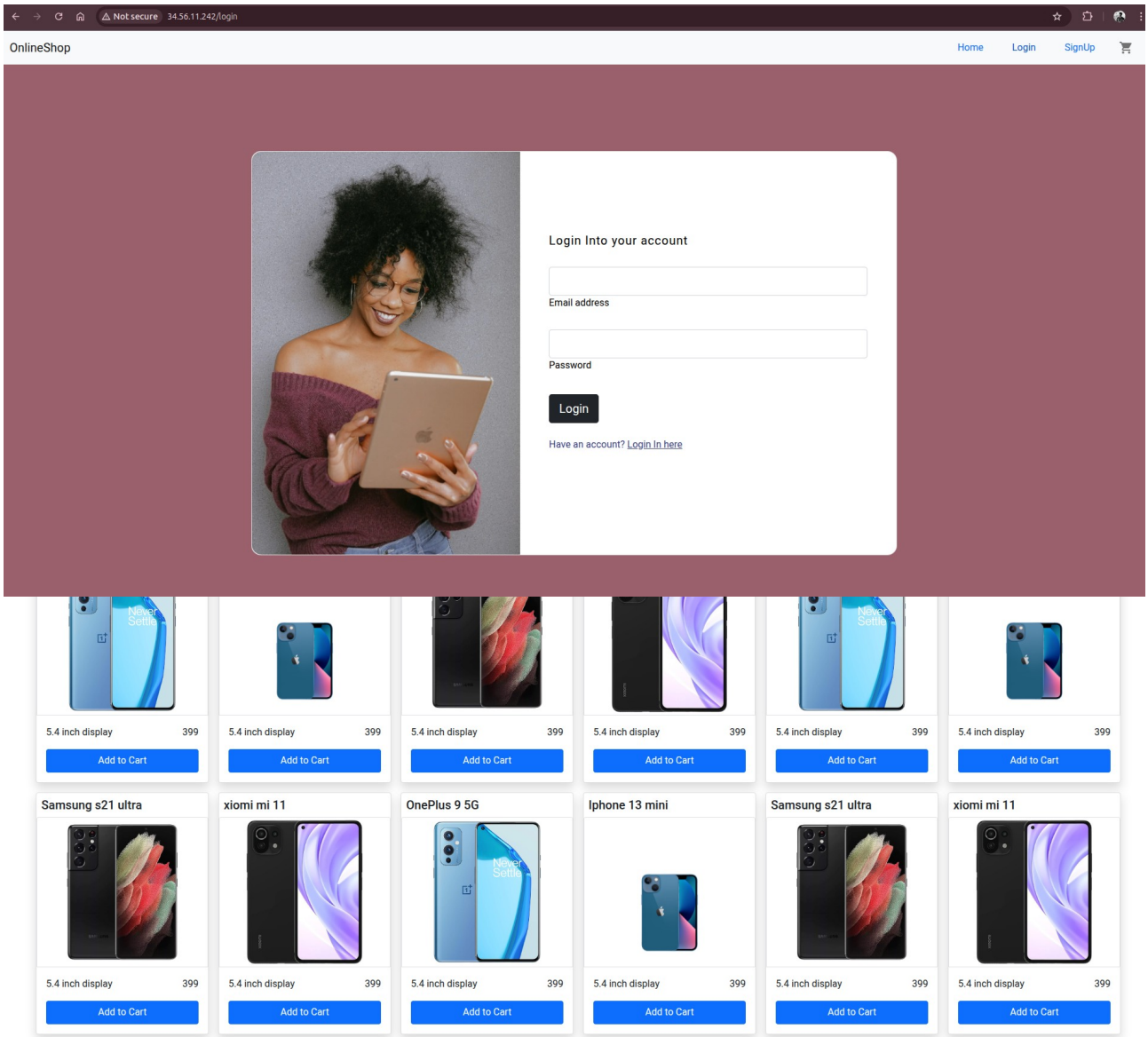

## Step 3: End-to-End Functional Testing

### 3.1 Browser Testing Checklist

- [ ] Application loads without errors
- [ ] All static assets are served correctly
- [ ] Responsive design functions properly
- [ ] No console errors in browser developer tools

### 3.2 Performance Metrics Validation

- Page load time < 3 seconds
- First contentful paint < 1.5 seconds
- Cumulative layout shift < 0.1




# Operations & Maintenance

## Routine Maintenance Procedures

### Daily Operations

```
# System health check
docker ps
```

```
systemctl status docker
df -h

# Application log review
docker logs react-app --tail 100
```

### Weekly Maintenance

```
# Clean up unused Docker resources
docker system prune -f

# Update security patches
sudo apt update && sudo apt upgrade -y

# Backup configuration files
tar -czf backup-$(date +%Y%m%d).tar.gz terraform/ monitoring/
```

### Monthly Reviews

- Review CloudWatch metrics and cost optimization
- Update base Docker images for security patches
- Validate disaster recovery procedures
- Performance benchmarking and capacity planning

## Scaling Considerations

| Metric | Threshold | Action |
|---|---|---|
| CPU Usage | >80% for 10 minutes | Scale up instance type |
| Memory Usage | >85% sustained | Add memory or scale horizontally |
| Network I/O | >80% of limit | Consider load balancing |
| Storage | >80% full | Increase EBS volume size |

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# Security Implementation

## Implemented Security Controls

### Network Security

- ✅ Security Groups with principle of least privilege
- ✅ SSH access restricted to authorized IP addresses
- ✅ HTTPS enforcement (via security groups configuration)
- ✅ Private subnets for database tier (when applicable)

### Application Security

- ✅ Container runs with non-root user
- ✅ Regular base image updates
- ✅ Secrets management via Jenkins credentials
- ✅ Environment variable encryption

**Operational Security**

- ✅ Automated security updates
- ✅ Centralized logging with CloudWatch
- ✅ Access monitoring and alerting
- ✅ Infrastructure as Code for consistency

## Security Best Practices Compliance

| Security Domain | Implementation Status | Notes |
|---|---|---|
| Identity & Access Management | ✅ Implemented | IAM roles with minimal permissions |
| Data Protection | ✅ Implemented | EBS encryption at rest |
| Network Security | ✅ Implemented | VPC with security groups |
| Logging & Monitoring | ✅ Implemented | CloudWatch integration |
| Incident Response | ⚠️ Partial | Alert mechanisms in place |

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# Troubleshooting & Support

## Common Issues and Resolutions

### Jenkins Pipeline Failures

**Issue:** Build fails with Docker authentication error
**Symptoms:** `unauthorized: authentication required`
**Resolution:**

1. Verify Docker Hub credentials in Jenkins
2. Check credential ID matches Jenkinsfile reference
3. Validate Docker Hub repository permissions

**Issue:** Terraform apply fails
**Symptoms:** `403 Forbidden` or `Access Denied`
**Resolution:**

1. Verify AWS CLI credentials configuration
2. Check IAM user permissions
3. Validate Terraform state file permissions

### Application Deployment Issues

**Issue:** Application not accessible via browser
**Symptoms:** Connection timeout or refused
**Resolution:**

1. Verify security group allows inbound traffic on port 80
2. Check container status: `docker ps`
3. Validate nginx configuration syntax

**Issue:** CloudWatch logs not appearing
**Symptoms:** Empty log groups or streams
**Resolution:**

1. Verify CloudWatch agent installation
2. Check IAM permissions for CloudWatch
3. Validate log file paths in configuration

## Escalation Procedures

### Level 1 Support (Self-Service)

- Consult this documentation
- Check application logs
- Verify basic connectivity

### Level 2 Support (Technical Team)

- Infrastructure issues
- Complex configuration problems
- Performance optimization

### Level 3 Support (Vendor/AWS)

- AWS service outages
- Advanced networking issues
- Critical security incidents

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# Disaster Recovery Procedures

## Backup Strategy

### Infrastructure Backups

- Terraform state files stored in S3 (recommended)
- AMI snapshots of configured instances
- Configuration files version controlled in Git

### Application Backups

- Docker images stored in multiple registries
- Database backups (if applicable) with point-in-time recovery
- Static asset backups in S3

## Recovery Procedures

### Complete Environment Recovery

```
# Restore from Terraform
```

```
cd terraform/
terraform init
terraform plan
terraform apply

# Redeploy application
./deploy.sh
```

#### Partial Service Recovery

```
# Restart application container
docker-compose down
docker-compose pull
docker-compose up -d
```

### Recovery Time Objectives (RTO)

| Scenario | Target RTO | Recovery Method |
|---|---|---|
| Application failure | < 5 minutes | Container restart |
| Single instance failure | < 15 minutes | Instance replacement |
| Complete environment loss | < 60 minutes | Full infrastructure rebuild |

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## Conclusion

This deployment guide provides a comprehensive framework for implementing a production-ready React application with modern DevOps practices. The solution ensures high availability, scalability, and maintainability while adhering to industry security standards.

### Key Benefits Delivered

- **Automated Deployment Pipeline** reducing manual errors and deployment time
- **Infrastructure as Code** ensuring consistent and reproducible environments
- **Comprehensive Monitoring** providing visibility into application and infrastructure health
- **Security-First Approach** implementing defense-in-depth principles
- **Scalable Architecture** supporting business growth and varying load patterns

### Next Steps

1. Complete initial deployment following this guide
2. Implement SSL/TLS certificates for production
3. Configure automated backups and disaster recovery testing
4. Establish monitoring thresholds and alert procedures
5. Plan for horizontal scaling based on usage patterns

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#### Document Control

| Version | Date | Author | Changes |
|---|---|---|---|
| 1.0 | September 2025 | Surya Prakash C | Initial comprehensive guide |